



Water Rights Analysis Package (WRAP) Modeling System Users Manual

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Users Manual

by

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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*, an introductory *Fundamentals Manual*, and *Daily, Hydrology, and Salinity Manuals* covering specific additional features. The *Reference Manual* explains basic WRAP capabilities and methodologies. This *Users Manual* provides the operational logistics for applying the modeling system described in the *Reference Manual* by explaining the organization of input and output files and the content and format of input records. The other supplemental manuals document additional modeling capabilities incorporated in WRAP that are not covered in this basic *Users Manual* and companion *Reference Manual*.

WRAP Programs

The software package documented by this *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 a river/reservoir water allocation/management/use 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.

The following programs providing additional modeling capabilities not covered by this *Users Manual* are documented by the *Hydrology, Daily, and Salinity Manuals*.

HYD develops or updates monthly naturalized stream flow and reservoir net evaporation less precipitation depth data for *SIM* hydrology input files.

SIMD is an expanded version of *SIM* with additional features for daily time steps, flow forecasting and routing, pulse flows, and flood control operations.

DAY assists in developing daily hydrology input for *SIMD* including monthly-to-daily flow disaggregation and determining 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 as follows.

<u>Covered in this Manual</u>		<u>Covered in Supplemental Manuals</u>	
<i>WRAP-SIM</i>	<i>SIM.exe</i>	<i>WRAP-HYD</i>	<i>HYD.exe</i>
<i>TABLES</i>	<i>TAB.exe</i>	<i>WRAP-SIMD</i>	<i>SIMD.exe</i>
<i>WinWRAP</i>	<i>WinWRAP.exe</i>	<i>WRAP-DAY</i>	<i>DAY.exe</i>
		<i>WRAP-SALT</i>	<i>SALT.exe</i>

WinWRAP User Interface Program

Each of the WRAP programs can be executed individually in Microsoft Windows, independently of *WinWRAP*. However, the *WinWRAP* interface facilitates running the WRAP programs within Microsoft Windows in an integrated manner along with use of Microsoft programs to access data files and *HEC-DSSVue* to graph simulation results. *WinWRAP* connects executable programs and data files. The WRAP programs (executable files) should be in the same folder as *WinWRAP*. Program *WinWRAP* can be activated with the conventional Windows options including a mouse click of the executable file, the run window, or a desktop shortcut icon. 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 Files					
All WRAP Files	DOS Editor	SIM-TAB	HEC-DSSVue	TABLES TIN File	WinWRAP Instructions
Main Input Files	NotePad	SALT-TAB	HEC Website	SIM DAT Template	WinWRAP Version
Main Output Files	WordPad	HYD		HYD DAT Template	WRAP Documentation
Hydrology Files	Word	DAY			-----
Special Files	Excel	-----			TCEQ WAM
Message Files		Terminate			TWRI
DAT Files					TAMU WRAP
SOU Files					
TIN Files					
TOU Files					
DSS 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 Files* pull-down menu provides access to data files through a Microsoft Windows window. Clicking or selecting/opening a data file activates a user-selected program such as WordPad or NotePad which opens the file. The Windows operating system provides mechanisms described in Windows Help for designating the program associated with any particular file extension. An extension may be assigned to WordPad, Notepad, or other programs by selecting any file with that extension. A right mouse click or double left click activates a menu that includes an *open with* option that activates a dialog box containing a check-box indicating that the file extension is to always be associated with the selected program. Clicking a DSS file opens DSSVue.

The *MS Programs* pull-down menu is designed for opening the Microsoft programs listed in Table 1.1. A mouse click or select/open button activates the selected program. Existing WRAP data files can then be opened or new files created from the Microsoft program. However, the *WRAP Files* menu with pre-assigned filename extensions is a quicker way to edit existing data files.

The *WRAP Programs* pull-down 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 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.

HEC-DSSVue can be executed from the *HEC-DSSVue* pull-down menu or by clicking a DSS file assuming that the program has been loaded on the computer. Options in the WRAP programs 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*. *WinWRAP* also provides a link to the Hydrologic Engineering Center website from which the *HEC-DSSVue* software and documentation are available for download.

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. However, *TABLES* input files are more often created and edited using the same Microsoft editors as used for the other input files rather than this built-in *WinWRAP* editor. Copies of text file templates may be accessed from the *File Building Aids* menu to help start new *SIM* and *HYD* input files.

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 river flow sequences, subject to reservoir storage capacities, net reservoir evaporation-precipitation and channel losses, and specified diversion, instream flow, and hydroelectric power requirements. Water balance computations are performed for each month of the hydrologic simulation period. Flexibility is provided 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 840-month 1940-2009 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 river flows, reservoir net evaporation less precipitation, and channel losses (Chapter 3 of the *Reference Manual*).
- *Water rights* include all aspects of water resources development, allocation, use, and 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 (Chapter 4 of the *Reference Manual*).

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. *TABLES* is covered in Chapters 5, 6, and 7 of the *Reference Manual* and Chapter 4 of this *Users Manual*. The *Fundamentals Manual* provides an introductory condensed coverage of *WinWRAP*, *SIM*, and *TABLES*.

Programs HYD, SIMD, DAY, and SALT

The WRAP programs *HYD*, *SIMD*, *DAY*, and *SALT* are covered in the *Hydrology*, *Daily*, and *Salinity Manuals* which are introduced in the *Reference Manual*. *HYD* facilitates developing and updating *SIM* hydrology input files. *HYD* is a set of computational options designed to provide assistance in developing or extending 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.

SIMD expands the monthly *SIM* simulation model to include sub-monthly (daily) time steps, flow forecasting and routing, pulse flow environmental instream flow targets, and flood control reservoir operations. The *Daily Manual* supplements the basic *Reference* and *Users Manuals* in documenting *SIMD* and corresponding daily features of *TABLES*. The program *SALT* reads a *SIM* output file and simulates salinity loads and concentrations through the river/reservoir system. The *Salinity Manual* describes *SALT* and the corresponding salinity features of *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.

The WRAP programs *SIM*, *SIMD*, *SALT* and *HYD* have options for storing hydrology data and simulation results as either text files or HEC-DSS binary files. The post-simulation program *TABLES* also includes options for writing the time series variables from the *SIM*, *SIMD*, or *SALT* simulation results as either text files or HEC-DSS files. The *TABLES* time series 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 simulation results in columns for export to Microsoft Excel or other spreadsheet programs for plotting or other manipulations.
3. A HEC-DSS file may be created to be read by HEC-DSSVue for graphing time series plots or other data management or computation purposes.

Editor and Spreadsheet 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.

Notepad++ can also be easily installed and accessed through the WRAP files menu in WinWRAP. Notepad++ is an enhanced text editor that is similar to Microsoft Notepad and Wordpad but provides additional features which are useful in creating and editing WRAP input files and viewing output files. Notepad++ is available free-of-charge at:

<http://notepad-plus-plus.org> or http://portableapps.com/apps/development/notepadpp_portable

Hydrologic Engineering Center's HEC-DSSVue

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. 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 dates back to 1979. The HEC-DSS Visual Utility Engine (HEC-DSSVue) is a more 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*.

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. Data can also be conveniently exchanged between HEC-DSSVue and Microsoft Excel. The public domain HEC-DSSVue software and documentation may be downloaded from the Hydrologic Engineering Center website: <http://www.hec.usace.army.mil>

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 programs are linked at compilation with a HECDSS library of routines allowing them to read input data and store simulation results as HEC-DSS files. HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. The pathnames for input and output are assigned automatically by the WRAP programs. The DSS pathnames for WRAP output files are in the following standard format.

- A – filename root of output file
- B – identifier of control point, water right, reservoir, or water right group
- C – identifier of variable such as NAT, REG, STO
- D – date of the beginning of the time series such as 01JAN1940
- E – time interval = MON or YEAR for *SIM* results (*SIMD* includes sub-monthly.)
- F – CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

ESRI ArcGIS and WRAP Display

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. As noted in *Reference Manual* Chapters 1 and 6, the *WRAP Display Tool* available from the TCEQ displays WRAP simulation results in ArcGIS. The tool is applied as a toolbar installed in ArcMap to display water supply reliabilities, flow and storage frequencies, and other percentage-based indices derived from *WRAP-SIM* simulation results by ranges as color coded symbols on a map. *SIM* time series output data can also be plotted. The *WRAP Display Tool* provides flexibility for customization as well as standardized display features.

Input and Output Files

The WRAP programs are generalized for application to any river/reservoir system, with input files being developed for the particular river basin of concern. The TCEQ WAM System includes datasets for all of the river basins of Texas. Application of WRAP in Texas typically involves modifying existing data files for a river basin of concern. Proposed water development projects and management strategies and changes in water use are added to the existing WAM System datasets to support particular studies and analyses. For applications outside of Texas where datasets have not been compiled, collecting data and creating input datasets for the river basin or region of concern represents the majority of the effort of a WRAP simulation study.

The model-user provides input data files. Certain WRAP programs also create files that are read by other WRAP 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 DSS files and optional binary *SIM* output file, 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. The *SIM* output OUT file can optionally be either binary or text.

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* and *TABLES* are discussed in Chapters 2 and 4 of this *Users Manual*. Files associated with *SIMD*, *DAY*, *HYD*, and *SALT* and the *TABLES* routines for manipulating *SIMD* daily simulation and *SALT* salinity simulation results are covered in the other manuals.

Names of files are in the format *root.extension*. The root is an arbitrary name assigned by the user. 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. 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 filename extension differentiates the different types of data contained in the files.
- Assigning a different root (root2 in Table 1.2) for the hydrology files (FLO, EVA, HYD, DIS, 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) for *TABLES* input and output files may be convenient though not required. Also, unlike all the other file types, *TABLES* output filenames optionally allow user-specified extensions other than the set standard.
- Program *HYD* is typically applied with the input and output files differentiated with different roots (root5 and root6 in Table 1.2)

Table 1.2 Input and Output Files

<u>SIM and SIMD Input Files</u>	
root1.DAT	required main input file containing all input <i>data</i> , except the voluminous hydrology related data contained in the following files
root2.FLO	inflow <i>IN</i> records with naturalized stream <i>flows</i> (optional filename root.INF)
root2.EVA	<i>evaporation EV</i> records with net evaporation-precipitation rates
root2HYD.DSS	<i>hydrology DSS</i> file with naturalized flows and evaporation-precipitation rates
root2.DIS	flow <i>distribution FD</i> and <i>FC</i> and watershed parameter <i>WP</i> records
root2.HYD	<i>IN</i> and <i>EV</i> records provided in a single <i>hydrology</i> file instead of FLO and EVA files
root2.FAD	flow <i>adjustment FA</i> records for adjusting naturalized stream flows
root2.HIS	hydrologic index series on <i>HI</i> records
root1.BES	<i>beginning and/or ending storage</i> listing activated by <i>JO</i> record field 5
root2.RUF	<i>regulated-unappropriated RU</i> flow adjustment records activated by <i>JO</i> field 12 or 13
root2.DCF	<i>daily</i> or other sub-monthly <i>control point and flow</i> data read by <i>SIMD</i>

<u>SIM and SIMD Output Files</u>	
root1.MSS	<i>messages</i> reporting simulation progress and input data errors
root1.OUT	main simulation results <i>output</i> file read by <i>TABLES</i> and <i>SALT</i>
root1.SOU	main simulation results <i>output</i> file in columnar format
root1.DSS	simulation results output file in HEC-DSS (<i>data storage system</i>) binary format
root1.HRR	<i>hydropower</i> and <i>reservoir release</i> file read by <i>TABLES</i>
root1.YRO	yield- <i>reliability</i> output table presenting the results of a <i>FY</i> -record analysis
root1.CRM	conditional <i>reliability modeling</i> simulation results read by <i>TABLES</i>
root1.ZZZ	changes in stream flow availability in water rights sequence activated by <i>ZZ</i> record
root1.BES	<i>beginning and/or ending storage</i> listing activated by <i>JO</i> record field 5
root1.BRS	<i>beginning reservoir storage</i> listing activated by <i>JO</i> record field 6
root1.SUB	<i>SIMD sub</i> -monthly time step simulation results
root1.SMM	<i>SIMD</i> sub-monthly messages and supplemental reports
root1.AFF	<i>SIMD annual flood frequency</i> file with annual series of peak flow and storage

<u>SALT Input Files</u>	
root2.SIN	required salinity <i>input</i> file with concentrations or loads of entering flows
root2.DAT	required main <i>SIM/SIMD</i> input file from which <i>CP</i> records are read
root2.OUT	required main <i>SIM/SIMD output</i> file with simulation results
root2.BRS	<i>beginning reservoir storage</i> file created by <i>SIM/SIMD</i> and read by <i>SALT</i> to provide beginning reservoir storage if specified by <i>JC</i> record field 8
root2.BRC	<i>beginning reservoir concentration</i> file created by <i>SALT</i> and also read by <i>SALT</i> as specified by <i>JC</i> record field 9

<u>SALT Output Files</u>	
root1.SAL	<i>salinity</i> simulation results read by <i>TABLES</i>
root1.SMS	salinity <i>message</i> file with simulation trace, error and warning messages, and intermediate and summary simulation results tables
root1.BRC	<i>beginning reservoir concentration</i> file created and read by <i>SALT</i>

Table 1.2 Input and Output Files (continued)

TABLES Input Files

root3.TIN	required TABLES <i>input</i> file with specifications regarding tables to be developed
root1.DAT	<i>SIM/SIMD</i> input DAT file
root1.OUT	<i>SIM/SIMD</i> output OUT file
root1.ZZZ	<i>SIM/SIMD</i> output ZZZ file
root1.HRR	<i>SIM/SIMD</i> output HRR file
root1.DIS	<i>SIM/SIMD</i> input DIS file
root1.AFF	<i>SIMD</i> annual <i>flood</i> frequency output file with annual series of peak flow and storage
root1.CRM	<i>SIM/SIMD</i> conditional <i>reliability</i> modeling output file
root1.SFF	storage- <i>flow</i> -frequency file created by <i>5CR1</i> record and read by <i>5CR2</i> record

TABLES Output Files

root4.TOU	TABLES <i>output</i> file with the tables developed by the various routines (User-selected filename extensions may replace the default TOU.)
root4.TMS	TABLES <i>message</i> file with tracking the computations and reporting input data errors
root4.DSS	Hydrologic Engineering Center <i>Data Storage System</i> file read by <i>HEC-DSSVue</i>
root4.SFF	storage- <i>flow</i> -frequency file created by <i>5CR1</i> record and read by <i>5CR2</i>

HYD Input Files

root5.HIN	HYD file with all <i>input</i> data not included in the following hydrology files
root5.FLO	inflow <i>IN</i> records with stream <i>flows</i>
root5.EVA	<i>evaporation</i> <i>EV</i> records with net evaporation-precipitation rates
root5.DIS	flow <i>distribution</i> <i>FD</i> & <i>FC</i> and watershed parameter <i>WP</i> records
root5.HYD	<i>IN</i> and <i>EV</i> records in single <i>hydrology</i> file in modified format
root5.DSS	<i>Data Storage System</i> file of stream flows and evaporation-precipitation depths

HYD Output Files

root6.HOT	file with all output not included in the following files
root6.HMS	HYD <i>message</i> file tracking the computations and reporting input data errors
root6.FLO	inflow <i>IN</i> records with naturalized stream <i>flows</i>
root6.EVA	<i>evaporation</i> <i>EV</i> records with net evaporation-precipitation rates
root6.DSS	<i>Data Storage System</i> file of stream flows and evaporation-precipitation depths

DAY Input Files

root1.DIN	main DAY <i>input</i> file
root2.FLO	input file of monthly <i>flows</i> in either <i>IN</i> record or columnar format
root2.DCF	input file of <i>daily</i> <i>flows</i> in either <i>DF</i> record or columnar format

DAY Output Files

root1.DAY	DAY output file
root1.DMS	DAY <i>message</i> file

Table 1.3 Matrix of Input and Output Files and Programs

File Name	File Function	WRAP Programs					
		SIM	SIMD	SALT	TABLES	HYD	DAY
<u>Main Required Input File for Each Program</u>							
DAT	<i>SIM</i> and <i>SIMD</i> input data file	input	input				
SIN	<i>SALT</i> input file			input			
TIN	<i>TABLES</i> input file				input		
HIN	<i>HYD</i> input file					input	
DIN	<i>DAY</i> input file						input
<u>Hydrology Input Data</u>							
FLO	<i>IN</i> record naturalized flows	input	input			in & out	input
EVA	<i>EV</i> record net evaporation	input	input			in & out	
DSS	DSS file with flow and evap data	in & out	in & out			in & out	
DIS	flow distribution parameters	input	input			input	
HYD	hydrology <i>IN</i> and <i>EV</i> records	input	input			input	
FAD	flow adjustments	input	input				
DCF	daily or sub-monthly flow data		input				input
<u>Main Simulation Results Output File for Each Program</u>							
OUT	<i>SIM</i> and <i>SIMD</i> main output file	output	output	input	input	input	
CRM	conditional reliability model file	output	output		input		
SOU	results in columnar tables	output	output				
SUB	<i>SIMD</i> sub-monthly time step file		output		input		
SAL	<i>SALT</i> main output file			output	input		
TOU	<i>TABLES</i> main output file				output		
DSS	DSS file with simulation results	output	output	output	output		
DAY	<i>DAY</i> main output file						output
<u>Message File for Each Program</u>							
MSS	<i>SIM</i> and <i>SIMD</i> message file	output	output				
SMM	<i>SIMD</i> message file		output				
SMS	<i>SALT</i> message file			output			
TMS	<i>TABLES</i> message file				output		
HMS	<i>HYD</i> message file					output	
DMS	<i>DAY</i> message file						output
<u>Special Purpose Files</u>							
HRR	hydropower and reservoir release	output	output		input		
YRO	yield reliability output	output	output				
ZZZ	priority sequence flows	output			input		
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		
AFF	annual flood frequency		output		input		

Format of Input Records

The system of file and record types is designed to create well-organized datasets that can be conveniently read and modified by human model-users as well as efficiently read, written, and manipulated by computers. The WRAP structure for organizing files and records is designed for effectively managing datasets that cover the full spectrum from small and simple to extremely large and complex.

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* and *TABLES* are defined in Chapters 3 and 4, respectively, of this manual. *SIM* input records begin with one of the two-character record identifiers listed in Table 3.1. *TABLES* records begin with the four-character identifiers listed in Table 4.2.

Records are divided into fields. Tables found in Chapters 3 and 4 define the data that is entered in each field. The tables in Chapters 3 and 4 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. Either format is fine for the computer to read, but the fixed-width format is much easier for human model-users to read and edit.

Fixed Field Width Format

Most fields on *SIM* input records with numeric data have a width of eight characters. Most *TABLES* TIN file record fields for numeric entries are four characters wide. Some of the alphanumeric entries such as control point and reservoir identifiers have six-character fields; others have 8-character fields. Water right identifiers may contain up to 16 characters. Various fields also have other widths.

The Fortran format specifications found in the fourth column of the record description tables in Chapters 3 and 4 are defined by the following examples of possible formats.

- A6 – Alphanumeric label in a field that is 6 characters wide. A character variable with the format Aw is limited to a maximum of w characters (6 in this example).
- 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. Numbers ranging from -9999999 to 99999999 may include 72648.5, 0.00019, and -4172.85.
- 12F8.0 – Twelve 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.

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 per 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* or *CP* records or elsewhere are used as needed to convert the input data to a consistent set of units.

Period-of-Analysis and Time Step

The hydrologic period-of-analysis (simulation period) may encompass any integer number of years. The minimum length is one year. There is no limit on the maximum length in years of the hydrologic 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, which is 28 or 29 days in February and 30 or 31 days in the other months.

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 options. Forecasting and routing are not pertinent with a monthly interval but are significant with smaller time steps such as a day. *SIMD* looks forward over a forecast period in determining stream flows upon which to base diversion and reservoir operating decisions and uses routing methods to lag and attenuate flow adjustments moving spatially downstream and forward in time.

SIM and *SIMD* include the same routines for performing short-term conditional reliability modeling (CRM) simulations, with the results being used by *TABLES* to perform 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 sequences with each simulation beginning with the same storage condition. CRM is described in Chapter 7 of the *Reference Manual*.

Dataset Size, Memory Requirements, and Execution Times

A *WRAP-SIM* or *SIMD* dataset 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 other types of records included in a dataset, except for those types for which there is never more than one record.

Arrays in the Fortran code are dimensioned to reserve memory space. Dynamic dimensioning allows array sizes to be set automatically by the program based on information obtained from the input files. Thus, computer memory requirements are dependent on the size of the input dataset. Program *SIM* performs an initial reading of the DAT and DIS files during which certain records are counted and certain parameters read solely for purposes of setting dimension limits and determining which other input files to activate. *SIM* sets dimension limits for most arrays based on the information obtained from the initial reading of data files, but several minor dimension limits are fixed at specified sizes which are noted at appropriate places in this manual. *SIMD* and *SALT* allocate memory for variable arrays similarly to *SIM*. *TABLES*, *HYD*, and *DAY* are structured somewhat differently than simulation models. However, all of the programs incorporate dynamic dimensioning to efficiently manage computer memory resources while imposing essentially no limits on the number of input records or system components incorporated into the datasets for particular river basins being modeled.

Computer memory requirements for *SIM* and *TABLES* are generally modest but do vary greatly depending upon the size of the input dataset and selection of optional input and output file

management features. Likewise, execution times are relatively minimal but can vary significantly depending largely on the same factors that influence memory requirements. Memory requirements and run times depend on the size of the input dataset, user choices regarding selection of simulation results to write to output files, and optional organization and formats of input and output files. Memory requirements and run times depend upon the number of control points, water rights, reservoirs, and other system components in the input dataset, organization of hydrology input files, simulation options, and the size and format of the simulation results output file.

Memory requirements are also highly dependent upon the organizational format of input and output files. The grouping of *IN* records (naturalized flows) and *EV* records (net evaporation depths) are specified in *JO* record field 2. With options based on grouping the hydrology input by year, *SIM* has only one year of naturalized flows and evaporation rates in memory at one time. With options based on grouping the hydrology input by control point, *SIM* stores in memory concurrently naturalized flows and evaporation rates for all years. Likewise, with the program *SIM* standard OUT output file, simulation results are written to the OUT file as computed, with minimal memory requirements. With DSS or SOU output files activated, the program *SIM* stores all simulation results in memory for writing to the DSS and/or SOU file at the completion of the simulation. Activation of the optional DSS and/or SOU output files results in a dramatic many-fold increase in memory requirements.

Run times for *SIM* and *TABLES* are typically small enough to be of no concern to model-users unless the input datasets are extremely large. Computer execution times can be more than doubled or reduced by greater than 50 percent depending on user specification of the number of control points, water rights, and reservoirs to include in the output file. Writing simulation results to the output file requires considerable computer time relative to performing the simulation computations. The larger Texas WAM System datasets have many hundreds of control points, water rights, and reservoirs. Although the actual simulation computations are not affected, execution times can be greatly reduced by limiting the output written to the output file. Run times for the Texas WAM System datasets on a typical desktop computer range from several seconds to several minutes. For the larger datasets, *SIM* run times of two to three minutes incurred with all of the many hundreds of control points, water rights, and reservoirs included in the output data written to the OUT, SOU, or DSS files may be reduced to a minute or less simply by limiting output to a smaller number of selected control points, water rights, and/or reservoirs of particular interest.

The *SIM* simulation results OUT and CRM output files can optionally be created as either a formatted text file or unformatted binary file as specified by *JD* record field 7. The unformatted binary file is read only with *TABLES*, not directly with editors such as WordPad. The size of the output file is significantly reduced and, for simulations with large amounts of output data, the execution time is significantly reduced by selecting the unformatted binary output file option.

The preceding discussion focuses on monthly time step *SIM* simulations. Daily time step *SIMD* simulations have much greater memory and execution time requirements due to flow forecasting as well as the smaller computational time step. The strategies for reducing memory requirements and execution times for *SIM* are also applicable to a daily *SIMD* simulation. The optimization-based naturalized flow extension routine in *HYD* can also have computer execution times of multiple hours.

CHAPTER 2 WRAP-SIM FILES

Applying WRAP involves working 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.

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 model-users to refer to the different file types. For example, an input file with a filename of *root.DAT* is called a DAT file.

Table 2.1
Types of *SIM* Input and Output Files

<u>Standard Default Input Files Read by SIM</u>		
DAT	all input data except the hydrology data	Required
FLO	inflow <i>IN</i> records with naturalized stream flows	<i>JO</i> record field 2
EVA	evaporation <i>EV</i> records with net evaporation depths	<i>JO</i> record field 2
<u>Standard Default Output Files Created by SIM</u>		
	OUT simulation results	default
	MSS messages	automatic
<u>Additional Optional Input Files Read by SIM</u>		
DIS	flow distribution watershed parameters	<i>CP</i> record 6 and 9
FAD	<i>FA</i> record adjustments to naturalized flows	<i>JO</i> Record field 3
HIS	<i>HI</i> record hydrologic index sequences	<i>TO</i> , <i>FS</i> , <i>CV</i> records
BES	input/output file for beginning-ending storage options	<i>JO</i> Record field 5
HYD	alternative to FLO and EVA hydrology files	<i>JO</i> Record field 2
DSS	DSS file as alternative to FLO and EVA hydrology files	<i>JO</i> Record field 2
RUF	<i>RU</i> record regulated-unappropriated flow adjustments	<i>JO</i> Record 13 and 14
<u>Additional Optional Output Files Created by SIM</u>		
SOU	simulation results in columnar format	<i>OF</i> Record
DSS	simulation results in DSS (data storage system) file	<i>OF</i> Record
YRO	yield-reliability table with firm yield	<i>FY</i> Record
ZZZ	stream flow availability in rights priority sequence	<i>ZZ</i> Record
HRR	hydropower production and reservoir releases	<i>JO</i> Record field 4
BES	input/output file for beginning-ending storage options	<i>JO</i> Record field 5
CRM	conditional reliability modeling simulation results	<i>CR</i> record
BRS	beginning reservoir storage used by <i>TABLES</i> conditional reliability modeling routine and program <i>SALT</i>	<i>JO</i> Record field 6

SIM OUT and CRM output files may be created as either text files or binary files read only by *TABLES*. HEC-DSS (Hydrologic Engineering Center Data Storage System) files are in a direct-access binary format accessed only by HEC-DSSVue, WRAP programs, or other programs specifically designed to interact with DSS files. Otherwise, *SIM* input and output files are text files that can be read with any editor. Files are automatically opened or activated by *SIM* in response to options specified on the *JD*, *JO*, and/or *OF* records or other input records in the DAT file.

The DAT input file (filename root.DAT) is the only absolutely required input file. FLO and EVA files are standards that are typically used but are not mandatory. The main simulation results are written to either an OUT, SOU, DSS, and/or CRM file. A conditional reliability *CR* record in the DAT file activates a CRM output file. Otherwise, the OUT file is created by default. An output file *OF* input record allows creation of SOU and/or DSS files in addition to or in lieu of the default OUT file. The other optional input and output files each serve a specific purpose.

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 with filename extension 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 (filename extensions FLO and EVA) are the defaults for storing the stream flow inflow *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 naturalized stream flow volumes and net evaporation-precipitation depths optionally may be input as a DSS file, with the filename rootHYD.DSS, instead of the default FLO and EVA files. DSS files are in a binary format that can be read by *SIM* or *HEC-DSSVue* but not by most other editors. The DSS hydrology input file option is activated by *JO* record field 2.

The flow distribution file with 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 stream flows 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 6 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 stream flow adjustment file (extension 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, 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 activated by *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 by default to the OUT file. The same simulation results can be written to the DSS, SOU, and/or OUT files, with the only difference being format. The CRM file replaces the OUT file when *SIM* is executed in conditional reliability modeling (CRM) mode. Information to help locate errors and potential problems in the input data is written to the MSS file. Supplemental output related to multiple-reservoir system releases and hydroelectric energy generation is written to the optional HRR file. A *ZZZ* file activated by a *ZZ* record tabulates intermediate stream flows during the water rights priority loop. 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 BES file is both an output and input file.

Program *TABLES* reads the *SIM* OUT, CRM, DAT, HRR, *ZZZ*, and BRS 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 analyzing 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. *TABLES* can also read an OUT file and convert the *SIM* simulation results to a DSS file either directly without change or after performing various arithmetic manipulations of the data.

HEC-DSSVue reads DSS files created by either *SIM* or *TABLES* in order to develop plots or perform various data manipulations. The MSS, SOU, and YRO files are viewed directly by the model-user with an editor such as Microsoft WordPad without using *TABLES* or HEC-DSSVue.

Basic Simulation Results Output (OUT) File

The *SIM* OUT file (filename extension OUT) is created as a formatted text file by default, but can optionally be created as an unformatted binary file as specified by *JD* record field 7. The OUT and CRM files are the only files that can be written as unformatted binary files read only by *TABLES* rather than text files or DSS files. The OUT and CRM files contain long-term conventional simulation results and short-term CRM results, respectively. Unlike a text file, a binary OUT file can be read only by *TABLES* but is smaller and requires less computer time to write and read. The primary reason for an unformatted binary OUT file is to reduce memory requirements and execution time. Precision may also be optimized since numbers are stored in the same form as they are computed. The formatted text OUT or CRM file is created in a direct access format with line returns inserted differently than the other text files. Microsoft WordPad reads the OUT and CRM file line breaks fine, but NotePad does not.

The contents and organization of the OUT file are outlined in detail in *Reference Manual* Chapter 5. The CRM version of the OUT file is explained in *Reference Manual* Chapter 7. *TABLES* provides capabilities to organize, analyze, tabulate, summarize, and display *SIM* simulation results in a variety of formats. Although *TABLES* is usually used to organize the simulation results in the OUT file, the model-user may sometimes want to examine the OUT file directly to track simulation results, explore problems, or better understand the computations. Of course, in this case, the OUT file must be created as a text file.

The OUT file is designed to compactly store the voluminous output data in the order in which it is computed. Within each month of simulation results, output records for user-specified water rights are written first in priority order, followed by selected control point output records, followed by the records for selected reservoir/hydropower projects. The simulation results variables recorded on water right, control point, and reservoir/hydropower output records are listed in Table 2.2 below and precisely defined in Chapter 5 of the *Reference Manual*. Output records are all optional. As discussed later in this chapter, the model-user specifies in the DAT file which types of output records and which water rights, control points, and/or reservoir/hydropower projects to include in the OUT file.

Table 2.2
Variables in the *SIM* Simulation Results Output File

<i>WR</i> Record Right	Instream Flow Right	Control Point	Reservoir/Hydropower
diversion or energy target	instream flow target	diversion target	energy generated
diversion/energy shortage	flow shortage	diversion shortage	energy shortage
reservoir storage volume	reservoir storage volume	reservoir storage volume	secondary energy
evap-precip volume	evap-precip volume	evap-precip volume	storage contents volume
available stream flow	available stream flow	unappropriated flow	storage capacity volume
stream flow depletion	stream flow depletion	stream flow depletion	evap-precip volume
reservoir releases	required reservoir release	naturalized flow	evap-precip depth
return flow	reservoir release	regulated flow	adjusted evap-prec depth
available flow increase	reservoir release shortage	reservoir releases	reservoir inflow
water right identifier	flow switch volume	return flow	reservoir release
first group identifier	flow switch count	channel loss	turbine flow
second group identifier	water right identifier	channel loss credit	water surface elevation
		instream flow target	reservoir identifier

Some variables are unique to either water right, control point, or reservoir/hydropower records. For example, naturalized, regulated, and unappropriated flows are associated only with control points. Other data are repeated on two or three of the record types. For example, reservoir storage and net 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.

Simulation Results Output (SOU and DSS) Files

The DSS and SOU files record identically the same simulation results as the OUT file but in different formats. The time series variables are listed in Table 2.2. The selection of control points, water rights, and reservoir/hydropower projects to include in the simulation results output is the same for either the OUT, DSS, or SOU files and is described later in this chapter. DSS and SOU files are activated by selections on the output files *OF* input record. All, none, or any combination of OUT, DSS, and SOU output files may be created with the *OF* record. The DSS file is in a direct access binary format designed to be read by HEC-DSSVue. The SOU file option tabulates the simulation results in columns designed for either direct viewing or export into Microsoft Excel.

Message (MSS) File

The message files created by *SIM* and each of the other WRAP programs should be viewed routinely to ascertain that the input datasets are executing correctly and to be alerted to any irregularities. The *SIM* message file (filename extension MSS) provides trace messages tracking the progress of the simulation, error and warning messages, and various 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:

- trace messages that track the progress of model execution and reading of input data
- error messages noting missing or erroneous input records with run termination
- warning messages noting potential problems without stopping execution
- features to reproduce input records to track which records were successfully read
- miscellaneous information created by special options such as negative incremental flow adjustments or dual simulation stream flow depletions

Trace messages are written as the input records are read and thus may be used to locate problems if program execution is terminated prior to completion of the simulation. *SIM* includes a number of data check routines that write error messages and stop program execution. Other routines in the model write warning messages without terminating program execution. The use of messages written to the MSS file for locating errors is discussed further in Chapter 7 of the *Reference Manual*.

Various other types of information may also be recorded in the message file. Negative incremental stream flow options activated by the *JD* record result in negative incremental flows being written to the MSS file. Dual simulation options specified by the *SO* or *PX* record allow stream flow depletions to be written to the message file. The *GR* record has an option for listing water right information to the MSS file.

Hydropower and Reservoir Release (HRR) File

The HRR contains the hydroelectric energy target and amount of energy generated and the releases from primary and secondary reservoirs for each month of the simulation for each system water right selected for output. The parameter *SYSOUT* from the *JO* record creates the optional HRR file. The *SIM* HRR output file is read and reorganized by the *TABLES* 4HRR input record.

The HRR file stores (1) releases from each of the reservoirs of multiple-reservoir system rights and (2) energy targets and amounts produced for hydropower rights. The HRR file includes hydropower, multiple-reservoir system, and other system rights. The following data is recorded on an output record for each water right for each month of the simulation.

- year and month
- water right identifier
- number of reservoirs associated with the water right
- year and month
- hydroelectric energy target and quantity of energy actually generated
- reservoir release and reservoir identifier for each reservoir connected to the water right listed in the same order as the *WS* records in the input file

The release from a primary reservoir is simply the diversion met by the right. This amount may include water from stream flow depletions and water released from secondary reservoirs as well as water taken from storage in the primary reservoir. The HRR file is the only *SIM* output file that contains releases from the individual secondary reservoirs of a multiple-reservoir system for a water right. The reservoir releases for a water right in the *OUT* file are the summation of releases from all the secondary system reservoirs.

The 4HRR record activates the only program *TABLES* routine that reads a HRR file. The *TABLES* 4HRR record rearranges the data from the HRR file in a columnar format that is convenient to view or to export to Microsoft Excel or Microsoft Word.

Priority Sequence Stream Flow Availability (ZZZ) File

The *ZZ* record activates a *SIM* feature that builds a special table described in Chapter 6 of the *Reference Manual* that is stored in a *ZZZ* file (filename extension *ZZZ*). The regulated flow, available flow, and upstream reservoir release at one or more specified control points are tabulated as each water right is simulated in the water rights priority sequence. The feature is designed to facilitate assessments of the impacts of individual water rights on stream flow availability at specified locations. The *ZZZ* file tabulation can be viewed directly with any editor or read by *TABLES* and organized as either time series or frequency tables.

Yield versus Reliability Output (YRO) File

The firm yield *FY* record activates a routine described in Chapter 6 of the *Reference Manual* to develop a table of annual yield versus reliability, which is written to the *YRO* file. In a conventional *SIM* simulation, an annual water supply diversion target or hydropower target is entered in 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.

Beginning-Ending Storage (BES) File

The beginning-ending storage (BES) options described in Chapter 6 of the *Reference Manual* and controlled by the BES parameter in *JO* record field 5 involve writing end-of-simulation storages to the BES file and/or reading initial storages from the same file. This is the only file that may serve as both a *SIM* input and *SIM* output file.

The BES file consists of three columns: integer reservoir identifier, alphanumeric reservoir identifier, and 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 BES file, beginning storages are set in *SIM* by *WS* record fields 3 and 8 in the conventional manner.

Beginning Reservoir Storage (BRS) File

The beginning reservoir storage (BRS) file consists of a table listing all reservoirs with the following four columns: reservoir identifier, control point, storage capacity, and beginning-of-simulation storage content. The BRS file is activated by *JO* record field 6. Program *SALT* and a *TABLES* conditional reliability modeling routine have options to read beginning-of-simulation storage from a BRS file. The reservoir listing in the BRS file may also be useful for general information.

Conditional Reliability Modeling (CRM) File

The conditional reliability modeling (CRM) file activated by a *CR* record. *SIM* creates either an OUT file or CRM file, but not both. The same simulation result variables are contained in either the OUT or CRM file in the same format. However, the CRM file reflects the subdivision of the hydrologic period-of-analysis into multiple sequences associated with CRM. Short-term conditional reliability modeling is covered in *Reference Manual* Chapter 7.

Specification of Information to Include in the Simulation Results

WRAP-SIM simulation results are written to the OUT, SOU, and DSS output files in the form of the following three sets of output records, which are repeated for each month.

1. *WR* record water right and *IF* record instream flow right output records
2. control point output records
3. reservoir/hydropower project output records

Simulation result tables developed with *TABLES* are based on data 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 OUT file. Most tables in *TABLES* also include options for selecting sets of individual rights, control points, or reservoirs from those in the *SIM* output file. Thus, in organizing *SIM* simulation results with

TABLES, selection of water rights, control points, and/or reservoir/hydropower projects to be included is controlled by *SIM* input parameters discussed below governing creation of the OUT file and by *TABLES* input parameters discussed in Chapter 4 governing reading the OUT 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 and computer execution time may be reduced 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 OUT, DSS, and SOU files. The same water rights are included in the optional HRR output file.

JD record fields 5, 6, and 12 in combination with *WO*, *GO*, *CO*, and *RO* records are used to specify which water rights, control points, and reservoirs to include in the output 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 any number of water rights, water right groups, control points, and/or reservoirs listed on *WO*, *GO*, *CO*, and *RO* records, respectively. To reduce file size and run times, only simulation results of actual interest should be recorded.

Reservoir/Hydropower Output Records

The *RO* record provides the only means to specify reservoir/hydropower output records. The options are all, none, or those reservoir/hydropower projects listed on *RO* records. Variables included on reservoir/hydropower records are listed in Table 2.2. Storage and net evaporation-precipitation are recorded on control point and water rights records as well as on the reservoir/hydropower records. Energy production and shortage are included on both water rights and reservoir/hydropower records. In many typical applications, in order to reduce computer run time and file size, reservoir/hydropower records will not be included in the output file if all the information of interest is available on water right and/or control point output records.

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 stream flows 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 two of the *JD* field 5 options.

Water Right Output Records

As indicated by Table 2.2, the water right and control point output records include the following variables in common: diversion shortage, diversion target, evaporation-precipitation volume, storage, and stream flow 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. Water right, control point, and reservoir/hydropower output records all contain reservoir storage and net evaporation-precipitation volumes. Storage is refilled in priority order by any number of water rights associated with the same reservoir. The reservoir storage and net evaporation-precipitation volumes on the water right record are those amounts associated with that particular water right.

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

- *JD* record field 6 allows selection of either no rights, all rights, all *WR* record rights excluding hydropower rights, all hydropower rights, or all instream flow rights.
- *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 *JD* record field 6 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 10 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. Unless specifically referenced by

other records, 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 right.

Two alternative sets of three water rights identifiers may be included in the last six fields of the *WR* records (fields 12, 13, 14 and alternate fields 15, 16, 17). Only one of the two sets is read in a single execution of *SIM*. Input variable *IDSET* in *JD* record field 12 specifies whether the first or second set of three identifiers on the *WR* records is adopted in a particular model run.

Water right identifiers are used within the *SIM* simulation in selecting output and to reference rights for the firm yield *FY*, target options *TO*, and backup right *BU* record features. Control point identifiers are used much more extensively in the model computations to assign locations to various system features and otherwise define the spatial connectivity of the system.

The water right identifier fields on the *WR*, *IF* and other records do not have to be 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 right identifiers serve to identify rights in input and output files and tables created by *TABLES*. *TABLES* also includes options to aggregate the data associated with all rights with the same group identifier. The diversion targets, shortages, diversions, stream flow depletions, reservoir storage contents, and evaporation-precipitation volumes included in the output records for all water rights with the same group identifier in fields 13 and 14 or alternate fields 16 and 17 of the *WR* records may be summed within *TABLES* to obtain a set of aggregated total values.

For grouping purposes, all water 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 stream flow 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 Files

All of the WRAP programs contain similar features for detecting missing and erroneous records in the input files, which are described in Chapter 8 of the *Reference Manual*. Routines in

SIM and the other programs facilitate finding many types of errors that violate format rules or result in detectable inconsistencies. These features include:

- trace messages tracking model progress in reading input and performing the simulation
- error messages accompanied by termination of model execution
- warning messages alerting users to possible peculiarities without stopping execution

Trace messages are written to the monitor tracking the progress of the *SIM* simulation. Other trace messages focused more on progress in reading input data are recorded in the message file (filename extension MSS). Warning and error messages are also written to the MSS file.

Routines incorporated in *SIM* for detecting input data inconsistencies and irregularities and associated warning and error messages are described in Chapter 8 of the *Reference Manual*. Error messages are written to the monitor and MSS file and program execution is terminated if definite problems are encountered in reading input data or performing the simulation computations. Warning messages are recorded in the MSS file without terminating program execution to alert the model-user to possible irregularities in the input data. Warning messages signal potential concerns that may or may not actually be problems. Message files generated by *SIM* and the other WRAP programs should be routinely reviewed to trace the simulation and view warning messages even if the program executes normally without premature termination.

Numerous different error and warning messages are possible. Most of the messages are generated by problems detected by the program while reading input data files, though various checks incorporated in the simulation computation routines also may generate error and warning messages. The messages are usually self-explanatory, but the *Reference Manual* Chapter 8 may be consulted as needed to better understand and respond to the messages.

Optional levels of information recorded in the *SIM* message MSS file for checking input data are specified by variable *ICHECK* in field 4 of the *JD* record and listed in Table 2.3. An *ICHECK* of 0 or 1 is usually adopted. An *ICHECK* of 1 activates all error and warning checks. Most warning message checks and several of the error checking routines requiring the most computer time are in effect only if *ICHECK* is 1. Deactivating the checking routines will reduce execution times slightly and may greatly reduce the size of the message file. After a number of runs of *SIM* with a particular dataset repeatedly generating a long list of warning messages, the model-user may prefer to deactivate the warning messages by switching *ICHECK* to 0.

If program execution is terminated prior to normal completion, the error message will usually provide sufficient information to identify the problem without needing to resort to the *ICHECK* options 2 through 7 activated by *JD* record field 4. However, *ICHECK* options are sometimes useful in locating an erroneous input record as well as otherwise providing general information. The *ICHECK* options are all defined in *Reference Manual* Chapter 8. *ICHECK* Options 1 and 9 control the number of warning and error routines that are activated. Options 2 through 7 reproduce input records. Option 8 writes information to the MSS file that is developed by the *PX* record dual simulation. Option 10 outlines the hydrologic sequences generated by a conditional reliability *CR* record, which are explained in Chapter 7 of the *Reference Manual*. Option 11 deals with *RU* regulated-unappropriated flow adjustments which are described in the *Hydrology Manual*. *ICHECK* option 12 lists instream flow targets.

Table 2.3
Information Recorded in Message File for Various Values of ICHECK

ICHECK = 0	Trace messages are written to the MSS file. Some error detection routines and most of the warning messages are deactivated.
ICHECK = 1	Trace messages and all error and warning routines are in effect.
ICHECK = 2	Trace messages plus all <i>UC</i> and <i>RF</i> records are written as read.
ICHECK = 3	Trace messages plus all <i>CP</i> records are written as read.
ICHECK = 4	Trace messages plus all <i>WR</i> and <i>IF</i> records are written as read.
ICHECK = 5	Trace messages plus all <i>SV</i> and <i>SA</i> records are written as read.
ICHECK = 6	Trace messages plus all <i>IN</i> and <i>EV</i> records are written as read.
ICHECK = 7	Trace messages plus all <i>FD</i> , <i>FC</i> , and <i>WP</i> records written as read.
ICHECK = 8	Trace messages plus all dual simulation information.
ICHECK = 9	Trace messages and most error checks are in effect but most of the warning messages are deactivated.
ICHECK = 10	Trace written to MSS file for conditional reliability modeling showing the sub-division of the hydrologic period-of-analysis into multiple sequences.
ICHECK = 11	Trace messages plus all <i>RU</i> records are written as read.
ICHECK = 12	Trace messages plus instream flow targets are recorded in the MSS file.

Locating Errors in the SIM Output File

The content and format of the output records are defined in Tables 5.1 through 5.5 and accompanying narrative in Chapter 5 the *Reference Manual*. Essentially all of the monthly time series variables computed by *SIM* can be written to the OUT file and examined to track the computations. 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 OUT file in text format may be read with Microsoft WordPad to track simulation results, including locating the last numbers computed prior to termination of the simulation. If program execution is completed without an early termination, the SOU file provides an alternative easier-to-read organization of simulation results but does not directly trace the sequence of the computations.

After a *SIM* input dataset has been successfully debugged, irregularities in the *SIM* output OUT file should be rare. However, program *TABLES* includes a routine activated by the TEST record that performs a series of checks on a *SIM* output OUT file. The TEST option in *TABLES* is designed for use in the extremely unusual situation in which *TABLES* can not read an OUT file from an apparently successful *SIM* simulation. The TEST record is included in Chapter 4 of this *Users Manual* along with the other *TABLES* input records. The tests activated by the TEST record are described in Chapter 8 of the *Reference Manual*. The tests are applicable only for an OUT file written in the default text file format, not the optional binary machine language form of OUT file activated by *JD* record field 7.

CHAPTER 3 WRAP-SIM INPUT RECORDS

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

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 a fourth of the 61 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*, *OF*, *XL*, *CR*, *ZZ*, and *FY* records, if used, 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 in this chapter.

Records in the DAT File

Title *T1*, *T2*, and *T3* Records.- The DAT input file begins with a required *T1* record followed by optional *T2* and *T3* records. The titles or headings provided on the title records are reproduced at the beginning of the main output file created by *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 extension DAT)

Records for organizing the simulation

T1, T2, T3	Titles 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, JO	Job control Data for simulation and Job Options switches for various features
CR	activation switch and specifications for Conditional Reliability modeling
OF	optional Output Files
XL	multiplication factors and parameter Limits
ZZ	special feature for tracking stream flow availability in water rights priority sequence
FY	Firm Yield and yield-reliability table
WO, GO, CO, RO	Water right, Group, Control point and Reservoir/hydropower Output
ED	End of Data

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

CP	Control Point connectivity and naturalized flow, evaporation, and channel loss data
CI	Constant Inflows or outflows entering or leaving system at a control point

Records for entering water rights information

RG	Water Rights Group with shared parameters
UC	monthly water Use distribution Coefficients
UP	water Use type Priority adjustment factors
RF	monthly Return Flow factors
WR	Water Right requirements
IF	Instream Flow requirements
SO	Supplemental water right Options
ML	Monthly Limits on stream flow depletions
BU	BackUp water right
TO, LO	Target Options and stream flow depletion Limit Options
CV, FS	Cumulative Volume and Flow Switch for developing targets and limits
TS/TSR	Target Series and Target Series Repeat
PX/AX	Priority sequence circumvention options
WS	Water right reservoir Storage
HP	Hydroelectric Power parameters
OR	Operating Rules for secondary reservoirs in a multiple-reservoir system
DI/IS/IP/IM	Reservoir storage index or Drought Index for setting targets
EA/EF/AF	Evaporation and flow Allocation options for reservoirs shared by multiple entities

Records for describing additional characteristics of reservoirs

SV/SA	Storage Volume (SV record) versus Surface Area (SA record) table
PV/PE	Storage Volume (PV record) versus Elevation (PE record) table for hydropower
TQ/TE	Tailwater discharge (TQ record) versus Elevation (TE record) table for hydropower
MS/OS	Monthly varying Storage capacity and Observed Storage Capacity

Table 3.1 (Continued)
Types of SIM Input Records

<u>Hydrology Files (filename extensions FLO and EVA)</u>	
IN	<i>IN</i> flows to the system (naturalized or otherwise defined monthly stream flows)
EV	<i>EV</i> vaporation (reservoir monthly net evaporation less precipitation depths)
<u>Flow Distribution File (filename extension DIS)</u>	
FD	<i>Flow Distribution</i> specifications for transferring flows from gaged to ungaged sites
FC	<i>Flow distribution Coefficients</i> for certain flow distribution options
WP	<i>Watershed Parameters</i> used in the flow distribution computations
ED	<i>End of Data</i>
<u>Other Hydrologic Time Series Files (filename extensions FAD, RUF, and HIS)</u>	
FA	<i>Flow Adjustments</i> to be added to the stream flows (FAD file)
RU	<i>Regulated-Unappropriated flow adjustments</i> (RUF file)
HI	time sequence of hydrologic index referenced by <i>TO</i> , <i>LO</i> , <i>FS</i> , and <i>CV</i> records (HIS file)

Job Control Data JD and Job Options JO Records.- General information controlling the simulation include the hydrologic period-of-analysis and parameters for several *SIM* computational features including options associated with negative incremental flows, system reservoir release decisions, beginning-ending storage, priority system, input and output, and input error checking.

Conditional Reliability CR Record.- The *CR* record activates the conditional reliability modeling simulation mode that is described in Chapter 7 of the *Reference Manual*.

Optional Output Files OF Record.- The *OF* record activates the DSS and SOU output files. The same simulation results are recorded in either a DSS, SOU, or OUT file but in different formats.

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.

Flows in Water Rights Priority Sequence ZZ Record.- A table of regulated and available stream flows at specified control points after each water right in the simulation is created in a *ZZZ* file.

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

Output Specification CO, WO, GO, RO Records.- *SIM* OUT file output records are of three types: 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

<u>Organization of the Simulation</u>	
file activation	JO fields 2, 3, 4, 5, 6, OF
output control	WO, GO, CO, RO, JD, OF
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
<u>Hydrology Features (Chapter 3 of Reference Manual)</u>	
naturalized stream flows	IN, JO field 2, CP fields 4, 6, 7, 11
net reservoir evaporation-precipitation	EV, JO field 2, CP fields 5, 8
net evaporation-precipitation adjustment	FD, WP, CP 9, JD 10
stream flow distribution to ungaged sites	FD, FC, WP, CP fields 6, 7, 11
stream flow adjustments	FA, JO field 3
channel losses	CP field 10
watershed flow option	SO field 2
negative incremental stream flow options	JD fields 8, 9
<u>Water Management Features (Chapter 4 of Reference Manual)</u>	
water supply diversions and return flows	WR, UC, SO, PX, TO, RF, ML, TS
instream flow requirements	IF, UC, WS, TO, CV, FS, SO, TS
hydroelectric power	WR, HP, UC, PV, PE, TQ, TE, XL
setting water use targets	WR, UC, DI, TO, FS, SO, TS
drought (storage versus target) index	DI, IS, IP, IM
water right priorities	WR, IF, UP, JO field 8
flow allocation for rights with same priority	PX, AX, AF
circumvention of priority sequence	PX, RG
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, AF
limits on stream flow depletions	ML, LO, SO fields 3, 4
limits on withdrawals from reservoir storage	SO fields 7, 8
stream flow depletions from multiple locations	SO field 5
constant inflows and outflows	CI, FA, CP fields 11, 13
backup right	BU

Use 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 stream flow 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 targets), drought index identifier (connection to *DI* record), and return flow specifications. *WS*, *HP*, *OR*, *SO*, *TO*, *FS*, *TS*, and *PX* records attached to a *WR* or *IF* record provide optional additional information regarding the right.

Instream Flow IF Record.- The *IF* record is similar to the *WR* record, except a instream flow target is entered rather than a diversion target, and several of the *WR* record fields are not applicable. *WS*, *UC*, *UP*, *DI*, *TO*, *FS*, and *TS* records are used the same with either *IF* or *WR* records. The minimum 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 minimum flow target and priority.

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Supplemental Options SO Record.- *WR* and *IF* record water right requirements may be supplemented by additional information provided on a *SO* record. Monthly, seasonal, and annual limits may be placed on stream flow depletions, diversions, and the amount of water that may be withdrawn from reservoir storage. An alternate control point location for making stream flow depletions may be specified. Intermediate targets to include in the output file may be selected. Certain options may be excluded from particular water rights.

Monthly-Varying Limits on Stream flow Depletions ML Record.- Stream flow 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.

Backup BU Right.- The shortages incurred by one or more other water rights may be added to the diversion, minimum instream flow, or hydropower target of a right designated as a backup right by a *BU* record in the set of supporting records following its *WR* or *IF* record. Shortages may be split between backup rights. Backup rights may backup other backup rights.

Target Options TO and Limit Options LO Record.- Diversion, instream flow, hydropower, and storage targets may be defined as a function of various variables using *TO* records. Maximum and minimum limits may also be imposed. The same options are applied by an *LO* record in developing maximum stream flow depletion limits.

Cumulative Volume CV and Flow Switch FS Records.- Water right targets, flow depletion limits, and release limits may be developed, switched on and off, or otherwise adjusted as a function of the accumulative volume of a selected variable over a specified number of time steps.

Target Series TS and Repeat Series TSR Records.- Diversion, instream flow, or hydropower targets or stream flow 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.

Priority Circumvention Options PX and AX Records.- Dual simulation options involve a repeat of the simulation with changes to water rights. Stream flow depletions from an initial simulation may serve as limits in a subsequent simulation. Stream flow availability limits and transient rights are designed to circumvent the normal priority sequence. The priority-based determination of water availability may be adjusted. A right may be activated and deactivated at different points in the simulation based on priorities. A return flow may be governed by a different priority.

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.

Reservoir System 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.

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 a surface area on the *SA* record. The *SV/SA* records represent one of two optional methods for providing reservoir storage versus area relationships. 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 PV versus Elevation 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 are entered on the *PE* record. The storage-elevation relationship 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 Capacity MS Records.- A set of 12 monthly reservoir storage capacity limits may be entered on a *MS* record to define monthly-varying rule curve operating plans, such as seasonal reallocations of storage capacity between flood control and conservation pools. Any storage contents above capacity are spilled at the beginning of each month.

Observed Storage OS Records.- Time series of observed storage volumes may be entered on *OS* records. Any storage contents above these capacity limits are spilled at the end of each month.

Drought Index Reservoirs DI Record, Storage IS versus Percentage IP Records, and IM Record.- 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. In each month of the simulation, given the computed storage in the specified reservoirs, the index as a percentage is determined from this relationship by linear interpolation. The percentage is converted to a fraction and multiplied by the diversion, instream flow, or hydroelectric power target determined from a *WR* or *IF* record and *UC* record and other target setting records to compute an adjusted target.

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Evaporation Allocation *EA*, Evaporation Factors *EF*, and Available Flow *AF* 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. An *AF* record is used to allocate available stream flow for rights sharing the same priority.

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. The *ED* record has no input fields and simply indicates the end of the data file. An *ED* record also ends the flow distribution *DIS* and flow adjustment *FAD* input files.

Records in the Hydrology Files (Filename Extensions *FLO* and *EVA*)

Inflow *IN* and Evaporation *EV* Records.- Naturalized stream flow sequences covering the hydrologic period-of-analysis for each control point are either entered on series of inflow *IN* records or computed from naturalized flows entered on *IN* records at one or more other control points. Reservoir net evaporation-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 *FLO* 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.

Records in the Flow Distribution File (Filename Extension *DIS*)

Flow Distribution *FD* Record.- *FD*, *FC*, and *WP* records provide information for transferring naturalized stream flows 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 equations used in two different alternative flow distribution methods (options 3 and 10) are entered on a *FC* record associated with a *FD* record.

Watershed Parameter *WP* Record.- The watershed drainage area, curve number, and mean precipitation are provided on a *WP* record for each relevant gaged and ungaged control point.

End-of-Data *ED* Record.- The *ED* record is placed at the end of the *DIS* input file as well as at the end of the *DAT* file. The *ED* record has no input fields and simply indicates the end of the data file.

Other Hydrologic Sequences (Filename Extensions *FAD*, *RUF*, and *HIS*)

Stream Flow Adjustment *FA* Record.- Sequences of adjustments in *FAD* file are added to the naturalized flows at a control point and all downstream control points. Whereas *CI* records contain a set of 12 monthly adjustments that are repeated each year, *FA* records provide multiple-year series of flow adjustments that vary between years as well as between the 12 months of the year.

Regulated-Unappropriated *RU* Record. - *RUF* file adjustments controlled by *JO* record options.

Index *HI* Record. - Hydrologic index series in *HIS* file referenced by *TO*, *LO*, *FS*, and *CV* records.

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 Table 3.3 in the sequential order in which they occur in the file.

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.

Both comma-delimited and fixed field-width formats are outlined in Chapter 1. Either format option may be used. However, the records are described in the remainder of this chapter in terms of the fixed field-width format. Several representative Fortran format specifications found in the fourth column of the record description tables are defined as follows.

- F8.0 – Real number in field of 8 characters with any number of digits to the right of the decimal. Either include the decimal or right justify the number.
- 5F8.0– Five real numbers, each having a F8.0 specification.
- I8 – Integer number with maximum of 8 digits. Right justified, no decimal.
- 3I8 – Three integers with each right justified in field of 8 characters.
- A2 – Alphanumeric label (character variable) in a field that is 2 characters wide.
- 2x – Two spaces are skipped. Fields with the spacing descriptor x are not read.
- 2x,A6 – Two blank spaces followed by an alphanumeric variable with maximum of six characters.

Variables with integer specifications (I format) 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 with any number of digits to its right. 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 such as control point, water right, and reservoir identifiers. Thus, as long as the alphanumeric identifiers are in the correct field, right-justification is not required.

The remainder of this chapter consists of a series of tables and accompanying explanations providing 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 3.3
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 records follow.
**	Comments	Comments may be inserted throughout.
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.
<hr style="border-top: 1px dashed black;"/>		
OF	Optional Output Files	Optional OF record is located any place between JD and UC records.
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.
ZZ	Flow Availability	Optional ZZ record is located any place between JD and UC records.
RG	Rights Group	Optional RG record is located any place between JD and UC records.
<hr style="border-top: 1px dashed black;"/>		
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. All CO records grouped together; WO records together, etc.
RO	Reservoir Output	
WO	Water Rights Output	
GO	Groups of Water Rights to Output	
<hr style="border-top: 1px dashed black;"/>		
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.
<hr style="border-top: 1px dashed black;"/>		
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.
<hr style="border-top: 1px dashed black;"/>		
IF	Instream Flow	IF and WR records are grouped together in any order, with the set of SO, WS/HP/OR, ML, BU, TO, LO, CV, FS, TS, and PX records following the corresponding WR or IF record. HP and OR records must follow a WS record. WS, SO, ML, BU, TO, LO, TS, and PX/AX records may be in any order, but the complete set must immediately follow their WR or IF record. CV and FS records are also included with the sets of WR/IF and auxiliary records. However, CV and FS records included with one right may also be connected to one or more other water rights.
WR	Water Right	
SO	Supplemental Options	
ML	Monthly Limits	
BU	Back-up Right	
TO,LO	Target/Limit Options	
CV	Cumulative Volume	
FS	Flow Switch	
TS,TSR	Target Series	
PX,AX	Priority Circumvention and Stream flow Allocation Factors	
<hr style="border-top: 1px dashed black;"/>		
WS	Reservoir Storage	HP and OR records follow a WS record.
HP	Hydroelectric Power	
OR	Operating Rules for a Multiple-Reservoir System	
<hr style="border-top: 1px dashed black;"/>		
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	

Table 3.3 (Continued)
Sequential Order of Input Records

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

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, OS, DI/IS/IP, and EA/EF records are connected to reservoirs. Sets of MS, OS, DI/IS/IP, EA/EF records are placed in the DAT file after the complete grouping of all SV/SA, PV/PE, and TQ/TE records and before the ED record. All MS records are grouped together. All sets of DI/IS/IP records are grouped together. All pairs of EA/EF records are grouped together. However, the relative placement of the MS, DI/IS/IP, and EA/EF groups are arbitrary. For example, the EA/EF records may be either before or after the MS and/or DI/IS/IP records.

MS	Monthly Varying Storage Capacity	Set of all MS records grouped together.
OS	Observed Storage	Set of all OS records grouped together.

DI	Drought Index Reservoirs	Set of all DI/IS/IP records grouped together. Each DI record must be followed by an IS record followed by an IP record.
IS/IP	Index Storage/Percentage	

EA	Evaporation Allocation/Factors	Set of all EA/EF/AF records grouped together. EF record follows EA record. AF follows EA/EF.
EF	Evaporation Allocation Factors	
AF	Available Stream flow Allocation Factors	

ED	End of Data	Last record in DAT file except optionally for IN/EV records.
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Stream Flow (root.FLO) and Evaporation-Precipitation (root.EVA) Files
Standard default format is 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.

Other Hydrologic Time Series Files (filename root.FAD, root.RUF, or root.HIS)

FA	Flow Adjustment	Set of all FA records in FAD file.
RU	Regulated-Unappropriated Flow Adjustment	Set of all RU records in RUF file.
HI	Hydrologic Index	Set of all HI records in HIS file.

Table 3.4
Quick Reference Chart for SIM

Fields											page
1	2	3	4	5	6	7	8	9	10	11	
2	8	16	24	32	40	Columns 48	56	64	72	80	

Basic Input Data File (filename root.DAT)

T1											39
T2											39
T3											39
**											39
JD	NYRS	YRST	ICHECK	CPOUT	OUTWR	OUTFILE	ADJINC	NEGINC	EPADJ	TL	40
JO	INEV	FAD	SYSOUT	BES	BRS	STOFLG	STODI	NPOPT	PASS2	DUALD	42
CR	CR1	CR2	CR3	CR4	CR5						44
FY	FYIN1	FYIN2	FYIN3	FYIN4	FYIN5	FYWRID	FYGROUP	MFY	SIM3		45
XL	STX	INX	EVX	CIX	SAX	POWFACT	DEPTHX	CNLN	CNUB	MPLB	46
CON	CPOUT	CPOUID	CPOUID	CPOUID	CPOUID	CPOUID					52
RON	NREOUT	REOUID	REOUID	REOUID	REOUID	REOUID					52
WO	NWOUT		WROUT		WROUT		WROUT		WROUT		53
GO	NGOUT	GROUP	GROUP	GROUP	GROUP	GROUP					53
UC	USEID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	58
UP	USEID	USEP	USEM	USEADD	USEMUL	USEFAC					59
RF	RFID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	60
CI	CIID	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	61
CP	CPID1	CPID2	CPDT1	CPDT2	INMETHOD	CPIN	CPEV	EWA	CL	L, INWS	62
WR	CP	AMT	USE	priority	Type	RFM	RFAC	RCP	DINDEX	WRID	64
IF	CP	AMT	USE	priority	IFMETH	DINDEX				CP2	66
SO	WSHED	MONDEP	ANNDEP	ACPID	BACKUP	MRW	ARW	ISHT	ADL	LM1	72
TO	TARGET	FACT	TOCOMB	TOLIM	TOLIM	TOFLOW	TORES	TOWR	TOCONT		76
ML	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	79
FS	FSV	FSCP	FSX(1)	FSX(2)	FSX(3)	FSX(4)	FSI,FSI	FSI,FSI	FSI,FSI	FSI,FSI	84
BU	BU	BUX	BUWRID	BUG							87
TS	TSL	TSYR	QTS	QTS	QTS	QTS	QTS	QTS	QTS	QTS	88
WS	RES	capacity	A	B	C	INACT	BEGIN	IEAR	SA	LAKESD	90
HP	WRSYS	WRSYS(2)	TELEV	TQCAP	TPCAP						92
OR	CP	WRSYS(2)	WRSYS(5)	WRSYS(4)	SN2	WRSYS(6)	WRSYS(7)	WRSYS(8)	FSOR,J		93
PX	DUAL	XAX	XCP	XCPID	XP	XPR	XPRIOR	XPOUT		WRID1	96
SV	RES	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	101
SA		TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	101
PV	RES	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	TARA	101
PE		TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	TARB	101
MS	RES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	103
DI	NDI	NR	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	104
IS	NS	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	104
IP		DIPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	104
IM	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	105
ED											39

Flow File (filename root.FLO)

IN	ID	NYR	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	109
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Net Evaporation-Precipitation File (filename root.EVA)

EV	ID	NYR	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	109
----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Flow Distribution File (filename root.DIS)

FD	ID	DSG	NG	UGID(1)	UGID(2)	UGID(3)	UGID(4)	UGID(5)	UGID(6)	UGID(7)	113
FC	COEF1	COEF2	COEF3								113
WP	ID	DA	CN	MP	DAF						113
ED											39

Flow Adjustment File (filename root.FAD)

FA	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	115
----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

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 an optional *T1* record that optionally may be followed by *T2* and *T3* records. Headings provided by these title records are printed at the beginning of the OUT file and on the *TABLES* cover page. Without the title records, the three title lines default to blanks.

**** 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 two asterisks ** is not read by the program, except for the ** identifier. Comment ** 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 the DAT, DIS, FAD, and RUF files. The *ED* record is the last record in the DAT file if the *IN* and *EV* records are stored in FLO 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. The *ED* record is the last record in a RUF file signaling the end of the *RU* records.

Sequencing of T1, T2, T3, JD, JO, and CR records in DAT File

A DAT file begins with the optional *T1*, *T2* and *T3* records, if used, followed by *JD*, *JO*, and *CR* records. The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order. Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries on the *JD* record, with the other fields left blank unless actually needed. The optional *JO* record normally follows behind the *JD* record.

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 <i>IN</i> and <i>EV</i> records before year YRST will be skipped.
<u>Level of Error Checks and Traces</u>					
4	24	ICHECK	I8	blank,0 1 2 3 4 5 6 7 8 9 10 11 12	Normal trace, reduced error, and no warning checks. Normal trace and complete error and warning checks. <i>UC</i> and <i>RF</i> records are copied to MSS file. <i>CP</i> records are copied to MSS file. <i>WR/IF</i> records are copied to MSS file. <i>SV/SA</i> records are copied to MSS file. <i>IN/EV</i> records are copied to MSS file. <i>FD/FC/WP</i> records are copied to MSS file. Dual simulation information is recorded in MSS file. Full error checks but warning messages deactivated. Conditional reliability modeling trace is written. <i>UR</i> records are copied to MSS file. instream flow targets are recorded in MSS file.
<u>Simulation Results Output</u>					
5	25-32	CPOUT	I8	blank,0 + -1 -2	Control point output is specified only by <i>CO</i> records, Control point output is limited to first CPOUT control points plus those cps listed on <i>CO</i> records. Control point data is output for all control points. Control point data is output only for cps with <i>IN</i> records plus those cps listed on <i>CO</i> records.
6	33-40	OUTWR	I8	blank,0 + -1 -2 -3 -4 -5	<i>WR</i> output is specified only by <i>WO</i> and <i>GO</i> records. Water right output is limited to first OUTWR rights in input file plus those listed on <i>WO</i> and <i>GO</i> records. Water rights data is output for all <i>WR</i> and <i>IF</i> record rights except hydropower rights. All <i>WR</i> and <i>IF</i> record rights including hydropower. Only non-hydropower <i>WR</i> record rights. Only instream flow (<i>IF</i> record) rights. Only hydroelectric power rights are output.
7	48	OUTFILE	I8	blank,0,1 2	OUT file is created as a formatted text file. OUT file is created as an unformatted binary file.
<u>Negative Incremental Naturalized Flow Options</u>					
8	56	ADJINC	I8	blank,0,6 1,2,3,-3,4,-4,5,7,8	Option 6 defined in <i>Reference Manual</i> is the default. Options described in <i>Reference Manual</i> Chapter 3.
<u>Negative Incremental Flow Adjustments to MSS File</u>					
9	64	NEGINC	I8	blank,0,1 2 3 4 5	No adjustments written. Downstream adjustments written to MSS file. Upstream adjustments written to MSS file. Only summary table written to MSS file. Summary table and control point list.

JD Record – Simulation Job Control Data (Continued)

field	columns	variable	format	value	description
					<u>Default for Evaporation-Precipitation Adjustment</u>
10	72	EPADJ	I8	blank,0 -1 -2	No adjustment unless specified on CP record Adjustments based on ungaged CP (FD field 2) Adjustments based on gaged CP (FD record field 3)
					<u>Dimension Limit for IS/IP, SV/SA, PV/PE, and TQ/TE Records</u>
11	80	TL	I8	Blank, ≤12 ≥13	Default maximum limit = 12 pairs of values in tables. Maximum limit on number of entries in tables.
					<u>Alternate Water Right Identifiers in WR Record Fields 12-14 and 15-17</u>
12	88	IDSET	I8	blank,0,1 2	First set of identifiers on WR input records are used. Second set of identifiers on WR records are used.

Explanation of JD Record Fields

Field 4: The various levels of checks and messages are defined in Table 2.3 of Chapter 2. *ICHECK* options 1 or 0 should normally be selected unless specific needs arise for other options.

Fields 5 and 6: Fields 5, 6, and 12 in combination with *CO*, *RO*, *WO*, and *GO* records control which simulation results are written to the output file as explained in the preceding Chapter 2.

Field 7: With the default option 1, the OUT file is in text format readable with Microsoft WordPad. Creating the OUT file in binary machine language format (option 2) readable only with *TABLES* reduces run-time, reduces the file size, and increases precision for small numbers.

Fields 8 and 9: The negative incremental flow options are explained in Chapter 3 of the *Reference Manual*. *ADJINC* in field 8 controls the choice of optional simulation computation method. *NEGINC* in field 9 allows either all of the negative incremental adjustments used in the computations to be printed to the message file or alternatively a summary table and/or listing of control points and number of negative increments can be created. *ADJINC* option 6 is the default recommended standard for most applications with a monthly *SIM* simulation. *ADJINC* options 4 and 6 yield the same simulation results, but option 6 reduces the computer execution time. Option 7 is recommended for daily *SIMD* simulations with routing and forecasting.

Field 10: Methodology for correcting the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir is explained in the *Reference Manual* Chapter 3. *EPADJ* in field 10 sets a default. 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.

Field 11: The table defining a drought index (*IS/IP* records) and tables of reservoir storage volume versus surface area (*SV/SA* records), storage volume versus elevation (*PV/PE* records), and tailwater discharge versus elevation (*TQ/TE* records) are entered as pairs of numbers, which by default can not exceed 12 entries on each record. The maximum limit on the number of entries on *IS*, *IP*, *SV*, *SA*, *PV*, *PE*, *TQ*, and *TE* records can be increased above the default of 12 by entering a higher dimension limit *TL* in *JD* record field 11.

JO Record – Simulation Job Options

field	columns	variable	format	value	description
1	1-2	CD	A2	JO	Record identifier
					<u>Organization of IN and EV Records</u>
2	8	INEV	I6	blank,0,1 -1 2 -2 3 4 5 6	Grouped by years in FLO and EVA files. Grouped by years in FLO file. No EVA file. Grouped by control points in FLO and EVA files. Grouped by control points in FLO file. No EVA file. Grouped by years in DAT file. Grouped by control points in DAT file. Grouped by years in HYD file in HYD file format. HEC-DSS hydrology input file.
					<u>Flow Adjustment (FAD) File Options</u>
3	16	FAD	I8	1 2 3	Optional FAD input file is activated. Explanation of options 1, 2, and 3 for organizing and applying FA records is provided later with FA record description.
					<u>Hydropower and Reservoir Release (HRR) File</u>
4	24	SYSOUT	I8	1	Optional HRR output file is created.
					<u>Beginning-Ending Storage (BES) Options</u>
5	32	BES	I8	blank, 0 1 2 3 4 5 6	Feature is not used and BES file is not created. Ending storages written to BES file. Beginning storages read from BES file. Both beginning read and ending written to BES file. Cycling with BES file automatically created/read. Cycling without use of a BES file. Information-only table with water rights data added.
					<u>Beginning Reservoir Storage (BRS) File</u>
6	40	BRS	I8	1	Optional BRS output file is created.
					<u>Multiple-Reservoir System Release Options</u>
7	48	STOFLG	I8	blank,0 1	End-of-period storage used for system release rules. Beginning-of-period storage is used for system rules.
					<u>Drought Index Reservoir Storage Timing</u>
8	56	STODI	I8	blank,0 1 2	Beginning-of-period storage used for drought index. End-of-period storage is used for drought index. Average of beginning and ending storage is used.
					<u>Alternative Water Right Priority Schemes</u>
9	64	NPOPT	I8	1 2 3	Automated natural upstream-to-downstream priority. Priorities are set by sequencing of WR & IF records. Priorities are set by sequencing of CP records.
					<u>Defaults for IFMETH, RFMETH, and DUAL</u>
10	72	PASS2	I8	blank,0,1 2	IFMETH in IF record field 8 controls 2 nd pass option. Second pass is activated for all months regardless.
11	76	RFD	I4	blank,0,+	Default for RFMETH options in WR record field 2.
12	80	DUALD	I4	blank,0,+	Default for DUAL options in PX record field 2.

JO Record – Simulation Job Options (Continued)

field	columns	variable	format	value	description
<i>Options for Applying RU Record Adjustments</i>					
13	84	RUFIN	I4	1	Adjustments added to inflows at beginning.
				2	Adjustments added to inflows at end of simulation.
14	88	RUF	I4	1	Option 1 for <i>RU</i> record regulated flow adjustments.
				2	Option 2 for <i>RU</i> record regulated flow adjustments.
				3	Option 3 for <i>RU</i> record regulated flow adjustments.

Explanation of JO Record Fields

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

Field 3: This field activates the flow adjustment input file (filename extension FAD) which consists of *FA* records with flow volume amounts to be added to stream flows. The three options for organizing and applying the FAD file are described on pages 113-114 with the *FA* record.

Field 4: *SYSOUT* activates the optional hydropower and multiple reservoir system release output file (filename extension HRR) which is reorganized with the *TABLES* 4HRR record.

Field 5: The beginning-ending storage *BES* switch activates options outlined in Chapter 6 of the *Reference Manual*. All options except option 5 automatically activate a BES file.

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*. The BRS table may also be created for general information.

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* record (*Reference Manual* Chapter 4). *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.

Field 8: A drought index is defined by *DI*, *IS*, and *IP* records. *STODI* in *JO* record field 8 allows the drought index to be alternatively based on either beginning-of-period storage, latest computed end-of-period storage, or the average of the beginning and latest ending storage. The latest end-of-period storage for all of the *DI* record reservoirs is recomputed when each right connected to the drought index is considered in the water right priority sequence. More senior rights at each reservoir are reflected in the end-of-period storage, but junior rights are not.

Field 9: These alternative priority options replace the normal priorities entered in field 5 of the *WR* and *IF* records. With NPOPT option 1, priorities are automatically set in upstream-to-downstream order making each right senior to all other rights located at downstream control points. With option 1, for multiple rights at the same control point, priorities from *WR/IF* field 5

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govern. With NPOPT option 2, priorities are set in the order that *WR* and *IF* records are entered in the DAT file, with the first right entered being most senior. With NPOPT option 3, priorities are set by the order in which control points are placed in the DAT file. With option 3, for multiple rights at the same control point, priorities are set by the order of the *WR* and *IF* records.

Field 10: *PASS2* over-rides the *IFMETH* option entered in *IF* record field 8 and forces a second pass through the water rights computation loop in every month regardless of conditions.

Field 11: The return flow method selected by the parameter *RFMETH* in *WR* record field 7 over-rides the default *RFD* in *JO* record field 11. *RFMETH* option 1 is the default for *RFD*.

Field 12: The dual simulation options selected by the parameter *DUAL(wr)* entered in *PX* record field 2 or *SO* record field 14 are defined later in the description of the *PX* record. A default option for all water rights can be set in *JO* record field 11 subject to being replaced for individual water rights by *PX* record field 2 or *SO* record field 14.

Fields 13 and 14: The *RU* record options are described with the *RU* record.

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,0,1 2	Output limited to last 12 months of sequence. All months output for CR1 greater than 12. Applicable only if CR1 > 12 months and CR2 > 0.
5	25-32	CR4	F8.0	+ blank,0 ≤ -1.0	Factor by which all starting storages are multiplied. Default = 1.0 Storage multiplier factor = 0.0
6	33-40	CR5	I8	blank,0,1 2	Months excluded from output file are still simulated. Only the months written to output file are simulated. Default CR5 (blank field 6) is recommended.

The *CR* record activates the conditional reliability modeling (CRM) simulation mode and is the only *SIM* input record associated specifically with CRM. CRM is described in Chapter 7 of the *Reference 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 based on either weighting all the sequences equally or assigning varying probabilities. The *Reference Manual* documents *TABLES* methodologies and input records for conditional reliability analyses.

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	+ blank,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. 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	+ blank,0	Incremental decrease for second level of decreases. Optional second level is not used.
6	33-40	FYIN(5)	F8.0	+ blank,0	Incremental decrease for third level of decreases. Optional third and fourth levels are not used.
7	41-56	FYWRID	A16	AN	Water right identifier for <i>FY</i> record rights.
8	57-64	FYGROUP	A8	AN	Water right group identifier for <i>FY</i> record rights.
9	65-72	MFY	I8	blank,0,1 2	Proportional to amounts in <i>WR</i> record field 3. Based on priorities in <i>WR</i> 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 6 of the *Reference Manual*. The *FY* record is inserted any place between the *CR/JD/JO* 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 5 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.

XL Record – Multiplication Factors and Parameter Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	XL	Record identifier
<i><u>Multiplication Factors Applied to Input Data</u></i>					
2	3-8	STX	F6.0	+	Multiplier of reservoir storage volumes on <i>WS</i> , <i>OR</i> , <i>SV</i> , <i>PV</i> , <i>MS</i> , and <i>IS</i> records. Blank, 0 Default = 1.0
3	9-16	INX	F8.0	+	Multiplier of flows on <i>IN</i> records, subject to being superceded by non-blank <i>CP</i> record field 4. Blank, 0 Default = 1.0
4	17-24	E VX	F8.0	+	Multiplier of E-P rates on <i>EV</i> records, subject to being superceded by non-blank <i>CP</i> record field 5. Blank, 0 Default = 1.0
5	25-32	CIX	F8.0	+	Multiplier of flows on <i>CI</i> records. Blank, 0 Default = 1.0
6	33-40	SAX	F8.0	+	Multiplier of reservoir surface areas on <i>SA</i> records. Blank, 0 Default = 1.0
<i><u>Multiplication Factors Used in Computations</u></i>					
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)
<i><u>Limits on CN and Mean Precipitation</u></i>					
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
<i><u>Warning Limit on Runoff EP-Adjustment</u></i>					
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 *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records must all be placed between the *CR/JD/JO* records and *UC* records but can otherwise be in any order.

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 *JD* record field 10 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 stream flows. An optional warning message is printed if the adjustment in the runoff depth exceeds a limit specified in *XL* record 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*.

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OF Record – Optional Output Files Record

field	columns	variable	format	value	description
1	1-2	CD	A2	OF	Record identifier
2	3-8	DSS(1)	I6	1 blank,0	OUT output file is activated. OUT output file is not activated.
3	9-16	DSS(2)	I8	1 blank,0	SOU output file is activated. SOU output file is not activated.
4	10-24	DSS(3)	I8	1 blank,0	DSS output file is activated. DSS output file is not activated.
5	25-32	DSS(4)	I8	blank,0 1 2, 3, ... ,13	Default set of variables in SOU and DSS files. All variables are included in SOU and DSS files. DSS file is limited to include only the first DSS(4) variables listed on page 50.
6	33-40	DSS(5)	I8	+ blank,0	Hydrology DSS input file is created. DSS input file creation option is not activated.
<i>DSS Message MSS File Options</i>					
7	41-48	DSS(6)	I8	1 blank,0,2 3 4 7 8 9	Messages that DSS files are opened or closed. Error and warning messages (default). Pathnames to MSS file as DSS records are written. Pathnames to MSS file as DSS records are read. Beginning level of DSS debugging messages. Intermediate level of DSS debugging messages. Maximum level of DSS debugging messages.
8	49-56	DSSMONTH	5x,A3	AN blank	First month in DSS file (JAN, FEB, MAR, ... , DEC) The default first month label is JAN

Without an *OF* record, *SIM* simulation results are written to an OUT file to be read by *TABLES*. The *OF* record creates output files with filename extensions SOU and DSS which are not read by *TABLES*. A DSS (Data Storage System) file is read by *HEC-DSSVue*. A *SOU* file is in text format read by any editor. The OUT, SOU, and DSS files contain the same simulation results output data, but in different formats. Variables included in the simulation results are defined in *Reference Manual* Table 5.1 and *Users Manual* Table 4.10 and are also listed here on page 50.

OF record field 5 activates another optional feature which converts the naturalized flows and net evaporation-precipitation depths read from *IN* and *EV* records to a DSS hydrology input file. The file conversion is performed by an execution of *SIM* without performing the simulation. INEV option 6 in *JO* record field 2 specifies reading of hydrology data from a previously created DSS file for an actual *SIM* simulation.

Explanation of OF Record Fields

Field 2: Without the *OF* record, *SIM* always creates either an OUT or CRM output file. With an optional *OF* record, the conventional OUT file is created only if activated in *OF* record field 2.

Field 3: The SOU file created by DSS(2) contains the same time series of simulation results as the OUT file but in a different format. The first and second columns of each table in a SOU file are the year and month and the subsequent columns are the corresponding values for each output variable. The SOU file is a text file which can be read with any editor but not by *TABLES*. The columns of output data can also be easily transported to a Microsoft Excel spreadsheet.

Field 4: The DSS output file contains the same simulation results as the OUT and SOU files but in a format that can be read only by *HEC-DSSVue* or other Hydrologic Engineering Center (HEC) Data Storage System (DSS) software. The time series of simulation results can be plotted, tabulated, or manipulated within *HEC-DSSVue*. The parts of a DSS pathname are always referenced as /A/B/C/D/E/F/ which are automatically defined within *SIM* as follows.

- A – filename root
- B – control point, water right, or reservoir identifier
- C – type of data such as NAT, REG, UNA, shown in parenthesis on following page
- D – starting date (day=1/month/year)
- E – 1MON specifying monthly time step
- F – CP, WR, or RES specifying control point, water right, or reservoir output record

Field 5: Output variables are listed on the following page as well as in Table 5.1 of the *Reference Manual* and Table 4.10 of this *Users Manual*. If *OF* record field 5 is blank, the default set of variables listed on the following page is included in the SOU and DSS files. With a 1 entered for DSS(4) in field 5, the DSS and SOU files contain all of the variables. With a DSS(4) of 2 or greater, the DSS file is limited to the first DSS(4) variables in the lists. The labels shown in parenthesis on the following page are used as identifiers in the DSS pathnames and SOU table headings and correspond to the time series record identifiers in Table 4.10.

Field 6: The special feature activated by field 6 converts FLO and EVA input files to a hydrology input DSS file with the filename rootHYD.DSS. With a 1 entered in field 6, *SIM* does nothing but create the hydrology input file; the simulation is not performed. Naturalized flows and net evaporation-precipitation rates are read from *IN* and *EV* records in FLO and EVA files or a DAT file and written to the DSS file. This DSS file is then read by *SIM* in subsequent simulations. The parts of a DSS pathname are always referenced as /A/B/C/D/E/F/ which are automatically defined for hydrology input files within *SIM* as follows.

- A – filename root with HYD appended
- B – control point identifier
- C – IN or EV indicating flows (IN records) or net evaporation rates (EV records)
- D – starting date (day=1/month/year)
- E – 1MON specifying monthly time step
- F – FLOW or EVAP specifying naturalized flow or net evaporation-precipitation

Field 7: DSS(6) sets the level of DSS messages to be written to the MSS message file. A higher level incorporates all lower level messages. The default is level 2. Levels 3 or 4 will provide a listing of the DSS records as they are read or written. Levels 7, 8, and 9 provide debugging messages for DSS subroutines which WRAP users should hopefully never see or need.

Field 8: DSS data includes a label of the first month of the time series. If field 8 is blank, the default label is JAN. Either of the labels FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC may optionally be entered to define the first month of the time series data.

Simulation Results Monthly Variables Recorded in OUT, SOU, and DSS Files

Control Point Output Records (DSS file) or Table Columns (SOU file)

Default List for DSS(4) = 0
 naturalized stream flow (NAT)
 regulated stream flow (REG)
 unappropriated stream flow (UNA)
 end-of-month reservoir storage (STO)
 diversion target (TAR)
 diversion shortage (SHT)

Complete List for DSS(4) = 1
 naturalized stream flow (NAT)
 regulated stream flow (REG)
 unappropriated stream flow (UNA)
 channel loss credits (CLC)
 channel losses (CLO)
 return flows returned here (RFR)
 upstream reservoir releases (URR)
 control point inflows (CPI)
 end-of-month reservoir storage (STO)
 reservoir net evaporation volume (EVA)
 stream flow depletions (DEP)
 diversion target (TAR)
 diversion shortage (SHT)
 diversion amount (DIV)
 instream flow target (IFT)
 instream flow shortage (IFS)

Reservoir Output Records (DSS file) or Table Columns (SOU file)

Default List for DSS(4) = 0
 end-of-month reservoir storage (STO)
 net evaporation-precipitation volume (EVA)
 net evaporation-precipitation depth (EPD)
 reservoir water surface elevation (WSE)

Complete List for DSS(4) = 1
 end-of-month reservoir storage (STO)
 net evaporation-precipitation volume (EVA)
 power shortage or secondary energy (HPS)
 hydroelectric energy generated (HPE)
 inflows from stream flow depletions (RID)
 inflows from reservoir releases (RIR)
 releases accessible to hydropower (RAH)
 releases not accessible to hydro (RNA)
 adjusted evaporation-precipitation depth (EPD)
 net evaporation depths (EVR)
 reservoir water surface elevation (WSE)
 reservoir storage capacity (RSC)

Water Right Output Records (DSS file) or Table Columns (SOU file)

Default for WR Record Water Rights
 diversion target (TAR)
 diversion shortage (SHT)
 diversion or energy amount (DIV)
 end-of-month reservoir storage (STO)
 stream flow depletion (DEP)

Default for IF Record Water Rights
 instream flow target (IFT)
 instream flow shortage (IFS)

Complete List for DSS(4) = 1
 reservoir storage volume (STO)
 reservoir net evaporation volume (EVA)
 stream flow depletion (DEP)
 diversion or hydropower target (TAR)
 diversion or energy shortage (SHT)
 diversion or energy amount (DIV)
 available stream flow (ASF)
 releases from secondary reservoirs (ROR)
 return flow (RFL) or instream flow target (IFT)
 available increase (XAV) or IF shortage (IFS)
 IF right FS record flow and count (FSV, FSC)

ZZ Record – Regulated and Available Flows in Water Right Priority Sequence

field	columns	variable	format	value	description
1	1-2	CD	A2	ZZ	Record identifier
2	3-8	ZZ	I6	+ blank,0,1	Number of control points. Default is one control point.
3	9-16	ZZX	F8.0	+ blank,0	Change required to include right in output table. All water rights are included in ZZZ file output table.
4	17-32	ZZWR	A16	AN blank,0	Most junior water right included in the output table. All water rights are included in ZZZ file output table.
5 6-no limit	35-40 41-no limit	ZZCP(Z) Z=1,ZZ	2x,A6	AN	Identifiers of control points for which flows are determined and tabulated in ZZZ file output table.

A *SIM* feature described in Chapter 6 of the *Reference Manual* and controlled by the *ZZ* record is designed to facilitate assessments of the effects of each individual water right on regulated and available stream flows at specified control points. Regulated flows, available flows, and upstream reservoir releases are tabulated in a *ZZZ* file after each individual water right is simulated in the priority loop. Intermediate available flows in the water rights priority sequence become unappropriated flows after the most junior water right is simulated. The reservoir releases included in the table are a component of regulated flows and include only releases from reservoirs located at or upstream of a control point that are made to meet water right diversion, storage, or instream flow requirements at a control point located further downstream.

The *ZZZ* file table may be read directly with any editor. The *TABLES 4ZZZ* and *4ZZZF* records activate *TABLES* options for reading a *ZZZ* file and organizing the simulation results in optional time series formats or developing frequency tables.

Explanation of ZZ Record Fields

Fields 2 and 5: Tables are created for one or more control points with identifiers listed in field 5 and subsequent fields. The number of control points is entered in field 2 with a default of one. A control point identifier must be entered in field 5 and additional identifiers may be entered in field 6 and subsequent fields. A stream flow tabulation is created for each control point listed.

Fields 3 and 4: With the default option, flows are tabulated each month at the beginning of the water rights priority loop and after each water right is simulated in the priority sequence. By default, all water rights from the most senior to the most junior are included in the tabulation. Options activated by *ZZ* record fields 3 and 4 are designed to limit the water rights included in the *ZZZ* file table to only pertinent rights. The parameter *ZZX* in *ZZ* record field 3 sets a minimum flow change required for a water right to be included in the table. Monthly flow volumes are tabulated after a water right is simulated only if the change in either the regulated flow, available flow, or upstream release equals or exceeds *ZZX*. If a water right identifier is entered in *ZZ* field 4, the tabulation stops after reaching that water right in the priority sequence.

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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 <i>CO</i> records. NCPOUT is entered only on first <i>CO</i> record. Field 2 should always be blank on the second and subsequent <i>CO</i> records.
				blank,0	<i>CO</i> 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 cps with these identifiers will be included in output file.

RO Record – Reservoir/Hydropower 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 <i>RO</i> records. NREOUT is entered only on first <i>RO</i> record. Field 2 should always be blank on the second and subsequent <i>RO</i> records.
				-1	All reservoirs are included in output.
				blank,0	<i>RO</i> 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.

Any number of *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, SOU, and/or DSS files. Any number of identifiers may be provided on any number of *CO*, *RO*, *WO*, and *GO* 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 11th record. The integer 53 would be entered in field 2 of the first *CO* record.

WO Record – Water Right 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 <i>WO</i> records. NWOUT is entered only on first <i>WO</i> record. Field 2 should always be blank on the second and subsequent <i>WO</i> records.
				blank,0	<i>WO</i> 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 <i>GO</i> records. NGOUT is entered only on first <i>GO</i> record. Field 2 should always be blank on the second and subsequent <i>GO</i> records.
				blank,0	<i>GO</i> 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 right identifiers are provided in fields 11-16 of the *WR* record. Only one of the two sets of three identifiers is read by *SIM*. The selection of which of the two sets to use is specified by *IDSET* in *JD* record field 12. Water right output records are selected by matching identifiers on *WO* records 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.

Sequencing of *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO* and *RG* Records in DAT File

SIM reads the *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records as the section of the DAT file that follows the *CR*/*JD*/*JO* records and precedes the *UC* records. The *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records must all be inserted between the *CR*/*JD*/*JO* records and *UC* records but can otherwise be in any order, except multiple *CO*, *RO*, *WO*, and *GO* records should be grouped together. For example, all *CO* records must be grouped together, and all *RO* records must be grouped together. *FY*, *XL*, *OF*, and *ZZ* records are each a single record.

RG Record – Parameters and Criteria Defining Selected Groups of Water Rights

field	columns	variable	format	value	description
1	1-2	CD	A2	RG	Record identifier
2	3-8	RGI(I,1)	I6	+	Water right information is listed in message file.
<i>Parameters Assigned to Selected Water Rights</i>					
3	9-16	RGID(I,1)	A8	AN	Second group identifier in <i>WR</i> record field 14.
4	17-20	RGI(I,2)	I4	+	DUAL(wr) in <i>PX</i> field 2 or DUALD in <i>JO</i> field 11.
5	21-24	RGI(I,3)	I4	+	XCP(px) in <i>PX</i> record field 4.
6	25-32	RGCP(I,1)	2x,A6	AN	XCPID in <i>PX</i> record field 5.
<i>Criteria for Selecting Water Rights</i>					
7	33-36	RGI(I,4)	I4	Blank,0,1 2 3	Only <i>WR</i> record rights are included. No <i>IF</i> rights. Both <i>IF</i> and <i>WR</i> record rights are included. Only <i>IF</i> record rights are included. No <i>WR</i> rights.
8	37-40	RGI(I,5)	I4	+	Lower limit on water right type in <i>WR</i> record field 6.
				-	Upper limit on water right type in <i>WR</i> record field 6.
9	41-48	RGA(I,1)	F8.0	+	Lower limit on target AMT in <i>WR</i> record field 3.
				-	Upper limit on target AMT in <i>WR</i> record field 3.
10	49-56	RGA(I,2)	F8.0	+	Lower limit on reservoir storage capacity.
				-	Upper limit on reservoir storage capacity.
11	57-64	RGI(I,6)	I8	+	Lower limit on priority in <i>WR</i> record field 5.
				-	Upper limit on priority in <i>WR</i> record field 5.
12	65-72	RGID(I,2)	A8	AN	Group identifier of water rights to include.
13	73-80	RGID(I,3)	A8	AN	Group identifier of water rights to exclude.
14	81-88	RGCP(I,2)	2x,A6	AN	Downstream control point limit.

Supplemental **RG2** Record – Additional Control Point Identifiers

field	columns	variable	format	value	description
1	1-2	CD	A2,I1	RG2	Record identifier
2	3-8	RGI(I,7)	I5	+	Number of downstream limits.
3	9-12	RGI(I,8)	I4	+	Number of upstream limits <i>WR</i> can not be above.
4	13-16	RGI(I,9)	I4	+	Number of upstream limits that <i>WR</i> must be below.
5	17-24	RGCP(I,3)	2x,A6	AN	Control point identifier for limit.
6	25-32	RGCP(I,4)	2x,A6	AN	Control point identifier for limit.
7	33-40	RGCP(I,5)	2x,A6	AN	Control point identifier for limit.
8	41-48	RGCP(I,6)	2x,A6	AN	Control point identifier for limit.
9	49-56	RGCP(I,7)	2x,A6	AN	Control point identifier for limit.
10	57-64	RGCP(I,8)	2x,A6	AN	Control point identifier for limit.
11	65-72	RGCP(I,9)	2x,A6	AN	Control point identifier for limit.
12	73-80	RGCP(I,10)	2x,A6	AN	Control point identifier for limit.
13	81-88	RGCP(I,11)	2x,A6	AN	Control point identifier for limit.
14	89-96	RGCP(I,12)	2x,A6	AN	Control point identifier for limit.

Any number of *RG* records may be included in the DAT file, inserted any place between the *CR/JD/JO* records and the *UC* records. An optional *RG2* record following the main *RG* record provides additional features for delineating sub-basin locations of water right control points.

The water right group defined by a *RG* record consists of all water rights for which all criteria specified on the *RG* and *RG2* records are met. The criteria in *RG* fields 7–14 and the *RG2* record are optional. With the exception of the field 7 default, each criterion is activated only if its field is not blank or zero. However, a water right is included in the group defined by a *RG* record only if each and every activated criterion (non-blank and non-zero entry) is satisfied by that right.

The *RG* record provides criteria for defining a group of water rights for the following purposes.

- Information for the selected water rights is listed in the message MSS file if specified in *RG* record field 2. Thus, rights meeting criteria of interest can be easily viewed.
- The *WR* record field 14 group identifier assigned to each of the rights by *RG* record field 3 is used in several of the *TABLES* routines that deal with groups of water rights defined by the two group identifiers in *WR* record fields 13 and 14.
- The values for the parameters for the dual simulation and downstream control point flow availability options in *RG* record fields 4, 5, and 6 are assigned to all rights included in the group. This provides a convenient means for assigning values for these parameters to a large number of rights without preparing individual *PX* records for each water right.

Any or all fields of the *RG* record, except for the CD of *RG* in field 1, may be blank. With only *RGI(L,1)* in field 2 activated by a non-zero entry, data from the *WR* and *PX* records for all *WR* record rights are written to the MSS file. Activation (non-blank fields) of the criteria in *RG* fields 7-14 reduces the number of rights in the selected group. A group identifier entered in *RG* field 3 replaces the group identifier in *WR* field 14. Entering values in *RG* fields 4, 5, and 6 results in replacing values from the *PX* records or providing values if water rights have no *PX* record.

Explanation of RG Record Fields

Field 2: An integer entered in *RG* record field 2 results in the following information being listed in the MSS file for each of the selected water rights. The rights included in the group are listed in the order in which their *WR* records are placed in the DAT file.

- water right identifier (*WR* record field 12)
- first group identifier (*WR* record field 13)
- second group identifier (*WR* field 14 replaced by *RG* field 3)
- control point (*WR* record field 2)
- annual target amount (*WR* record field 3)
- total reservoir storage capacity (*WS* record field 3) for water right types 1, 5, and 7 (*WR* record field 6)
- priority number (*WR* record field 5)
- water right type (*WR* record field 6)
- *DUAL(wr)*, *XCP(px)*, and *XCPID* from *PX* record fields 2, 4, and 5 or their replacements from *RG* record fields 4, 5, and 6 if activated

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Field 3: Two optional water right group identifiers WRIDS(wr,1) and WRIDS(wr,2) are assigned in *WR* record fields 13 and 14 and used in several of the *TABLES* routines. The group identifier RGID(I,1) entered in *RG* field 3 replaces WRIDS(wr,2) in *WR* record field 14.

Parameter Fields 4, 5, 6: The values for the input parameters DUAL(wr), XCP(px), and XCPID are assigned to each of the water rights in the group, replacing any values that may have been assigned to DUAL in *JO* record field 11 or DUAL(wr), XCP(px), and XCPID in *PX* record fields 2, 4, and 5. The simulation computations are performed with the values entered on the *RG* record. One *RG* record can be used to assign values for one or more of these parameters for any number of water rights. Other *RG* records can be used to assign different values for one or more of these parameters for any number of other groups of water rights. If *RG* record fields 4, 5, or 6 are blank, the corresponding fields of the *JO*, *WR*, and *PX* records are not replaced or supplied.

Criteria Fields 7-14: The *RG* record selection routine starts with all water rights and then eliminates rights as each of the individual criteria is applied to each right. All criteria are optional. A blank field 7 has a default. Each water right must satisfy all criteria for which *RG* record fields 8 through 14 are not blank in order to be included in the group of selected rights.

Field 7: The group may be limited to either *WR* record or *IF* record rights or include both.

Field 8: Water right types 1, 2, 3, 4, 5, 6, and 7 are defined in *WR* record field 6. *RG* record field 8 allows specification a lower or upper limit for the integers 1, 2, 3, 4, 5, 6, and 7. For example, a lower limit of 3 in *RG* field 8 results in inclusion of types 3, 4, 5, 6, and 7 in the group. Water right types 1, 2, and 3 are included in the group if a -3 is entered in *RG* field 8. With *RG* field 8 blank, water right type is not considered in defining the water right grouping.

Field 9: With a positive amount in *RG* field 9, rights are included only if the annual target from *WR* or *IF* record field 3 equals or exceeds that amount. Rights are included only if the *WR/IF* field 3 annual target equals or is less than the absolute value of a negative entry in *RG* field 9.

Field 10: With a positive amount in *RG* field 10, water rights are included only if the total *WS* record storage capacity of the reservoir filled by the right is equal to or greater than that amount. Alternatively, rights are included only if the storage capacity filled by the right is equal to or less than the absolute value of a negative entry in *RG* field 10.

Field 11: The priority number from *WR* or *IF* field 5 provides another criterion for delineating a right group. With a positive integer in *RG* field 11, only water rights with priorities equaling or exceeding the specified priority are included in the group. A negative sign placed before the priority switches to a criterion in which rights with priorities numbers larger than the absolute value of the *RG* field 11 entry are excluded from the group. Negative or zero priorities are not applicable with the *RG* field 11 criteria. The criterion is not applied if the field is blank or zero.

Fields 12 and 13: The optional water right group identifiers are assigned in *WR* record fields 13 and 14 can be used to select rights for either inclusion in the group or exclusion from the group.

Field 14: The control point location of each water right is provided in *WR* record field 2. A control point identifier may be entered in *RG* field 14. Water rights are not included in the group unless they are located at or upstream of the *RG* field 14 control point.

Explanation of Supplemental RG2 Record Fields

A single control point entered in field 14 of the main *RG* record provides a downstream limit on water rights included in the specified group. Thus, water rights located in a particular sub-basin defined by the control point are included in the group. A supplemental *RG2* record allows additional control points to be employed to impose location limits in the selection of water rights.

From one to ten control point identifiers may be entered in fields 5 through 14 of the *RG2* record. The manner in which these control points are applied to define sub-basins is specified in *RG2* record fields 2, 3, and 4. An error message is printed if a control point identifier entered on *RG* or *RG2* records is not also found on a *CP* record.

Field 2: The number of control points entered for RGI(I,7) in *RG2* field 2 represents the first RGI(I,7) control points in fields 5-14. For example, the integer 3 entered in *RG2* field 2 refers to the three control points listed in *RG2* fields 5, 6, and 7. These control points define downstream limits just like the control point in field 14 of the main *RG* record. Water rights are not included in the group unless they are located at or upstream of one of these control points. Thus, multiple sub-basins on different stream tributaries may be delineated.

If *RG2* record fields 3 and 4 are blank, all control points located above the sub-basin outlets defined as described above are included in the group. Sub-basins with upstream as well as downstream limits can be delineated by non-zero entries in fields 3 and/or 4.

Field 3: The number of control points entered for RGI(I,8) in field 3 represents the next RGI(I,8) control points following after the first RGI(I,7) control points in fields 5-14. Water rights are excluded from the group if located upstream of one of these control points. Thus, upper limits of a sub-basin can be placed at selected control point locations on multiple tributaries.

Field 4: The number of control points entered for RGI(I,9) in field 4 represents the next RGI(I,9) control points in fields 5 through 14 following after the RGI(I,7) and RGI(I,8) control points. Water rights are excluded from the group unless located at or downstream of one of the field 4 control points. With this option, program *SIM* finds all the control points located between each of these field 4 control points and the river basin outlet(s). The control point of a water right must be located along one of these reaches in order for the right to be included in the group.

Fields 3 and 4 both provide capabilities for specifying upstream limits in the delineation of sub-basins or river reaches. However, the upper limits are defined differently with field 3 versus field 4 with respect to tributaries other than the stream upon which the water right is located. With limits defined by field 4 control points, to be included in the group, water rights must be located at or between an upper limit control point and the basin outlet (or specified downstream limit control point). With limits defined by field 3 control points, water rights are included in the group if located on other tributaries as long as the rights are not located upstream of the upper limit control points.

Fields 5-14: From one to ten control point identifiers are listed. These must be control points defined on *CP* records.

SIM

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 <i>WR</i> and <i>IF</i> 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 <i>WR</i> and <i>IF</i> 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 set of all *UC* records follows after the completion of all *JD*, *JO*, *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* 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 connects sets of priority factors to the water use type in field 4 of <i>WR</i> and <i>IF</i> records.
3	9-16	USEP(I)	I8	+	Priority number which overrides <i>WR/IF</i> field 5.
4	17-24	USEADD(I)	I8	+	Integer number to be added to priority numbers.
5	25-32	USEMUL(I)	F8.0	+	Factor by which to multiply priority numbers.
6	33-40	USEFAC(I) I=1,NUSES	F8.0	+	Factor by which to multiply target amounts.

UP records allow modifications to priorities set in field 5 of *WR* and *IF* records to be applied to selected types of water rights identified by the use type identifier in field 4 of the *WR* and *IF* records and field 2 of the *UP* record.

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. The water use identifier in *UP* record field 2 must also either be also found in field 2 of a *UC* record or be the standard *NDAYS* or constant (blank) options associated with *WR* and *IF* record field 4.

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 adding to them an integer number entered in *UP* record field 4.

Field 5: Priorities set by *WR* or *IF* records are revised by multiplying by a factor entered in *UP* record field 5.

Field 6: Diversion, instream flow, or hydropower targets from *WR* and *IF* records are multiplied by *USEFAC* from *UP* record field 6 if this field is not blank. The default multiplier factor is 1.0.

Sequencing of Sets of UC, UP, RF, CP, and CI Records in DAT File

The set of all *UP* records follows immediately behind the set of all *UC* records.

The set of all *RF* records follows next after the set of all *UP* records.

The set of all *CP* records follows next after the set of all *RF* records.

The set of all *CI* records follows next after the set of all *CP* records.

SIM

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 <i>WR</i> 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 <i>WR</i> 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 Months 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.

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.

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 inflows and outflows from *CI* records to the naturalized stream flows and preceding month returns flows at the specified control point and, with adjustments for channel losses, at all downstream control points. *SIM* combines naturalized flows, next-month-option return flows from the previous month, *CI* record flows, and *FA* record flows at the beginning of each month after the optional negative incremental flow adjustment and flow distribution routines. Outflows may be entered as negative values on *CI* or *FA* records but are not allowed to reduce stream flows to below zero. Flow adjustments on *FA* records that vary between years and constant annual sets of 12 monthly *CI* record flows are treated by *SIM* each month in the same manner.

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.

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 blank,OUT	Identifier of next downstream control point. Outlet. There is no control point downstream.
<u>Multiplier Factors</u>					
4	17-24	CPDT(cp,1)	F8.0	+ blank,0	Factor by which inflows on IN records are multiplied Default factor = 1.0
5	25-32	CPDT(cp,2)	F8.0	+ blank,0	Factor by which evaporation rates are multiplied Default factor = 1.0
<u>Method for Obtaining Naturalized Flows</u>					
6	40	INMETHOD (cp)	I8	blank,0,1 2 3 4 5 6 7 8 9 10	IN records are input for this control point. Specifications are provided by CPIN(cp) in field 7. Distribution equation with FC record coefficients. NRCS CN with synthesized flow limited to source. NRCS CN method without above noted flow limit Channel loss coefficient with DAR method Drainage area ratio method (areas from WP records) NRCS CN method with channel losses Control point flow does not limit available flow. Equation proportioning flows at other control points.
7	43-48	CPIN(cp)	2x,A6	AN NONE ZERO	Control point from which IN records are repeated. The words none, zero, NONE, or ZERO entered in this field indicate zero stream flows at this control point.
<u>Method for Obtaining Net Evaporation-Precipitation</u>					
8	51-56	CPEV(cp)	2x,A6	blank AN NEXT NONE ZERO	EV records are read as input. Control point from which EV records are repeated. EV records for next downstream cp are repeated. The words none, zero, NONE, or ZERO in this field indicate zero net evaporation at this control point.
<u>Evaporation-Precipitation Adjustment</u>					
9	57-64	EWA(cp)	F8.0	blank,0 -1.0 -2.0 -3.0, <-3.0 +	Default set by JD record field 10 is used. Ungaged CP from FD record field 2 is used. Gaged CP from FD record field 3 is used. No adjustment. (Overrides non-blank JD field 10) Watershed area in acres for E-P adjustment.
<u>Other Input Parameters</u>					
10	65-72	CL(cp)	F8.0	+	Channel loss factor for reach below CP. Default = 0.0
11	73-76	L	I4	+ -1	Replace naturalized flow with field 13 constant flow. Change naturalized flow to zero.
12	77-80	INWS(cp)	I4	blank,0 +	Parameters on WP record are for the total watershed. Parameters for incremental watersheds.
13	81-96	CPF(cp)	F16.0	+	Constant monthly naturalized flow at control point.

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. Option 9 allows a control point without stream flow data to be excluded from the available flow computations. Options 3, 4, 5, 6, 7, 8, and 10 require DIS file *FD* records. Options 3 and 10 require *FC* records.

Field 7: The naturalized stream flows at a control point may be repeated from those provided at another control point or set at zero.

Field 8: The evaporation-precipitation depths at a control point may be repeated from another specified control point or from the nearest downstream control point with data 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 stream flows to prevent double-counting. $EWA(cp)$ of -1 or -2 results in the runoff depth adjustment being computed by dividing the naturalized stream flow 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 12: The drainage area, curve number, and mean precipitation provided on *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.

Fields 11 and 13: All control points must have naturalized flows assigned by one of the options from fields 6 and 7. However, these naturalized flows for all months can be replaced by the constant flow $CPF(cp)$ from field 13 or zero if so specified by parameter L in field 11.

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,+	Diversion (types 1-3 in field 6), inflow (type 4), hydropower (types 5-6), or storage (type 7) target
4	19-24	USE	2x,A6	blank AN NDAYS XMONTH	Monthly target is 1/12 of annual AMT in field 3. Use type identifier to connect to <i>UC</i> and <i>UP</i> records Distribution based on number of days in each month Monthly rather than annual target in field 3
5	25-32	WRNUM(wr,7)	I8	–,0,+	Priority number
<u>Water Right Type</u>					
6	36	WRNUM (wr,5)	I4	blank,0,1 2 3 4 5, –1 6, –3 7 8	Type 1 water right (refills reservoir storage) Type 2 water right (no refilling storage) Type 3 water right (no stream flow depletions) Type 4 water right (inflow to river system) Type 5 water right (hydroelectric power) Type 6 water right (hydroelectric power) Type 7 water right (target sets storage capacity) Target is computed for use with <i>FS</i> and <i>TO</i> records.
<u>Return Flow Specifications</u>					
7	40	RFMETH (wr)	I4	blank,0 1 2 3 4	Default <i>RFD</i> entered in <i>JO</i> record field 11. Constant factor, flows returned same month Constant factor, flows returned next month Monthly factors, flows returned same month Monthly factors, flows returned next month
8	41-48	RFAC RFIDWR	F8.0 2x,A6	+ AN	Constant return flow factor Identifier on RF record for monthly factors
9	51-56	RCP	2x,A6	blank AN	Flow returned to next downstream control point Identifier of control point to return flow
<u>Optional Flow Switch FS or Cumulative Volume CV</u>					
10	57-60	FSCV(wr)	I4	+,-	Identifier in <i>FS</i> or <i>CV</i> record field 2 (see page 68).
<u>Optional Drought Index (DI Record)</u>					
11	61-64	DINDEX (wr)	I4	+,-	Drought index identifier in <i>DI</i> record field 2. Sign specified step 2 versus step 10 on pages 69-70.
<u>First Set of Identifiers</u>					
12	65-80	WRID(wr)	A16	AN	Water right identifier
13	81-88	WRIDS(,1)	A8	AN	Optional water right group identifier
14	89-96	WRIDS(,2)	A8	AN	Optional water right group identifier
<u>Alternate Set of Identifiers (JD Record Field 12)</u>					
15	97-112	WRID(wr)	A16	AN	Alternate water right identifier
16	113-120	WRIDS(,1)	A8	AN	Alternate second water right identifier (group)
17	121-128	WRIDS(,2)	A8	AN	Alternate third water right identifier (group)

Explanation of WR Record Fields

Field 2: The water right has access to available stream flow at this control point. Stream flow depletions for diversions and maintaining storage for the right occur at this control point.

Field 3: An annual diversion volume (type 1, 2 or 3), inflow volume (type 4), hydroelectric energy (type 5 or 6), or storage volume (type 7) target is converted within *SIM* to monthly targets by using *UC* record factors and may be further adjusted by options on other auxiliary records. With *XMONTH* entered in field 4, the target in field 3 is a monthly rather than annual amount. A -1 sets a very large AMT, which is greater than any possible stream flow. Resulting targets and shortages are incorporated in the simulation but are not included in summations and output.

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 term *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.

XMONTH or *xmonth* in field 4 indicates that the target in field 3 is already a monthly amount.

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 5 assigns a priority of zero, which is treated like any other integer number. The priority in field 5 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 9.

Field 6: The water right types defined in *Reference Manual* Chapter 4 specify rules for meeting water right requirements. The default type 1 right allows a diversion target to be supplied from stream flow depletions and/or storage in one or more reservoirs. The diversion is met from stream flow to the extent that stream flow is available and then from storage. One primary reservoir can be refilled from stream flow depletions and releases from other system reservoirs. The diversion and primary reservoir must be at the control point (field 2) with both having access to available stream flow at that control point. Types 2 and 3 rights do not refill storage and thus do not have to be at the same control point as the reservoir. A type 2 right is supplied by stream flow depletions at the *WR* record field 2 control point and releases from storage in one or more reservoirs. A type 3 right is supplied only by releases from reservoir storage.

Types 5 and 6 rights are similar to types 1 and 3 rights except hydroelectric power generation replaces the diversion target. A type 4 right discharges water into the stream. Type 7 rights refill a reservoir to a monthly target storage capacity determined the same way as a diversion target.

Fields 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. Hydropower releases are also treated as return flows. The optional methods are outlined in Chapter 4 of the *Reference Manual*.

Fields 10, 11: *DI* and *FS* or *CV* records are connected to the water right by reference in *WR* field 10 and 11 to the integer identifier defined in field 2 of the *FS*, *CV*, or *DI* record. See page 68.

Fields 12-17: 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 minimum instream flow target
4	19-24	USE	2x,A6	blank AN NDAYS XMONTH	Monthly target is 1/12 of annual AMT in field 3. Use type identifier to connect to <i>UC</i> and <i>UP</i> records Distribution based on number of days in each month Monthly rather than annual target in field 3
5	25-32	WRNUM(7)	I8	-,0,+	Priority number
6	34	IFFLAG2 (wr)	I2	blank,0 1,non-zero	Instream flow limit is based on total regulated flow. Reservoir releases for downstream use are excluded.
7	36	WRNUM (wr,10)	I2	Blank,0,1 2 3	Junior <i>IF</i> target at cp replaces preceding senior target. Largest <i>IF</i> record target at control point is adopted. Smallest <i>IF</i> record target at control point is adopted.
8	39-40	IFMETH (wr)	I4	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
9	41-44	FSCV(wr)	I4	+,-	Identifier in <i>FS</i> or <i>CV</i> record field 2 (see page 68).
10	47-48	DINDEX (wr)	I4	+,-	Drought index identifier in <i>DI</i> record field 2. Sign sets location in target setting sequence.
11	49-64	WRID(wr)	A16	AN	Water right identifier (optional)
12	65-70	CP2	A6	AN	Control point defining downstream end of reach.

Explanation of IF Record Fields

The data entered in fields 1, 2, 3, 4, 5, 9, 10, and 11 of the *IF* record are similar for both *IF* and *WR* record water rights. These common variables are explained on the preceding page. *IF* fields 6, 7, 8, and 12 dealing specifically with instream flow right computations are discussed below.

Field 6: An option allows instream flow requirements that do not credit reservoir releases for downstream rights as contributing to the regulated flows that must satisfy the *IF* requirement.

Field 7: The field 7 option switch is pertinent only if more than one *IF* record with associated *FS*, *TO*, *TS*, *SO*, and *WS* records assigns a target for the same control point. As the multiple *IF* records at the same control point are activated in the water rights priority sequence each month, the field 7 parameter controls the combination of *IF* record minimum instream flow targets. With the default option 1, the current *IF* record target replaces all other targets set at the control point by other more senior *IF* record rights. With option 2, the largest of the new versus preceding target is adopted. With option 3, the *IF* record instream flow target is adopted only if it is smaller than the target already set by the preceding more senior *IF* right.

Field 8: *IF* record field 8 *IFMETH* options 1 and 2 constrain stream flow 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 2, -2, 4 and -4 exist for the sole purpose of partially mitigating the problems of (1) senior *WR*-record rights not having access to water made available by junior *WR*-record rights through either same-month diversion return flows or hydropower releases and (2) reservoir releases not being credited in meeting instream flow targets at intermediate control points assuming *IFFLAG2* is zero (blank field 6). *IFMETH* options 1 and 3 should be used if these problems are not a concern and perhaps even if these problems are a concern.

IFMETH options 2 and 4 involve a possible repeat of the simulation, which is called a second pass through the water rights loop. 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 10 forces a second pass in all months regardless of the *IF* record *IFMETH* option.

With *IFMETH* options 2 and 4, instream flow requirements are not reflected in unappropriated flows for months without a second pass.

Field 12: The instream flow target is repeated for all control points for the reach from *CP* (*IF* field 2) downstream to *CP2* (field 12). *OUT* or *out* entered in *IF* field 12 sets *CP2* at the outlet.

Sequencing of *WR* and *IF* Records and Associated *SO, TO, LO, ML, CV, FS, TS, BU, WS/HP/OR, and PX/AX* 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 and set of all *CI* records. The set of records for each individual water right consists of a *WR* or *IF* record followed by optional *SO, TO, LO, ML, CV, FS, TS, PX*, and/or set of *WS, HP, and OR* records. The set of all 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, LO, ML, CV, FS, TS, BU, WS, HP, OR, PX* and *AX* records within the set is arbitrary other than:

- All *TS* records for the water right must be grouped together in chronological order by year.
- All *TO* records for the water right must be grouped together. Likewise, all *LO* records for the right must be grouped together.
- A hydropower *HP* must follow the *WS* record of the reservoir to which it is connected. The optional *OR* record follows directly after the optional *HP* record.
- 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.
- An *AX* record is entered if and only if *-al* is entered in *PX* record field 3. The *AX* record follows behind the *PX* record.
- Additional flexibility can be employed in placing *CV* and *FS* records as described next.

Options for Employing Cumulative Volume CV and Flow Switch FS Records

Cumulative volume *CV* and flow switch *FS* records activate routines that sum volumes of the variable selected in their field 3 over any number of past time periods and/or the current period. The two record types are organized similarly but perform distinctly different though similar computations. *CV* and/or *FS* records may be employed in developing:

IF record instream flow targets,
WR record diversion, hydropower, or storage targets,
LO record stream flow depletion limits, and
OR record reservoir release limits.

SIM automatically numbers *CV* and *FS* records in the sequential order (1, 2, 3, ...) in which they are found in the DAT file. The sequential numbering provides integer identifiers for the records. *WR* record field 10, *IF* record field 9, and *OR* record field 10 reference these numbers. Since all *CV* and *FS* records are numbered automatically within *SIM*, the only purpose of *CV/FS* field 2 is to allow model users to conveniently identify different *CV/FS* records. Field 2 can be left blank. *SIM* performs an error check to assure that field 2 is either blank or contains the correct integer representing the sequential numbering. All *CV* and *FS* records are included together in the same sequential numbering with no differentiation between *CV* versus *FS* records.

Any number of *CV* and *FS* records can be provided for any of the water rights in a DAT file. Any number of water rights can apply the same *CV* or *FS* record. *CV* and *FS* records can be employed in the following alternative modes.

- *CV* and *FS* records can be included in the set of auxiliary water right records (*SO*, *TO*, *LO*, *TS*, *BU*, *PX*, and *WS/HP/OR*) that follow a *WR* or *IF* record. *CV* and *FS* records are attached to the preceding *WR* or *IF* record in the same manner as the *SO*, *TO*, *LO*, *TS*, *BU*, *PX*, and *WS/HP/OR* records. The records can be entered in the DAT file in any order as discussed on the preceding page 67. Quantities are computed in the priority sequence simulation at the priority specified by the *WR* or *IF* record.
- A *WR* or *IF* record can reference a *CV* or *FS* record that is located with the records for some other *WR* or *IF* record right by entering the *CV* or *FS* integer identifier $FSCV(wr)$ in *WR* record field 10 or *IF* record field 9. The same *CV* or *FS* record results developed at the same priority sequence can thus be applied for any number of water rights. The product provided by the *CV* record is a target volume. The *FS* record provides either a switch ($FSCV(wr)$ flagged with negative sign) or target volume (positive $FSCV(wr)$).
- A *CV* or *FS* record can be used in setting a maximum release limit for a reservoir by entering the integer identifier of the *CV* or *FS* record in *OR* record field 10. The product of the referenced *CV* or *FS* record is a release limit volume or flow switch.
- *TO* and *LO* records for the current right can access a target computed for another right (*WR*, *IF*) using *CV*, *FS*, *UC*, *SO*, *TO*, *LO*, *TS*, *BU*, *PX*, *WS/HP/OR*, and *DI/IS/IP* records.

Water right type is specified in *WR* field 6. Type 8 rights are created solely to be referenced by *TO*, *LO*, *OR*, *CV*, and *FS* records as noted above. A type 8 right stops after computing a target or *FS* switch without supplying the target or otherwise affecting the simulation. However, its target or switch can be used in *TO*, *LO*, *OR*, *CV*, and *FS* operations performed for other water rights.

Framework for Building Diversion, Instream Flow, and Hydropower Targets

Various options may be applied individually or in combination to define targets for water supply diversions (*WR* record type 1, 2, or 3), discharge into a stream (*WR* type 4), hydroelectric energy (*WR* type 5 or 6), refilling storage (*WR* type 7), or minimum instream flows (*IF* record). Targets are normally associated with diversion, hydropower, and instream flow requirements. However, type 4 discharge and type 7 storage targets are computed the same way as the others. For *WR* record rights, a target is set by a single *WR* record along with auxiliary optional *UC*, *SO*, *TO*, *TS*, *FS*, *DI*, and *BU* records. For *IF* record water rights, a minimum instream flow target at a control point is likewise set by an *IF* record, along with its optional supporting *UC*, *SO*, *TO*, *TS*, *FS*, or *DI* records, but the instream flow target can be defined within the water rights priority sequence by multiple *IF* records at the same control point. A target may be set by combining *IF* records.

The current discussion focuses on developing water right targets. However, as discussed later, the *LO* record has the same format as the *TO* record but builds a maximum stream flow depletion limit rather than a target using essentially the same computation procedures.

Targets for most rights are set simply by applying only the first step outlined below. More complex requirements are modeled by exercising ingenuity in combining multiple options within the framework outlined below. *SO* record field 9 options allow intermediate amounts after each of the steps below to be recorded. In combining targets determined in different ways, *SIM* may adopt either the smallest or largest or may combine quantities through arithmetic operations. A monthly target is set in *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 a monthly multiplier determined from *UC* record distribution coefficients to obtain a target for a particular month. *UC* records are not required if the target is constant over the year.
2. The backup right *BU* record activates the backup option as this second step in the target building routine or alternatively as step 10. The shortages incurred by one or more other specified rights are added to the target of the current right determined in step 1 above.
3. The optional drought index defined by a set of *DI/IS/IP/IM* 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 delays 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 stream flow, 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 may be placed on the stream flow/storage-based targets by *TO* record fields 5 and 6. The first two of the three different applications of the *TO* record fields 5 and 6 limits described applied here in step 4. The third variation is activated by *TOTARGET*=10 with the limits applied later as step 7.

SIM

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 or the *TO* fields 5 and 6 limits applied. The *TO* record target building may be repeated any number of times. Each new intermediate target is combined with the preceding cumulative intermediate target.

TOTARGET option 13 in *TO* record field 2 uses a target previously developed for another water right in developing the target for the current water right. Thus, the target-building routines can be stacked.

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.
 - *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 6th step of the sequence or as step 3 above, as specified by *INDEX* on the *WR/IF* record.
7. *TOTARGET=10* in *TO* record field 2 results in *TO* record fields 5 and 6 limits being applied at this point in the computations as discussed on the next page.
8. A cumulative volume *CV* or flow switch *FS* record may create or modify the target based on the total volume of a selected variable accumulated during a specified preceding number of months and/or current month. Unlike step 9 below, step 8 applies the any number of *CV* and *FS* records entered with the current *WR* or *IF* record water right along with the other records.
9. The *FS* or *CV* record for step 9 is entered with another right and referenced by an integer identifier in *WR* field 10 or *IF* field 9 of the current right. A negative *FS* record reference results in the target of the current right being multiplied by a flow switch consisting of either *FSX(FS,1)* or *FSX(FS,2)* selected by the referenced *FS* record. Otherwise, the referenced *FS* or *CV* record provides a target volume for the current right. A referenced *FS/ CV* record target may reflex the preceding steps 1-8 for its water right record group, but, unlike step 8 above, does not apply the preceding steps 1-8 with records entered for the current water right.
10. The *BU* record backup feature allows the shortage from one or more other rights to be added to the target determined as outlined above. Optionally, the backup may be applied as step 2.
11. The target is adjusted for monthly or annual reservoir withdrawal limits of *SO* fields 7 and 8.
12. The target is adjusted for the annual or seasonal diversion or regulated flow limits of *SO* record field 10.

TO Record Lower and Upper Limits on Targets

The lower and upper limits on targets specified in *TO* record fields 5 and 6 are applied in step 7 for *TOTARGET* option 10 and otherwise in step 4. With the first two options listed below applied in step 4 described on the preceding page, the limits are imposed upon completion of the other step 4 adjustments specified by a particular *TO* record. Different limits may be specified for each individual *TO* record in a series of multiple *TO* records in step 4.

- With option *LIM* entered in *TO* record field 4, the target computed in step 4 is adopted if it falls between the lower and upper limits; otherwise the target is set at zero.
- Without *LIM* in *TO* field 4 and without 10 in field 2, *TO* record fields 5 and 6 limits are also applied in step 4. If the target would otherwise fall below the lower limit, it is set at the lower limit. If the target is otherwise greater than the upper limit, it is set at the upper limit.
- With *TOTARGET* option 10 in *TO* record field 2, *TO* record fields 5 and 6 lower and upper limits are imposed upon the computed target amount as step 7. If the target computed in steps 1 through 6 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.

CV and FS Record Adjustments Based on Cumulative Flow Volume

The cumulative volume *CV* and flow switch *FS* record routines are motivated primarily by instream flow requirements that depend on volumes accumulated over multiple time periods. However, *CV* and *FS* records may be applied to either instream flow, diversion, or hydropower targets or to the other quantities discussed in the next paragraph. Targets or limits may be developed, modified, or switched on-or-off based on the accumulative volume of a user-selected variable for a specified control point or water right. Options are provided for defining the time period over which monthly volumes are summed to obtain the total cumulative volume of the selected governing parameter. The flow accumulation period may include the current period in which the target is being set and/or any number of preceding periods. Optionally, the flow accumulation period may be limited to a specified season of the year.

CV, FS, TO, LO, and OR Record Use of Targets for Other Purposes

A diversion, hydropower, or storage target is the primary product of the target creation features of a *WR* or *IF* record and auxiliary *TO*, *TS*, *SO*, *DI*, *BU*, *CV*, and *FS* records. The quantity adopted as a target can also be used by a *FS* record (*FSV* option 9) as a flow switch variable, by a *LO* record (*TOTARGET* option 13) as a stream flow depletion limit, or by a *TO* record in developing a diversion, hydropower, instream flow, or storage target for another water right. A *CV* or *FS* record flow switch can be used by *OR* record field 10 in developing reservoir operating rules. The *CV* or *FS* record connected to the *OR* record can access a *WR* or *IF* record target.

FS, *TO*, and *LO* records can use the target created by any water right. However, right type 8 (*WR* record field 6) is designed for creating a quantity, using target computations, for the sole purpose of use by *FS*, *TO*, and *LO* records. The type 3 right does not affect the simulation in any way other than creating a quantity using a set of *WR* *TO*, *TS*, *SO*, *DI*, *BU*, and *FS* records that is incorporated into the *FS*, *LO*, and *TO* record flow switch, depletion limit, or water right target.

SO Record Limits on Diversions, Stream Flow Depletions, and Regulated Flows

MONDEP and *ANNDEP* in *SO* record fields 7 and 8 place monthly and annual or seasonal limits on stream flow 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 stream flow is accumulated, and the instream flow requirement is deactivated upon reaching the limit $ADL(wr)$. The dual simulation options of *SO* field 14 or the *PX* record allow stream flow depletions determined during an initial simulation to serve as limits on depletions during a subsequent simulation. *LO* and *ML* records also create stream flow depletion limits as discussed later.

SO Record – Supplemental Water Right Options

field	columns	variable	format	value	description
1	1-2	CD	A2	SO	Record identifier
<u>Option for Limiting Water Availability</u>					
2	3-8	WSHED (wr)	F6.0	+ blank	Drainage area ratio or other naturalized flow multiplier. Watershed flow limit option not used.
<u>Stream Flow Depletion Limits</u>					
3	9-16	MONDEP (wr)	F8.0	+ blank,0	Monthly maximum limit on stream flow depletions. Either there is no monthly limit on stream flow depletions or limits are entered on a <i>ML</i> record.
4	17-24	ANNDEP (wr)	F8.0	+ blank,0	Annual or seasonal limit on stream flow depletions. No annual/seasonal limit on stream flow depletions.
<u>Alternate Control Point for Stream flow Depletions</u>					
5	27-32	ACPID	2x,A6	AN blank,0	Identifier of alternative control point for stream flow. Control point specified in field 2 of <i>WR/IF</i> record.
<u>Backup Water Right</u>					
6	35-40	BACKUP	2x,A6	BACKUP BFIRST RETURN blank	Shortages for another specified right are added to the target at the end of target building process. Shortages for another specified right are added to the target at the beginning of target building process. Diversion shortages for another right multiplied by RFAC (default=1.0) to be subtracted from target for type 4 right. Used only for type 4 right. Feature is not used, or <i>BU</i> record version is used.
<u>Reservoir Withdrawal Limits</u>					
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.

SO Record – Supplemental Water Right Options (Continued)

field	columns	variable	format	value	description
<u>Targets and Shortages Written to Output File</u>					
9	64	ISHT(wr)	I8	blank,0,13 1 2 3 4 5 6 7 8 9 10 11 12	Last target and shortage computed is in output file. After step 1 of the target building process described on pages 69-70. After applying <i>BFIRST</i> backup option (after step 2). After applying drought index (after step 3). After applying options on <i>TO</i> record (after step 4). After <i>TS</i> records (after step 5). After applying drought index (after step 6). After applying options on <i>TO</i> record (after step 7). After applying options on <i>CV</i> or <i>FS</i> record (step 8). After applying options on <i>CV</i> or <i>FS</i> record (step 9). After applying backup right (after step 10). After applying limits from <i>SO</i> fields 7 & 8 (step 11). After applying <i>ADL</i> from <i>SO</i> field 10 (after step 12).
<u>Diversion or Instream Flow Limits</u>					
10	65-72	ADL(wr)	F8.0	+ +	Annual or seasonal diversion limit for <i>WR</i> record. Annual or seasonal regulated flow limit for <i>IF</i> record.
<u>ANNDEP(wr), ARW(wr), ADL(wr) Seasons</u>					
11	79-80	LM(wr,1)	I8	blank,0,1 1-12 -1 to -9	Season begins in the first month of the year. Month of year defining beginning of single season. Cyclic season with length defined by <i>LM(wr,2)</i> .
12	87-88	LM(wr,2)	I8	blank,0,12 1-12	Season ends in the last (12th) month of the year. Month of year defining ending of single season. Length of season if <i>LM(wr,1)</i> is negative.
<u>Options to Not Apply Features for this Right</u>					
13	89-96	NOTFLAG	A6	IFNOTA NONSFD NEGSFD NORFCL NOCLWR	Instream flow <i>IF</i> rights do not restrict this <i>WR</i> right. Negative stream flow depletions are set to zero. Negative stream flow depletions are not set to zero. Channel losses are not applied to return flows. Channel losses are not applied to stream flow depletions and return flows for this water right.
<u>Dual Simulation (Same as PX Record Field 2)</u>					
14	97-104	DUAL(wr)	I8	PX Record field 2	The dual simulation feature is activated the same by either <i>PX</i> record field 2 or <i>SO</i> 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 stream flow available to the right is limited to the lesser of: (1) the naturalized stream flow at the control point of the right multiplied by the factor in field 2

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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 stream flow that may be taken by the right. This option typically involves 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 stream flow depletions at a control point other than the location indicated in *WR* record field 2. This option is applicable for a reservoir with inflows at the control point specified in *WR* record field 2 that also receives water through pipelines or canals from one or more other river/reservoir system locations.

Field 6: An expanded version of the backup feature is activated by the *BU* record. The *RETURN* option has been replaced with *PX* record *XP* option 1. Though made basically obsolete by the *BU* and *PX* records, *SO* record field 6 can still be used.

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: Targets are established in a series of optional steps activated by *SO*, *BU*, *DI*, *TO*, *FS*, 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. *ISHT(wr)* in *SO* record 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 one 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 or 3 in *SO* record field 9 specifies use of the target after applying a backup right (step 2) or drought index (step 3) and so forth. If the steps 2 through 12 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.

ISHT(wr) in *SO* field 9 governs the choice of which monthly targets and shortages are written to the *SIM* output file. The simulation computations are not affected in any way except for the back-up feature activated by a *BU* record or *SO* record field 6. The shortage of the other rights added to the target of the back-up right is the shortage specified by *ISHT(wr)*.

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 stream flow 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 target specified by an *IF* 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 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 stream flow 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. Integers 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: The parameter NOTFLAG switches off various modeling features for this particular water right. Field 13 is designed to be used for experimentation or in special circumstances.

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

NONSFD and *NEGSFD* deal with negative stream flow depletions. A negative net evaporation-precipitation depth from an *EV* record representing precipitation on a reservoir water surface exceeding evaporation combined with a reservoir filled to capacity may generate additional flow represented as a negative stream flow depletion. *NONSFD* results in negative stream flow depletions being changed to zero. With multiple refilling rights at the same reservoir, *SIM* normally limits negative stream flow depletions to the most junior right at the reservoir. *NEGSFD* allows multiple rights at the same reservoir to generate negative flow depletions.

NOCLWR and *NORFCL* affect only subroutine *AVALB* where downstream flows are adjusted for the effects of flows leaving or entering the stream at an upstream control point. *NOCLWR* results in channel losses not being applied to the stream flow depletions associated with this water right. *NORFCL* results in channel losses not being applied to return flows. *NORFCL* should be applied only with the same-month return flow options because the December return flow losses are not switched-off correctly for the next-month return flow options.

TO Record – Target Options

field	columns	variable	format	value	description
1	1-2	CD	A2	TO	Record identifier
					<u>Stream Flow at Control Point from Field 7</u>
2	7-8	TOTARGET (n)	I6	1	Target based on same-month naturalized stream flow.
				-1	Target based on prior-month naturalized stream flow.
				2, 22	Target based on same-month regulated stream flows.
				-2, -22	Target based on prior-month regulated stream flows.
				3	Unappropriated stream flows same month.
				-3	Unappropriated stream flows previous month.
					<u>Reservoir Specified in Field 8</u>
				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.
					<u>Water Right Specified in Field 9</u>
				6	Target based on stream flow depletion for month.
				7	Target based on seasonal/annual depletion to date.
				-7	Cumulative flow depletion excludes current month.
				8	Based on withdrawal from storage for month.
				9	Based on seasonal withdrawal from storage to date.
				-9	Cumulative withdrawal excludes current month.
				11	Target based on diversion for month.
				12	Target based on cumulative diversion to date.
				-12	Cumulative diversion excludes current month.
				13	Instream flow or diversion target.
				14	Instream flow shortage (target less flow if positive).
					<u>Other Options</u>
				10	Fields 5&6 limits applied as step 7 on page 70.
				15	Target is equal to the factor in the following field 3.
				16	Index on <i>HI</i> records in HIS file.
					<u>Multiplier Factor</u>
3	9-16	FACT(n)	F8.0	+ or -	Factor multiplied by field 2 amount (default=1.0)
					<u>Apply Limit or Combine with Intermediate Target</u>
4	17-24	TOCOMB (n)	5x,A3	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	<i>AMT</i> from <i>WR/IF</i> field 3 and <i>UC/DI</i> records applied if target falls within limits of <i>TO</i> fields 5 and 6
					<u>Lower and Upper Limits</u>
5	25-32	TOLIM(n,1)	F8.0	+	Lower limit on either target or quantity setting target.
				-1	Limit set at inflow to control point in field 7.
6	33-40	TOLIM(n,2)	F8.0	+	Upper limit on either target or quantity setting target.
				-1	Limit set at inflow at control point in field 7.

TO Record – Target Options (Continued)

field	columns	variable	format	value	description
					<u>Control Point, Reservoir, or Water Right Identifier</u>
7	43-48	TOFLOW	2x,A6	blank AN	Control point from <i>WR</i> record field 2 used for target. Control point of stream flow used to set target.
8	51-56	TORES(n)	2x,A6	AN	Identifier of reservoir used to set target (<i>TO</i> field 2).
9	57-72	TOWR(n)	A16	AN	Identifier of water right used to set target (<i>TO</i> field 2)
					<u>Continue with Another TO Record</u>
10	73-80	TOCONT	A8	blank CONT	Continuation option is not used. Following <i>TO</i> record continues building target.

One or more *TO* records may be included in the set of supporting records that follow a *WR* or *IF* record. *TO* record target setting options are components of the step-by-step procedure for setting targets for diversions, instream flows, hydroelectric power production, or storage that is outlined on pages 67-71. The *LO* record is identical to the *TO* record but creates a stream flow depletion limit instead of a target. *TO* records also can be used by *FS* records to create a flow switch.

Explanation of TO Record Fields

Field 2: *TOTARGET* specifies whether the target is based on naturalized, regulated, or unappropriated flow at the control point specified in field 7, or storage or drawdown in the reservoir specified in field 8, or variables associated with the water right specified in field 9. Options 2 and -2 refer to total regulated flows and options 22 and -22 to regulated flows excluding reservoir releases. Any of these variables may be multiplied by *FACT*(*n*) from field 3.

A positive 1, 2, 3, 4, or 5 for *TOTARGET* flags use of stream flow or storage amounts in the current month at that stage in the water rights priority-based computation loop. The regulated or unappropriated (available) flow 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.

With *TOTARGET* of 6, 7, 8, 9, 11, 12, or 13, the target is based on another right's total stream flow depletion (6,7), withdrawal from reservoir storage (8,9), diversion (11,12), or target (13), which may be either monthly amounts (6,8,11,13) or cumulative amounts since the beginning of the year (7,9,12). These are the latest amounts computed in the water right computation sequence for the right identified as *TOWR* in field 9. The monthly amounts are volumes in the current month for rights that are senior to the *WR* or *IF* record right supplemented by the *TO* record and preceding-month amounts for junior rights, with the following exception. Junior rights are affected by second pass options activated by *JO* record field 9 and *IF* record field 6. For a junior *TOWR* right, the stream flow depletion, reservoir withdrawal, or diversion from the preceding month is used for the first pass. The current-month amount from the first pass is used for the second pass. For a senior *TOWR* right, amounts computed in the current-month are always used.

Option 14 uses an instream flow shortage computed as the target (same as 13) less the flow at the *TOWR* control point at the priority of the *WR* or *IF* record to which the *TO* record is connected.

Options 7, -7, 9, -9, 12, -12 are based on an annual season defined by *SO* record fields 11 and 12, with the default being the entire year from month 1 through month 12. A *TOTARGET* of -7,

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−9, or −12 in *TO* record field 2 is the same as entries of 7, 9, or 12, except the current month is not included in the accumulative sum of depletions, withdrawals, or diversions. For options −7, −9, or −12, the current month is not included in the cumulative annual total to date. For options 7, 9, or 12, the current month is included in the cumulative total. The monthly amounts are volumes for either the current or preceding month as described in the preceding paragraph.

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. With option 15 in field 2, the target is set at the number entered in field 3 ($\text{target} = 1.0 * \text{FACT}(n)$).

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 ($\text{TOCOMB} = \text{SET}$). 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 second ($\text{TOCOMB} = \text{ADD}, \text{SUB}, \text{MUL}, \text{DIV}$). Negative results possible with subtraction are set equal to zero.
- Optionally, either the minimum or maximum adopted ($\text{TOCOMB} = \text{MAX}, \text{MIN}$).
- Optionally, ($\text{TOCOM} = \text{LIM}$), 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 limits may be applied in three different alternative ways described on page 71 either within step 4 (two alternatives) or as step 7 outlined on pages 69-70.

The lower and upper limits on the target may be entered directly as numbers in fields 5 and 6. Alternatively, a −1 in either field 5 or 6 sets the target limit at the inflow to the control point in *TO* record field 7 in the current month exclusion of releases from secondary reservoirs located upstream of the control point for water rights located at or downstream of the control point. This inflow is the regulated flow less secondary reservoir releases plus the stream flow depletions at the control point at that point in the water right priority sequence computations.

Field 7: For *TOTARGET* (field 2) of 1, −1, 2, −2, 3, −3, the control point location of the stream flow 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 stream flow 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 drawdown is adopted for setting the diversion or instream flow target is entered in field 8. A primary application for this option is to allow a diversion and return flow to refill a reservoir.

Field 9: For *TOTARGET* (field 2) of 6, 7, 8, 9, 11, 12, −12, 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.

LO Record – Stream Flow Depletion Limit Options

The *LO* record is identical in format to the *TO* record but creates a maximum stream flow depletion limit rather than a diversion, instream flow, hydropower, or storage target. The instructions for *TO* records on the preceding three pages can also be used for the *LO* record by simply changing the term “*target*” to “*stream flow depletion limit*.”

In WRAP terminology, a stream flow depletion is the flow appropriated by a water right to supply a diversion target and/or refill reservoir storage. A stream flow depletion limit is equivalent to placing a maximum limit on the amount of flow available for supplying a *WR* record water right diversion and/or storage refilling. Stream flow depletion limits are specified by *MONDEP* and *ANNDEP* in *SO* record fields 3 and 4 and *MSD* on a *ML* record as well as *LO* records. Stream flow depletion limits may also be specified on *TS* records. If multiple limits are specified for the same water right, the most constraining (smallest quantity) controls. A stream flow depletion does not affect the setting of a target, but rather limits the amount of stream flow available for both supplying the diversion or hydropower target and refilling reservoir storage.

Whereas *TO* records along with *UC*, *TS*, *DI*, *CV*, *FS*, and *BU* records, are a component of the 12-step target building process described on pages 68-70, *LO* records are not. *LO* records start with a quantity of zero and develop a maximum stream flow depletion limit using only the options provided by *LO* records. Any number of *LO* records may be used in combination. All *LO* records for a particular water right are grouped together. Likewise, *TO* records are grouped together. Sequencing of *SO*, *ML*, *BU*, *TO*, *LO*, *CV*, *FS*, *TS*, *PX*, *WS*, *HP*, and *OR* records is described on page 67.

ML Record – Monthly-Varying Limits on Stream Flow Depletions

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

Stream flow depletions for refilling reservoir storage and supplying 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 be entered as variable *MONDEP* in field 3 of the *SO* record. Limits may be computed as a function of various factors with *LO* records.

HI Record – Hydrologic Index in HIS File Referenced by *TO*, *LO*, *CV*, and *FS* Records

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 <i>HI</i> record repeated for multiple years
				blank,0	<i>HI</i> 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	HIS(cp,yr,1)	F8.0	+	Quantity for Month 1
6	25-32	HIS(cp,yr,2)	F8.0	+	Quantity for Month 2
7	33-40	HIS(cp,yr,3)	F8.0	+	Quantity for Month 3
8	41-48	HIS(cp,yr,4)	F8.0	+	Quantity for Month 4
9	49-56	HIS(cp,yr,5)	F8.0	+	Quantity for Month 5
10	57-64	HIS(cp,yr,6)	F8.0	+	Quantity for Month 6
11	65-72	HIS(cp,yr,7)	F8.0	+	Quantity for Month 7
12	73-80	HIS(cp,yr,8)	F8.0	+	Quantity for Month 8
13	81-88	HIS(cp,yr,9)	F8.0	+	Quantity for Month 9
14	89-96	HIS(cp,yr,10)	F8.0	+	Quantity for Month 10
15	97-104	HIS(cp,yr,11)	F8.0	+	Quantity for Month 11
16	105-112	HIS(cp,yr,12)	F8.0	+	Quantity for Month 12

The *HI* record is motivated by the use of the Palmer hydrologic drought index in setting environmental instream flow requirements. However, the quantities in the array HIS(identifier, year, month) entered on *HI* records can be time series of any index of interest. These are indices referenced by *TO*, *LO*, *CV*, and/or *FS* records. Control point identifiers entered on *TO*, *LO*, *CV*, and *FS* records connect to the control point identifier in *HI* record field 2. *HI* record sequences can be provided for any number of control points. All *HI* records for a *SIM* input dataset are contained in a single HIS file.

An *HI* record index series can be referenced by *TOTARGET* option 16 in *TO* record field 2 with the control point identifier specified by *TOFLOW* in *TO* record field 7. The *LO* record is the same as the *TO* record and references *HI* records in the same manner.

An *HI* record index can also be adopted as the variable referenced as *CVV* or *FSV* option 12 in *CV* or *FS* record field 3. The control point identifier is specified in *CV/FS* record field 4.

HI records in a hydrologic index series HIS file have the same record format and similar file organization as *IN* records in a FLO file and *EV* records in a EVA file. However, the rules for grouping *HI* records in the HIS are a little more flexible than FLO and EVA files. The *HI* records will typically be grouped by control point, with the *HI* records for a particular control placed together in chronology order by year. However, the *HI* records can be placed in essentially any order. If the *HI* records do not cover all of the years of the hydrologic period-of-analysis, a warning message is written in the message MSS file, and zeros are assigned in the array HIS(identifier, year, month) for the missing years.

FS and CV Records – Flow Switch (FS) and Cumulative Volume (CV) Records

CV and *FS* records are described on the following pages 82-86. *FS* and *CV* records allow a multiple-period past history of flows or other quantities to be incorporated in target setting rules. *CV* and *FS* records use a cumulative volume of a selected variable in developing *IF* record instream flow targets, *WR* record diversion, hydropower, or storage targets, *LO* record depletion limits, or *OR* record release limits. The cumulative volume variable (*CVV*) selected in *CV* field 3 and flow switch variable (*FSV*) selected in *FS* field 3 are defined identically the same and their volumes are summed over time periods in identically the same manner. However, the *CVV* and *FSV* are applied differently in the target setting computations.

A flow switch *FS* record and/or cumulative *CV* record can be applied along with other target setting options in setting instream flow, diversion, and hydropower targets. *FS* and *CV* records can also be used with type 7 rights (*WR* field 6) and release capacities (*OR* fields 9 & 10) in defining reservoir operating rules or with *LO* records.

Any number of *FS* and *CV* records can be provided for any of the water rights in a DAT file. Any number of water rights can apply the same *FS* or *CV* record. Options for connecting *CV* and *FS* records to *IF* and *WR* records are outlined on page 68.

Common FS and CV Record Fields

Fields 2, 3, and 4 are the same on the *FS* and *CV* records and are described below. The optional field 2 integer identifier are defined the same. The flow switch *FSV* or cumulative volume *CVV* variable is specified in the same manner in fields 3 and 4 of the *CV* and *FS* records.

The methodology for defining the time interval and computing the *CVV* or *FSV* cumulative volume and count are also identical with the *CV* and *FS* records. Fields 11, 12, 13, 14, and 17 of the *CV* record are the same as fields 12, 13, 14, 15, and 18 of the *FS* record. These variables are described with the *FS* record but are also applicable to the *CV* record.

Field 2: Field 2 is identical for *CV* and *FS* records. Both *FS* and *CV* records are included together in the same sequential numbering with no differentiation between *CV* versus *FS* records. *SIM* automatically numbers *CV* and *FS* records in the sequential order (1, 2, 3, ...) in which they are found in the DAT file. The sequential numbering provides integer identifiers for the records. *WR* record field 10, *IF* record field 9, and *OR* record field 10 reference these numbers. The optional *FS/CV* field 2 can be left blank. The only purpose of *FS/CV* record field 2 is to allow model users to conveniently identify different *FS* and/or *CV* records included in the DAT file. *SIM* performs an error check to assure that field 2 is either blank or contains the correct integer representing the sequential numbering.

Fields 3 and 4: Fields 3 and 4 are also identical for *CV* and *FS* records. *FS* record field 17 is the same as *CV* record field 16. The flow switch is based on the variable ($FSI(FS, I) = CVV$ or FSV) selected in field 3 at the control point in field 4 or for the water right in *CV* record field 16 or *FS* record field 17. All of the simulation time series including each of the variables that can be adopted as the *CVV* or *FSV* variable in field 3 is defined in Chapter 5 of the *Reference Manual*. *CVV/FSV* option 12 refers to the *HI* record hydrologic index described on the preceding page 80.

CV Record – Target or Limit Developed Based on Cumulative Volume

field	columns	variable	format	value	description
1	1-2	CD	A2	CV	Record identifier
2	3-5	N	I3	+	Optional CV and FS record sequential count identifier
<u>Variable for Cumulative Volume</u>					
3	8	CVV = FSI(FS,1)	I3	blank,0,1 -1 2 3 4 5 6 7 8 9 10 11 12	Regulated flow at control point (field 4). Regulated flow excluding reservoir releases (field 4). Naturalized flow at control point (field 4). Unappropriated or available flow at control point. Stream flow depletion at control point (field 4). Diversion at control point (field 4). Inflow to control point excluding upstream releases. Stream flow depletion for water right (field 16). Total diversion for water right (field 16). Diversion from reservoir storage for right (field 16). Target for water right (field 16). Instream flow shortage for IF record right (field 16). Index provided on HI records in HIS file (field 4).
4	9-16	CVCP	2x,A6	AN	Control point identifier of CVV variable location.
<u>Multiplication and Addition Factors</u>					
5	17-24	FSX(FS,1)	F8.0	+	Factor by which CVV is multiplied. Default = 1.0
6	25-32	FSX(FS,2)	F8.0	+	Factor added to CVV. Default = 0.0
<u>Lower and Upper CVV Bounds</u>					
7	33-40	FSX(FS,3)	F8.0	+	Lower bound. Default = 0.0
8	41-48	FSX(FS,4)	F8.0	+	Upper bound. Default = 9,000,000,000.0
9	49-52	FSI(FS,2)	I4	blank,0,1 2 3 4	X is not dependent on bounds at this stage. X is set at bounds if bounds are exceeded. X is set at zero if bounds are exceeded. X is set at zero if VXT-1/VXT-2 ratio exceeds bounds.
<u>Combining with Preceding Target</u>					
10	53-56	FSI(FS,3)	I4	blank,0,1 2 3 4 5 6	Start with zero. Preceding target is not considered. CV record X is added to the preceding target. Smallest of the two quantities is adopted. Largest of the two quantities is adopted. X is adopted if X exceeds bounds of fields 7 and 8. 0.0 if X exceeds bounds. Otherwise, preceding target.
<u>Parameters Defining Summation Period</u>					
11	57-60	FSI(FS,5)	I4	+	Number of time steps not counting the current period.
12	61-64	FSI(FS,6)	I4	blank,0 +	Beginning month (1, 2, ... , 12) for annual cycle. Default is continuous without an annual cycle.
13	65-68	FSI(FS,7)	I4	blank,0 +	Ending month for annual cycle summation period. Default is eleven months after the beginning month.
14	69-72	FSI(FS,8)	I4	blank,0,1 2 3	Second pass or latest regulated flow in current period. Latest regulated flow in current period in summation. Current period is not included in flow summation.

<u>Other Input Variables</u>					
15	73-76	FSI(FS,9)	I4	+	Computations are recorded in the message MSS file.
16	77-92	FSWR(FS)	A16	AN	Water right identifier for CVV options 7, 8, 9, 10, 11.
17	93-96	FSI(FS,14)	I4	+	Month for setting CVV volume and count to zero.

Explanation of CV Record Fields

Field 2: Field 2 is described on page 81. Both *FS* and *CV* records are included together in the same sequential numbering with no differentiation between *CV* versus *FS* records.

Fields 3, 4, and 16: The target is based on the variable *CVV* selected in field 3 at the control point in field 4 or for the water right in field 16. Fields 4 and 16 default to the control point and water right from the *IF/WR* record. These fields are described on page 81.

Fields 11, 12, 13, 14, and 17: Fields 11, 12, 13, 14, and 17 of the *CV* record are the same as fields 12, 13, 14, 15, and 18 of the *FS* record. The methodology for defining the time interval and computing the *CVV* or *FSV* cumulative volume are identical with the *CV* and *FS* records and are described along with the *FS* record.

Field 15: Option to write results in the message file is activated by *CV* field 15 or *FS* field 16.

Fields 5, 6, 7, 8, 9, and 10: These are the *CV* record fields that are different than the *FS* record. These fields control the converting of the cumulative *CVV* variable quantity *CVX* to the quantity *X* representing a *IF* record instream flow target, *WR* record diversion, hydropower, or storage target, *LO* record stream flow depletion limit, or *OR* record reservoir release limit, or (in combination with other records) an intermediate component in the development thereof.

Fields 5 and 6: The multiplication [*FSX*(*FS*,1)] and addition [*FSX*(*FS*,2)] factors are applied as

$$X = (CVX) [FSX(FS,1)] + [FSX(FS,2)]$$

Fields 7, 8, and 9: With *FSI*(*FS*,2) option 2, the bounds *FSX*(*FS*,3) and *FSX*(*FS*,4) are applied as follows.

If [*X* < *FSX*(*FS*,3)] then *X* is changed to *FSX*(*FS*,3)
 If [*X* > *FSX*(*FS*,4)] then *X* is changed to *FSX*(*FS*,4)

For *CV* record field 9 *FSI*(*FS*,2) option 3, the lower and upper bounds are applied as follows.

If [*X* < *FSX*(*FS*,3)] then *X* is changed to zero
 If [*X* > *FSX*(*FS*,4)] then *X* is changed to zero

FSI(*FS*,2) option 3 uses the ratio $R = VX_{T-1} / VX_{T-2}$ where *T-1* and *T-2* are the preceding day and its preceding day. *X* is changed to zero if this ratio exceeds the bounds *FSX*(*FS*,3) and *FSX*(*FS*,4).

Field 10: A target may be developed prior to the *CV* record by *IF*, *WR*, *UC*, *TO*, *TS*, *DI/IS/IP*, *FS*, *BU*, and/or other *CV* records. *CV* field 10 provides options for combining a preceding target with the *X* computed with this *CV* record. With option 1, the *X* computed by the *CV* record is its final product, with no use of a preceding target. Option 2 adds *X* to the preceding target. Options 3, 4, and 5 adopt either *X* or the preceding target. With options 5 and 6, the preceding target is adopted if *X* is within the fields 7 and 8 bounds, but otherwise *X* or zero is adopted.

FS Record – Flow Switch for Adjusting Targets or Limits Based on Accumulated Volume

field	columns	Variable	format	value	description
1	1-2	CD	A2	FS	Record identifier
2	3-5	N	I3	+	Optional <i>FS</i> and <i>CV</i> record sequential count identifier
<u>Cumulative Flow Variable Defining Switch</u>					
3	8	FSV = FSI(FS,1)	I3	blank,0,1 -1 2 3 4 5 6 7 8 9 10 11 12	Regulated flow at control point (field 4). Regulated flow excluding reservoir releases (field 4). Naturalized flow at control point (field 4). Unappropriated or available flow at control point. Stream flow depletion at control point (field 4). Diversion at control point (field 4). Inflow to control point excluding upstream releases. Stream flow depletion for water right (field 17). Total diversion for water right (field 17). Diversion from reservoir storage for right (field 17). Target for water right (field 17). Instream flow shortage for <i>IF</i> record right (field 17). Index provided on <i>HI</i> records in HIS file (field 4).
4	9-16	FSCP	2x,A6	AN Blank	Control point identifier of switch variable location. Control point from <i>IF/WR</i> record is the default.
<u>Target Multiplier Factors</u>					
5	17-24	FSX(FS,1)	F8.0	+	Factor applied if flow is within bounds. Default = 0.0
6	25-32	FSX(FS,2)	F8.0	+	Factor if flow is not within bounds. Default = 0.0
<u>Lower and Upper Volume Bounds for FSI(FS,2) Options 1 and 2 or Multiplier Factors for FSI(FS,2) Option 3</u>					
7	33-40	FSX(FS,3)	F8.0	+	Lower bound. Default = 0.0
8	41-48	FSX(FS,4)	F8.0	+	Upper bound. Default = 9,000,000,000.0
<u>Options for Applying the Flow Volume Bounds</u>					
9	49-52	FSI(FS,2)	I4	blank,0 1 2 3	The flow bounds are not applied to target or release. Cumulative total volume applied to setting target. Count of number of periods applied to setting target. Increasing versus decreasing FSV Volume
<u>Lower and Upper Count Bounds</u>					
10	53-56	FSI(FS,3)	I4	+	Lower bound on number of periods. Default = 0
11	57-60	FSI(FS,4)	I4	+	Upper bound. Default = 9,000,000 periods
<u>Parameters Defining Flow Summation Period</u>					
12	61-64	FSI(FS,5)	I4	+	Number of time steps not counting the current period.
13	65-68	FSI(FS,6)	I4	+	Beginning month (1, 2, ... , 12) for annual cycle.
				blank,0	Default is continuous without an annual cycle.
14	69-72	FSI(FS,7)	I4	+	Ending month for annual cycle summation period.
				blank,0	Default is eleven months after the beginning month.
15	73-76	FSI(FS,8)	I4	blank,0,1,2 3	Current period is included in FSV summation. Current period is not included in FSV summation.
<u>Other Input Variables</u>					
16	77-80	FSI(FS,9)	I4	+	Record flow switch results in message MSS file.

FS Record – Flow Switch (Continued)

field	columns	Variable	format	value	description
17	81-96	FSWR(FS)	A16	AN	Water right identifier for FSV options 7, 8, 9, 10, 11.
18	97-100	FSI(FS,14)	I4	+ blank, 0	Month for setting FSV volume and count to zero. Feature is not activated.

Explanation of FS Record Fields

Field 2: Field 2 is described on page 81. Both *FS* and *CV* records are included together in the same sequential numbering with no differentiation between *CV* versus *FS* records.

Fields 3, 4, and 17: The flow switch is based on the variable *FSV* selected in field 3 at the control point in field 4, *HI* record identifier in field 4, or for the water right in field 17. These fields are explained on page 81.

Fields 5 and 6: A water right target is initially computed based on a *WR* or *IF* record and other auxiliary records. The target is then multiplied by the *FSX* factor from either field 5 or 6 depending on whether or not the selected flow switch criterion is met. A *FS* switch record can also be applied similarly with the reservoir release capacity provided in *OR* record field 9. Multiplier factors of 0.0 and 1.0 act as a switch that turns the target completely off or on. However, any values of *FSX(FS,1)* and *FSX(FS,2)* may be used to adjust the target.

Fields 7 and 8: For *FSI(FS,2)* option 3 in *FS* field 9, multiplier factors *FSX(FS,3)* and *FSX(FS,4)* are entered in *FS* fields 7 and 8. Otherwise, lower and upper bounds *FSX(FS,3)* and *FSX(FS,4)* entered in fields 7 and 8 define a criterion range for the *FSV* flow volume. The default range of zero to an arbitrarily large volume means the *FSV* limits are always met.

Fields 9, 10, 11: A default (blank) field 9 sums volumes and performs counts for display with *TABLES 2FSV* and *2FSC* records but does not apply a flow switch to setting targets or limits. *FSI(FS,2)* options 1, 2, and 3 are alternative criteria for setting targets or limits.

FSI(FS,2) option 1 in field 9 is based on the total flow volume accumulated during the current and preceding time periods defined by *FS* fields 11–15. The cumulative volume summation for the field 3 *FSV* switch variable will fall either in or out of the range defined by the lower and upper bounds specified in fields 7 and 8. *FSX(FS,1)* is applied if:

$$FSX(FS,3) \text{ in field 7} \leq \text{accumulative volume of } FSV \leq FSX(FS,4) \text{ in field 8}$$

With *FSI(FS,2)* option 2, the number of periods during which the *FSV* volume falls within the range defined by *FSX(FS,3)* and *FSX(FS,4)* is counted. *FSX(FS,1)* is applied if:

$$FSI(FS,2) \text{ in field 10} \leq \text{count} \leq FSI(FS,3) \text{ in field 11}$$

With *FSI(FS,2)* option 3, the multiplier *FSX(FS,1)* is applied if:

$$(FSX(FS,3))(\text{preceding } FSV \text{ volume}) \leq (FSX(FS,4))(\text{current period } FSV \text{ volume})$$

Fields 12, 13, 14, 15: A length of time and scheme for computing the total accumulated volume or counting flows are specified in fields 12–15. The number of time intervals is defined by a combination of maximum length (number of periods) and season of the year (defined by

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beginning and ending months). The time period over which *FSV* volumes are summed may include the current time step and/or any number *FSI(FS,5)* of preceding time steps. *FSI(FS,7)* indicates whether or not and how the current time step is included in the volume summation. If *FSI(FS,5)* is zero, only the current time step is considered. The summation period *FSI(FS,5)* entered in field 12 may be any number of months in *SIM* or any number of days or other sub-monthly time intervals in *SIMD*. Optionally, a season of the year may be defined by specifying starting *FSI(FS,6)* and ending *FSI(FS,7)* months in *FS* fields 13 and 14. Only periods falling in the months *FSI(FS,6)* through *FSI(FS,7)* are included in the flow summation and/or flow count.

In setting a water right target or reservoir release capacity in a particular time step of the simulation, the *FSV* variable flow volume activating the target adjustment switch is the sum of the volumes in the current period and/or preceding *FSI(FS,5)* periods subject to the optional limitation of including only amounts that occur in months *FSI(FS,6)* through *FSI(FS,7)*.

Field 12: *FSI(FS,5)* is the number of time periods over which flows are added or counted, not counting the current time step. *FSI(FS,5)* may be any integer number. In *SIM*, *FSI(FS,5)* is a number of months. In *SIMD*, *FSI(FS,5)* is in units of days or other sub-monthly time steps. The *FSI(FS,4)* time steps immediately precede the current time step. For the first *FSI(FS,5)* plus one time steps of the simulation, the flow accumulation period is defined as usual with the additional limit of not extending back past the beginning of the simulation.

Fields 13 and 14: Specification of beginning and ending months allows a season to be defined that repeats in an annual cycle. Of the current and preceding *FSI(FS,5)* time periods, only those periods that fall in months between and including the beginning and ending months *FSI(FS,5)* and *FSI(FS,6)* are included in the flow volume summation. *FSI(FS,5)* and *FSI(FS,8)* define the sequence of time periods reflected in the flow summation, with the exception that any periods falling outside the season from *FSI(FS,6)* through *FSI(FS,7)* are omitted. Time steps after month *FSI(FS,7)* and before *FSI(FS,6)* are omitted from the flow summation. For example, with months 6 and 8 entered in fields 13 and 14, flow volumes during all months except June, July, and August (months 6, 7, 8) are omitted from the summation. With months 10 and 2 entered in fields 13 and 14, respectively, regulated flows in months 10, 11, 12, 1, and 2 (October through February) are eligible for inclusion in the moving cumulative flow volume summation for the flow switch variable *FSV* defined in field 3.

Field 15: With *FSI(FS,8)* option 3, the *FSV* volume in the current period is not included in the summation. Options 1 and 2 include the *FSV* volume in the current period in the summation. Option 2 is identical to option 1 unless both: (1) regulated flow is the *FSV* and (2) *PASS2* in *JO* record field 10 or *IFMETH* in *IF* field 7 results in a second pass through the water rights loop. With the default option 1, during a second pass through the water rights loop, the regulated flow at the end of the first pass is adopted in the cumulative summation. With option 2, regulated flow is treated just like other *FSV* variables with the latest value computed in the priority sequence, reflecting the effects of only senior rights, being adopted for the current period.

Field 16: The flow switch computations can be tracked by listing quantities in the message file.

Field 18: A non-zero field 18 activates this additional optional feature. The *FSV* cumulative volume and count of occurrences are set to zero at the beginning of the month specified as *FSI(FS,14)*. A *FSI(FS,14)* of 1 meaning January limits the criteria upon which the flow switch or other *FS/CV* record decisions are based to consideration of only flows occurring within the calendar year. *FSI(FS,14)* may be 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12.

BU Record – Backup Right

field	columns	variable	format	value	description
1	1-2	CD	A2	BU	Record identifier
2	3-8	BU	I6	blank,0,1,2 9	Back-up is applied as step 2 described on page 69. Back-up is applied as step 10 described on page 70.
3	9-16	BUX(n)	F8.0	+ blank,0	Factor by which the shortage is multiplied. Default = 1.0
4	17-32	BUWRID	A16	AN blank	Identifier of water right being backed up. Default is next preceding right record in the DAT file if both fields 4 and 5 are blank.
5	33-40	BUG(n)	A8	AN	Group of water rights being backed up.

The water right identified on the *WR* or *IF* record provides a supplemental backup for the diversion, instream flow, or hydropower requirement of one or more other *WR* or *IF* record rights identified in *BU* record fields 4 and 5. Shortages incurred by the other rights are added to the target of this back-up right in the water rights priority loop. If the other right is senior to the backup right, its shortage is added to the target of the backup right in the current month. If the other right is junior, its shortage is added to the target of the backup right in the next month. Back-up rights can back-up other back-up rights in sequences of any number of back-up rights.

If the *PX* record field 4 XCP control point limit option is activated for the right being backed up, the increase in stream flow depletion resulting from activating the XCP option, rather than shortage, is added to the target of the backup right.

Explanation of BU Record Fields

Field 2: Shortages may be added to the target of the back-up right at either of two alternative steps in the target building process outlined on pages 69-70. The shortages may be added to the target as either the default step 2 or as step 9.

Field 3: The shortages are multiplied by the factor *BUX* entered in field 3 prior to adding the product to the target of the back-up right. Shortages may be divided between multiple back-up rights by applying fractional multiplier factors for the individual back-up rights that sum to 1.0.

Fields 4 and 5: The water right identifier *BUWRID* in *BU* record field 4 connects to *WRID* in *WR* record field 11 or *IF* record field 10 of a single other right being backed up. The water right group *BUG* in field 5 corresponds to *WRIDS* in *WR* record fields 12 and 13 and allows any number of rights to be backed up by this backup right. Unique water right identifiers are assigned on *WR* or *IF* records to each individual right, but any number of *WR* records can share the same group identifier. The shortages incurred by all rights with water right identifier *BUWRID* and/or water right group identifier *BUG* are added to the target of the backup right. If *BU* record fields 4 and 5 are both blank, the default is for the single other right being backed up to be the *WR* or *IF* record right found immediately preceding the *WR* or *IF* record of the backup right in the DAT input file.

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TS Record – Target Series

field	columns	variable	format	value	description
1	1-2	CD	A2	TS	Identifier required for first year, optional thereafter.
<u>Manner of Applying TS Amounts</u>					
2	3-8	TSL (first record)	3X,A3	blank MAX, max MIN, min ADD, add SUB, sub MUL, mul SDL, sdl	TS record amounts are the only targets used. Maximum of two alternative targets is adopted. Minimum of two alternative targets is adopted. TS record amount is added to preceding target. TS record amount is subtracted from preceding target. (A negative result will be set equal to zero.) TS record amount is multiplied by preceding target. Upper limit on allowable stream flow depletions. TSL is read with just the first year. This field is not read after first record.
<u>Years Covered</u>					
3	9-12	TSYR1	I4	-	Beginning year (optional)
4	13-16	TSYR2	I4	+	Ending year (required)
<u>Amounts of Targets or Limits</u>					
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 as step 5 on page 70.

With *SDL* (stream flow depletion limit) entered in field 2 for variable *TSL*, the *QTS* values in fields 5-16 are defined as upper limits on stream flow depletions used to constrain water availability in the same manner as the other stream flow 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 *PX* record 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*, *PX*, *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 MAX, max MIN, min ADD, add SUB, sub MUL, mul SDL, sdl	<p style="text-align: center;"><u>Manner of Applying TS Amounts</u></p> <i>TS</i> record amounts are the only targets used. Maximum of two alternative targets is adopted. Minimum of two alternative targets is adopted. <i>TS</i> record amount is added to preceding target. <i>TS</i> record amount is subtracted from preceding target. <i>TS</i> record amount is multiplied by preceding target. Upper limit on allowable stream flow depletions.
3	9-16	K	I8	blank,0 +	<p style="text-align: center;"><u>Series to be Repeated</u></p> Repeat the last time series read. Number of the time series to be repeated.
4	17-24	TSA	F8.0	blank,0 +	<p style="text-align: center;"><u>Coefficients for Equation</u></p> Default multiplier = 1.0 Multiplier factor in the equation below.
5	25-32	TSB	F8.0	blank,0 +	Default number to be added = 0.0 Addition factor in the equation below. $QTS(yr,TSCOUNT,mt) = TSA [QTS(yr,K,mt)] + TSB$

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:

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

The factors TSA and TSB are entered in *TSR* record fields 4 and 5. $QTS(yr,TSL,mt)$ 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. K in *TSR* record field 3 is the integer identifier of the series to be repeated. For example, a 3 entered for K in *TSR* record field 3 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. <i>Storage-Area Relationship</i>
4	17-24	EVCFA	F8.0	+	Multiplier <i>A</i> for storage-area equation shown below.
5	25-32	EVCFB	F8.0	+	Exponent <i>B</i> for storage-area equation shown below.
6	33-40	EVCFC	F8.0	+	Constant <i>C</i> for storage-area equation shown below. $\text{surface area} = A (\text{storage})^B + C$ If fields 4, 5 & 6 are all blank, a table on <i>SV</i> and <i>SA</i> records is required to define the storage-area relation. <i>Optional Storage Specifications</i>
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. <i>Evaporation Allocation Reservoirs</i>
9	57-64	IEAR	I8	blank,0 +	Option not used. <i>EA</i> record identifier (1, 2, 3, ...). 1 for first <i>EA</i> record.
10	71-72	SA	I8	blank,0 -1	A separate storage-area relationship is provided. Use <i>SV/SA</i> records for first reservoir on <i>EA</i> record. <i>Downstream Versus Lakeside Diversions</i>
11	79-80	LAKESD = WRNUM(wr,11) or SN3(swr,sr)	I8	blank,0 -1	Water supply diversions are accessible to hydropower. 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* records 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. Fixed reservoir data include *WS* fields 4, 5, 6 and *HP* fields 4, 5, 6, and *SV/SA*, *PV/PE*, and *TQ/TE* record tables. After being entered with one water right, *WS* fields 4, 5, 6 do not have to be repeated for other rights at the same reservoir.

Explanation of WS Record Fields

Field 3: A type 1 (*WR* field 6) right refills a reservoir to the storage capacity entered in *WS* field 3 subject to water availability. Multiple type 1 rights at the same reservoir may refill storage to various levels at different priorities. The field 3 storage capacity also limits the amount of water that may be withdrawn by a right. A diversion right has access to storage up to but not above the top of conservation pool. 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 fields 4 and 6 are blank, a pair of *SV/SA* records must be provided for the reservoir. For multiple rights associated with the same reservoir, the storage-area input is provided only 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 are 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 storage volumes accessed by the different owners are separate rather than shared in common. 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 10 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,9)	F6.0	blank,0 +	Default efficiency = 0.85 Energy efficiency for hydroelectric power plant.
3	9-16	WRSYS(sr,10)	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. A *HP* record is not required for a hydropower right if the default values are adopted for all of the *HP* record parameters. For multiple hydropower rights at the same reservoir, *HP* record fields 4, 5, and 6 must be the same for all the rights, but do not have to be repeated on multiple *HP* records. *HP* record fields 2 and 3 apply to individual rights, but only one pair of *TQ/TE* records can be assigned to a particular reservoir even if it is associated with multiple hydropower rights.

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

An *OR* record follows the *WS* record or *WS/HP* records. *FS* or *CV* records can also be referenced by *OR* records. *OR* records are used to specify multiple-reservoir system operating rules based on the storage zones defined by the figure on the next page and the rank index equation with the multiplier factor *M* from *OR* record fields 4 and 5 and addition factor *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).

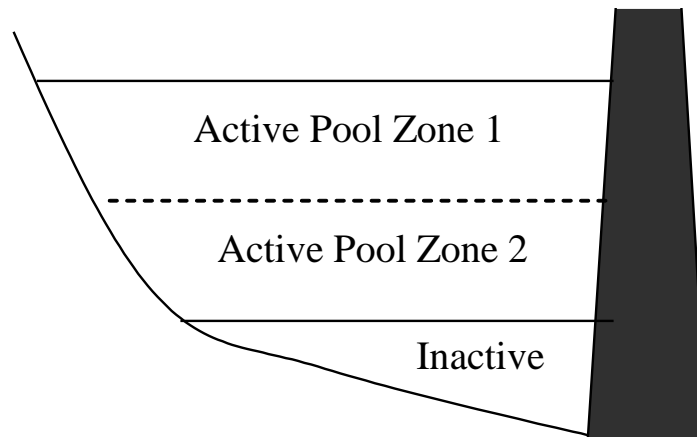
An *OR* record may also be used for a type 2 or type 3 water right with a single secondary (no storage refilling) reservoir with the diversion occurring at a location other than the control point of the reservoir. *OR* record field 6 activates the gravity flow or pump/pipeline options.

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 control point location must have been previously assigned.

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 blank,0	Control point identifier of reservoir location. Control point for reservoir is assigned by prior right.
3	9-16	WRSYS(sr,2)	F8.0	+ blank,0	Storage capacity at top of zone 2 (bottom of zone 1). Default = inactive storage from <i>WS</i> record field 7
4	17-24	WRSYS(sr,5)	F8.0	+ -1.0 blank,0	Zone 1 multiplier factor (M). Multiplier factor set at zero. Default = 1.0
5	25-32	WRSYS(sr,4)	F8.0	+ -1.0 blank,0	Zone 2 multiplier factor (M). Multiplier factor set at zero. Default = 1.0
6	33-40	SN2(swr,sr)	I8	-1 blank,0	Withdrawals through pump and pipeline conveyance as well as releases as river flow. Releases only as gravity flow in river channels.
7	41-48	WRSYS(sr,6)	F8.0	+ blank,0	Zone 1 addition factor (A). Default = 0.0
8	49-56	WRSYS(sr,7)	F8.0	+ blank,0	Zone 2 addition factor (A). Default = 0.0
9	57-64	WRSYS(sr,8)	F8.0	+ blank,0	Monthly release limit. Optional release limit feature is not used.
10	65-68	FSOR(sr)	I4	+	Identifier of <i>CV</i> or <i>FS</i> record connected to <i>OR</i> record.
11	71-72	J	I4	blank,-1	-1 activates <i>FS</i> switch. Default is <i>FS</i> or <i>CV</i> volume.

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



Each *OR* record is preceded by a *WS* record or pair of *WS* and *HP* records. *OR* records define multiple-reservoir system release rules. *OR* record field 6 may also be used with a single reservoir to model pump and pipeline or other non-stream conveyance facilities. *OR* records 9 and 10 may be used with single reservoirs as well as components of multiple-reservoir systems to set release capacities with or without application of a flow switch *FS* record or *CV* record.

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. 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 or developed using a *CV* or *FS* record.

Field 6: Diversion, instream flow, or hydropower requirements at locations other than the control point of the reservoir may be supplied from releases or withdrawals from the reservoir. For the default SN2 of zero (blank field 6), 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.

Fields 10, 11: The integer identifier of a *CV* or *FS* record may be entered in *OR* field 10 to develop or modify the maximum release limit. A *CV* record develops the reservoir release limit in the same manner as an *IF* or *WR* record water right target. With *OR* field 11 blank, a *FS* record likewise develops the release limit. Thus replaced, any entry in *OR* field 9 is not used.

With a -1 in *OR* field 11, the *FS* record provides a switch rather than a final volume for the release limit. This option requires a non-zero release capacity in *OR* field 9. The release capacity entered in *OR* field 9 is multiplied by one of the factors FSX(FS,1) and FSX(FS,2) entered in *FS* fields 5 and 6. The choice between the two multiplier factors depends on the parameters defined by the *FS* record. Multiplier factors of 1.0 or 0.0 act as a switch that turns the reservoir release capacity completely on or off. However, any values of the multiplier factors can be used to vary release capacity each period. Thus, releases from the conservation pool of the reservoir to which the *FS* record is connected (*OR* field 10) may be totally curtailed or altered each period as a function of the cumulative past and/or current (*FS* fields 12-15) volume of a flow switch variable defined in *FS* field 3 for any control point or water right.

PX Record – Priority Sequence Circumvention Options

field	columns	variable	Format	value	description
1	1-2	CD	A2	PX	Record identifier
<i>Dual Simulation Options</i>					
2	8	DUAL (wr)	I6	blank, 0, or -9 1 2 3, 33, 333 4 5, 55, 555	Water right is activated during all simulations. Flow depletion constraint feature is not applied. A -9 over-rides the default set in JO record field 11. 1 Right is activated only during the initial simulation. 2 Right is activated only during the second simulation and is not subject to stream flow depletion constraint. 3, 33, 333 Right is activated during both simulations. Stream flow depletions during the initial simulation serve as limits during the second simulation. 4 Right is activated only during the initial simulation. Stream flow depletion array is recorded. 5, 55, 555 Right is activated only during the second simulation. Preceding option 4 right depletions serve as limits.
<i>Stream Flow Availability Multiplier Factor</i>					
3	9-16	XAX	F8.0	blank,0 F8.0 -1	Not activating option is equivalent to XAX of 1.0. Factor by which flow availability is multiplied. Monthly factors are entered on following AX record.
<i>Downstream Control Point Flow Availability Limit</i>					
4	24	XCP(px)	I8	blank,0 1 2 3 4	Downstream control point limit is not activated. 1 XCPID and all downstream control points are excluded in determination of flow availability for wr. 2 Option 1 plus availability is limited to flow depletion. 3 Only control point XCPID is excluded. 4 Option 3 plus availability is limited to flow depletion.
5	25-32	XCPID	2x,A6	AN	Identifier of control point defining limit.
<i>Transient-Priority Water Right Options</i>					
6	40	XP(px)	I8	blank,0 1 2	Transient priority XP features are not used. 1 Return flow occurs later in the priority sequence. 2 Stream flow depletion, return flow, and storage are reversed later in the priority loop computations.
7	48	XPR(px)	I8	blank,0,1 2	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.
8	49-56	XPRIORITY	I8	+	Priority number of 2 nd component of water right duo.
9	63-64	XPOUT(px)	I8	blank,0,1 -1	Water right output is treated same as regular rights. Water right records are not included in output file.
10	65-80	WRID1(px)	A16	AN	Water right identifier for second component right.
11	81-88	WRID2(px)	A8	AN	Water right group identifier for 2 nd component right.
12	89-96	WRID3(px)	A8	AN	Water right group identifier for 2 nd component right.

AX Record – Monthly Stream flow Availability Multiplier Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	AX	Record identifier
<i>Stream Flow Availability Multiplier Factors</i>					
2	3-8	XA(px,1)	F6.0	+	Multiplier factor for month 1
3-13	9-96	XA(px,M) M = 2, 12	F8.0	+	Multiplier factor for months 2 through 12
<i>Minimum and Maximum Limits</i>					
14	97-104	XAMIN(px)	F8.0	+	Minimum limit above which factors are applied.
15	105-112	XAMAX(px)	F8.0	+	Maximum limit on stream flow availability.

The water right modeling capabilities provided by a *PX* record and auxiliary *AX* record are discussed in the last section of Chapter 4 of the *Reference Manual*. The dual simulation, stream flow availability multiplier factor, control point limit, and transient water right options are four different features for modeling water management schemes involving circumvention of the normal water rights priority sequence. However, although motivated by schemes for evading the priority system, the four *PX* record methodologies are generic options that may serve other purposes as well. The four different options may be adopted independently of each other or used in various combinations. *PX* fields 2, 4, 5 may be assigned to groups of rights with *RG* records.

Dual Simulation Options (PX Record Field 2)

The dual simulation options are activated the same by either *SO* field 14 or *PX* field 2. A default dual option may be set in *JO* record field 11. The dual simulation allows stream flow 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 stream flow 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 arrays of stream flow depletions for specified senior rights that refill reservoir storage. These initial flow depletions become constraints that limit the amount of flow available to specified rights during the second simulation. The following five options may be activated by the variable *DUAL* in *PX* record field 2 (or *SO* field 14 or *JO* field 11).

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 stream flow depletion constraint.

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Options 3, 33, 333: A dual simulation is automatically performed. Stream flow depletions computed during the first simulation serve as upper limits on water availability during the second simulation. The stream flow 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 stream flow depletion array is developed. If an option 5 right follows this right, the depletions serve as upper limits on water availability for the option 5 right during the second simulation. The stream flow depletions are written to the MSS file if *ICHECK*=8 on the *JD* record.

Options 5, 55, 555: A dual simulation is performed with this water right being activated only during the second simulation. The stream flow depletion array from the preceding option 4 right serves as an upper limit on flow depletions for this option 5 right.

With dual options 3 and 5, stream flow depletion limits are applied in the same manner as the constant monthly and annual depletion limits activated by *SO* record fields 3 and 4 and monthly-varying limits activated by *ML* records. The only difference is that the limits are determined by computing stream flow depletions in an initial simulation. Option 3 rights use their own stream flow depletion array 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 in the input file before the option 5 right. The stream flow 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.

Options 33, 333, 55, and 555 are variations of options 3 and 5 in which limits are based on accumulating stream flow depletions rather than depletions in each individual month. With options 33 and 55, for any month, for a particular right, the total cumulative depletions since the beginning of the second simulation can not exceed the corresponding cumulative depletions occurring in the initial simulation.

With options 333 and 555, for type 1 and 7 rights (*WR* record field 3) with reservoir storage, the limit during the second simulation is the accumulative stream flow depletions since the reservoir was last full. During the second simulation, the accumulation of initial simulation depletions is zeroed any time the reservoir contents are full to capacity. For water right types other than types 1 and 7 with storage, the options 333 and 555 limits applied during the second simulation are the first simulation depletion for the current month plus any excess depletion from the immediately preceding month. Unused depletions are carried into the next month but no further.

Option 4 rights may be used to write flow depletions to the MSS file even if the automated second simulation is not of interest. The stream flow 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.

Stream Flow Availability Multiplier Factor (PX Record Field 3 and AX Record)

As discussed in *Reference Manual* Chapter 4, this option is designed for modeling two or more water rights having the same priority. The constant factor (*XAX*) entered in *PX* record field 3 or monthly factors (*XA*) entered in the *AX* record are used to allocate available stream flow. The factors will typically be greater than zero and less than 1.0. The optional minimum and maximum stream flow availability volumes in *AX* record fields 14 and 15 may be combined with

the multiplier factors in adjusting stream flow availability. The amount of stream flow available to a water right is determined in the water rights priority loop computations as follows.

- The available stream flow volume (A_1) is first determined in the normal manner and then adjusted by the *PX/AX* record parameters as follows.
- If *XAMIN* is not zero, the adjusted available stream flow is set at A_1 as long as A_1 does not exceed *XMIN*.
- If A_1 exceeds *XAMIN*, the multiplier factor *XAX* or *XA(month)* is applied as follows
adjusted available stream flow = $XAMIN + (A_1 - XAMIN) \times XAX$
- If *XAMAX* is not zero, the adjusted available stream flow is set at *XAMAX* if the volume computed by the equation above exceeds *XAMAX*.

If *XAMIN* and *XAMAX* are not activated in *AX* record fields 14 and 15, the algorithm consists simply of multiplying the available river flow by a factor. A similar procedure using a constant rather than monthly varying factors is activated by the *AF* record connected to the *EA* record.

Control Point Limit Options (PX Record Fields 4 and 5)

The amount of stream flow available to a water right is determined within *SIM* as the lesser of the stream flow availability array at the control point of the right and at each control point located downstream. However, the control points considered may be altered by options activated by *PX* record fields 4 and 5. A control point is selected by entering its identifier *XCPID* in *PX* record field 5. The control point *XCPID* specified in *PX* record field 5 must be located downstream of the control point of the water right specified in *WR* record field 2. Computational options that may be activated by a selection entered for *XCP* in *PX* record field 4 are as follows.

- Option 1: Control point *XCPID* and all control points located downstream of it are omitted from consideration in determining the amount of stream flow available to the water right.
- Option 2: Option 1 is activated along with an additional feature that limits flow availability to not exceed the flow depletion by senior rights at *XCPID* adjusted for channel losses.
- Option 3: *XCPID* is the only control point omitted from consideration in determining river flow availability for the right. The depletion at *XCPID* is not applied as a maximum limit.
- Option 4: *XCPID* is the only control point omitted from consideration in determining river flow availability for the right, and the depletion at *XCPID* is applied as a maximum limit.

The increase (*XAV*) in the amount of stream flow available to the water right resulting from activating this option is written to the OUT file and may be tabulated as a *TABLES 2XAV* table. With options 2 and 4, *XAV* is limited to not exceed flow depletions by senior rights at control point *XCPID* increased to account for channel losses between the right and *XCPID*.

In adjusting downstream flows for the depletion incurred by the right, the decreases in flow at and below *XCPID* omit the effect of the additional stream flow depletion generated by the *XCP* feature. Another right with a backup right *BU* record may be created to offset this increase. The increase in stream flow depletion replaces the shortage as the quantity to be added to the diversion target of the backup right. The last section of *Reference Manual* Chapter 4 describes a strategy for modeling subordination agreements by combining *PX* and *BU* record options.

Transient Water Right Options (PX Record Fields 6 – 12)

The transient water right options governed by *PX* record fields 6 through 12 involve changes with respect to location in the priority loop computations. A *WR/PX* 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 *PX* field 8, respectively. The *PX* record activates two types of XP (dual switching priority) water rights.

1. With XP option 1 in *PX* field 6, 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 *PX* field 8 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. *PX* field 6 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 stream flow depletion, return flow, and storage change are later reversed automatically within the model as a second component right at the priority in *PX* field 8. Stream flow depletions are returned to the stream as return flows. Return flows are reversed as stream flow depletions. In typical subordination applications, the actual water right will be modeled with another *WR* record with its actual junior priority.

Field 6: 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 stream flow depletion, return flow, and depending on XPR (field 7) the change in storage.

Field 7: 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/PX* record water right may be treated just like a regular *WR/WS* record right.

Field 8: *XPRIORITY* is the priority number of the second component right of the *WR/PX* right duo. The priority number for the first component right is provided in *WR* record field 8. For XP (field 3) option 2, the *PX* 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 *PX* record priority is reached in the water right priority loop computations.

Field 9: 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 10, 11, 12: 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 *PX* fields 10-12.

Sequencing of SV/SA, PV/PE, and TQ/TE Records in DAT File

The set of all *SV*, *SA*, *PV*, *PE*, *TQ*, and *TE* records follow after the set of all *WR*, *IF*, and auxiliary water right records. The *SV*, *SA*, *PV*, *PE*, *TQ*, and *TE* records have the same format. 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.

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,TL	TL(F8.0)	+	Reservoir storage volumes corresponding to surface areas in same fields of the following <i>SA</i> 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,TL	TL(F8.0)	+	Reservoir surface areas corresponding to storage volumes in same fields of the preceding <i>SV</i> record

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,TL	TL(F8.0)	+	Reservoir storage volumes corresponding to surface elevations in same fields of the following <i>PE</i> 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,TL	TL(F8.0)	+	Reservoir surface elevations corresponding to storage volumes in same fields of the preceding <i>PV</i> record

SIM

TQ Record – Turbine 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,TL	TL(F8.0)	+	Turbine flow corresponding to tailwater elevations in same fields of the following <i>TE</i> 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,TL	TL(F8.0)	+	Tailwater elevations corresponding to turbine flows in same fields of the preceding <i>TQ</i> record

The *SV-SA*, *PV-PE*, and *TQ-TE* tables are allowed a maximum of TL pairs of values set by *JO* record field 10 with a default TL of 12. 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.

A storage volume versus water surface elevation (*PV-PE* records) table is required for each reservoir associated with hydropower rights for use in computing head. *PV* and *PE* records may also be provided for non-hydropower reservoirs for use in determining water surface elevations by linear interpolation. *SIM* writes water surface elevations to the reservoir/hydropower output record for all reservoirs with *PV-PE* records. The *TABLES 2WSE* record tabulates the reservoir water surface elevations.

Tailwater rating tables (*TQ-TE* records) are used only for computing head in hydroelectric power computations. The optional *TQ* and *TE* records are provided only for reservoirs associated with hydropower rights for which a constant tailwater elevation is not input on the *WS* record.

Sequencing of MS, OS, DI/IS/IP, and EA/EF Records in DAT File

MS, *OS*, *DI/IS/IP/IM*, and *EA/EF* records are connected to reservoirs. The sets of *MS*, *OS*, *DI/IS/IP*, and *EA/EF* records are placed in the DAT file after the complete grouping of all *SV/SA*, *PV/PE*, and *TQ/TE* records and before the *ED* record. All *OS* records are grouped together. All sets of *DI/IS/IP* records are grouped together. All pairs of *EA* and *EF* records are grouped together. However, the relative placement of the *MS* versus *OS* versus *DI/IS/IP* versus *EA/EF* groups is arbitrary. For example, the *EA/EF* records may be either before or after the *MS*, *OS*, and/or *DI/IS/IP* records. Likewise, the set of all *MS* records for any number of reservoirs may be placed before or after or between the set of all *DI/IS/IP* records and the set of all *EA/EF* records.

MS Record – Monthly Storage Capacity Limits

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)	12F8.0	+	Maximum storage volume limits for month M=1,12
15	105-112	STMON(13)	F8.0	+	Maximum release volume during a time period.

Storage limits for each of the 12 months of the year can be entered in *MS* record fields 3-14, with the 12 monthly-varying capacity limits being repeated each year of the simulation (one *MS* record for a reservoir). A *MS* record can be used to model a seasonal rule curve operating policy, which typically involves allocation of storage capacity between conservation and flood control pools by raising and lowering the designated top of conservation pool elevation.

The storage capacities *STMON(M)* on the *MS* record serve as upper limits constraining *WR/WS* record storage capacity. *FC* record flood control operations discussed in the *Daily Manual* allow flood storage above these levels. In each period, unless over-ruled by flood control operations, the beginning-of-period and end-of-period storage is limited to not exceed the *MS* record storage capacity for that month. In refilling storage, the storage capacity is the lesser of the *WS* record and *MS* record storage capacities. If the storage carried over from the previous month is above the specified capacity for the current month, releases called spills are made to lower the storage content. The amount of such release is limited by the release capacity *STMON(13)* entered in *MS* record field 15. In *SIM*, the release capacity is a volume per month. In *SIMD*, the release capacity is a volume per sub-monthly time interval.

OS Record – Observed End-of-Month Storage Capacity Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	OS	Record identifier
2	3-8	RES	A6 6x	AN	Reservoir identifier required only on first <i>OS</i> record. Field is not read for second and subsequent years.
3-14	9-104	OS(M) M = 1, 12	12F8.0	+	Maximum storage capacity for months 1-12 of a year. <i>OS</i> records are entered for each and every year.

OS records allow observed storage levels to be specified to which a reservoir is filled to the extent that stream flow is available for filling. Storage capacity limits are entered for every month of the simulation with one *OS* record for each year. The storage capacities *OS(M)* serve as upper limits constraining *WR/WS* record storage capacity. In refilling storage, the storage capacity is the lesser of the *WS* record and *OS* record storage capacities. Releases (spills) occur at the end of each month as necessary to limit storage contents to not exceed the *OS* record storage. Whereas the 12 storages on a *MS* record are for entire months with spills occurring at the beginning of the month, *OS* record storage sequences are defined by end-of-month spills.

SIM

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 -1 1,2,3, ... 12	Reservoir emptying option is not used. Reservoir(s) is emptied at beginning of every month. 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 <i>DI</i> 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 TL)
3-12	9-104	DISTO(I)	TL(F8.0)	+	Reservoir storage corresponding to <i>IP</i> 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)	TL(F8.0)	+	Percentages corresponding to <i>IS</i> record DISTO

A set of *DI/IS/IP* records defines a drought index based on reservoir storage that is used by one or more water rights (*WR* or *IF* records) in setting diversion, instream flow, hydropower, and/or storage targets. For each drought (storage) index, an *IS* record must follow its *DI* record. The *IP* record follows the *IS* record. The *IM* record is optional but, if used, follows the *IP* record.

DINDEX(wr) in *WR* record field 10 and *IF* record field 8 connect water rights to drought (storage) indices defined by *DI/IS/IP/IM* records. A storage versus target adjustment relationship is defined by the *IS/IP* records with no more than TL (*JD* record field 11, default=12) pairs of storage and index percentages. Water right targets are multiplied by factors linearly interpolated from the *IS/IP* table. Each drought index is based on either the total storage in one to 12 specified reservoirs or all the reservoirs in the model. The drought

The drought index each month is a percentage interpolated by *SIM* from the *IS* versus *IP* record table as a function of simulated storage contents. *SIM* converts this percentage to a factor (for example, 127.43% to 1.2743 or 50.00% to 0.5000) by which the intermediate target is multiplied.

IM Record – Monthly Switches Controlling the Drought Index

field	columns	variable	format	value	description
1	1-2	CD	A2	IS	Record identifier
2	7-8	IM(1)	I6	0,1,+,-	
3	11-12	IM(2)	I4	0,2,+,-	One of the following three options is selected for
4	15-16	IM(3)	I4	0,3,+,-	each of the 12 months of the year:
5	19-20	IM(4)	I4	0,4,+,-	
6	23-24	IM(5)	I4	0,5,+,-	zero, blank – the index is not applied this month.
7	27-28	IM(6)	I4	0,6,+,-	positive integer – index is set and applied this month.
8	31-32	IM(7)	I4	0,7,+,-	negative integer – the most recent previously set
9	35-36	IM(8)	I4	0,8,+,-	index is applied again.
10	39-40	IM(9)	I4	0,9,+,-	
11	43-44	IM(10)	I4	0,10,+,-	
12	47-48	IM(11)	I4	0,11,+,-	
13	51-52	IM(12)	I4	0,12,+,-	

An optional *IM* record allows the *DI/IS/IP* storage index to be switched on or off in each month. Alternatively, using the *IM* record, the index determined based on reservoir storage contents in a selected month may be repeated in later months. For example, the index applied in setting a target during each month of June through October could be determined based on the storage content at the beginning of June. The index determined in November could be applied in March and April of the next year. The following choices are selected for each of the 12 months of the year on the *IM* record.

- A zero or blank field indicates that the drought index is not to be computed and is not to be applied in the water right target setting procedure for that month.
- An entry of any positive integer will activate the drought index for that month. Although any positive integer has the same effect, the month (1, 2, 3, ... ,12) may be entered to help the model user visualize actions taken in each month.
- An entry of any negative integer will result in the drought index being applied in setting the water right target for that month. However, the drought index is not computed for that month. Rather, the most recently computed index is applied again. If no index has been determined, the default is always a multiplier of 1.0.

Regardless of whether the optional *IM* record is used, *STODI* in *JO* record field 8 allows the *DI/IP/IS* record drought index to be based alternatively on either beginning-of-period storage, latest end-of-period storage, or the average of the two. A drought index is computed once at the beginning of each month if based on beginning-of-period storage. If end-of-month or average storage is used, the drought index is recomputed in the water rights loop each time a right uses the index. The latest end-of-month storage computed in the water right priority sequence reflects other senior rights, but does not reflect junior rights.

The framework for building *WR* record diversion, hydropower, and storage targets and *IF* record instream flow targets is outlined on page 69-70. The drought index is applied in either step 1 or step 6 depending on the entry for *DINDEX(wr)* in *WR* record field 10 or *IF* record field 8.

SIM

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	+	<i>EA</i> record integer identifier which may be blank since <i>SIM</i> automatically numbers. NEA = 1, 2, 3, ...
					<u><i>Allocation Method</i></u>
3	16	NEAF (NEA)	I8	blank,0,1 2, 22 3, 33 4	Incremental based on water right priorities. Based on beginning-of-month storage content. Based on factors from the following <i>EF</i> record. Incremental combined with factors from <i>EF</i> record.
					<u><i>Reservoirs</i></u>
4-23	17-176	EARES (NEA,I)	20 (2x,A6)	AN	Reservoir identifiers for from 2 to 20 reservoirs. I = 1, 20

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 3 4	Any individual reservoir; beginning storage. Sum of storage in all reservoirs; beginning storage. Any individual reservoir; EAF factors; for NEAF=4. All reservoirs; EAF factors; for NEAF=4 only.
3	9-16	EAL(NEA)	F8.0	blank,0 +	Default = 0.0 Fractional (0.0 to 1.0) storage limit switch.
4-23	17-176	EAF (NEA,I)	20F8.0	+	Factors for the reservoirs listed on the <i>EA</i> record used with <i>EA</i> field 3 NEAF options 3, 33, and 4.

AF Record – Stream flow Availability Allocation Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	AF	Record identifier
2	3-8	AFMIN	F6.0	+	Minimum available stream flow for any reservoir.
3	9-16	AFMAX	F8.0	+	Maximum available stream flow for any reservoir.
4-23	17-176	AFX (NEA,I)	20F8.0	+	Factors for the reservoirs listed on the <i>EA</i> record by which available stream flow is multiplied.

The *EA/EF/AF* records are placed in the DAT file somewhere after the sets of *SV/SA*, *PV/PE*, and/or *TQ/TE* records and before the *ED* record. All *EA/EF/AF* records are grouped together.

EA records are used in situations where multiple water supply entities hold rights to separate 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 volume in all of the component reservoirs versus total water surface area, for use in the computation of net evaporation less precipitation volumes. Each *EA* record represents a multiple-owner reservoir modeled as from two to 20 component reservoirs. Each component reservoir has its own *WR* and *WS* records. *WS* record field 2 identifiers of component computational reservoirs that compose the actual multiple-owner reservoir are listed in fields 4-23 of the *EA* record. *WS* record field 9 connects the *WR/WS* records to an *EA* record.

The *EA* record evaporation allocation routines are applied only to type 1 or 7 rights (*WR* field 6). However, any number of other types of water rights may be associated with the same reservoir listed on an *EA* record subject to restrictions outlined in Chapter 4 of the *Reference Manual*.

SIM numbers the *EA* record data sets in sequential order (1, 2, 3, ...) with no limit on the maximum allowable number of *EA* records representing different multiple-owner reservoirs. The optional *NEA* in field 2 must conform to this numbering system; otherwise, an error message is activated. The *EA* record *NEA* identifiers connect to and match the *IEAR* in field 9 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 does not have to be repeated for the other reservoirs. *WS* record field 10 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.

An *EF* record follows directly behind an *EA* record if and only if allocation method options 3 or 4 are selected as *NEAF* in *EA* record field 3. Each *EF* record *EAF(NEA,I)* factor corresponds to a reservoir on the *EA* record. These multiplier factors are applicable only during months of the simulation with storage above levels defined by *EAO* and *EAL* in *EF* record fields 2 and 3.

As each component reservoir is modeled in the water right priority loop, its end-of-month storage may necessarily be approximated by beginning-of-month storage in the evaporation computations. In order to assure that the combined total evaporation is precisely correct, for options 2 and 3, the evaporation for the last reservoir listed on the *EA* record is computed as the exact total evaporation minus the sum of the evaporation allocated to the other reservoirs. Thus, the last reservoir listed on the *EA* record should be junior to the other reservoirs, and no factor is entered on the *EF* record for the last reservoir listed.

Options 22 and 33 are identical to options 2 and 3 with the exception of not applying the feature described in the preceding paragraph for assuring the correct total evaporation. Options 22 and 33 treat all component reservoirs including the last reservoir listed on the *EA* record the same.

The following alternative methods for allocating net evaporation-precipitation between the component reservoirs are selected by *NEAF* in *EA* record field 3.

Option 1 assigns the most senior right the evaporation computed prior to considering any other junior rights. Each subsequent right is allocated its incremental additional evaporation as the rights are considered in the simulation in priority order. Thus, evaporation allocated to the component reservoir associated with a particular right is independent of other component reservoirs associated with rights with junior priorities.

Options 2 and 22 allocate net evaporation between reservoirs in proportion to their beginning-of-month storage. A factor for each reservoir is computed as its beginning-of-month storage divided by the total beginning-of-month storage in all of the *EA* record reservoirs. If the beginning-of-month storage is zero in all reservoirs, evaporation is divided equally between the reservoirs.

Options 3 and 33 allocate net evaporation between the reservoirs based on multiplying the total evaporation by the *EAF* factors provided on an *EF* record. The computations switch to option 2 described above based on beginning-of-month storage ratios in any month in which the beginning-of-month storage is below the limit specified by *EAO* and *EAL* in *EF* record fields 2 and 3. If the beginning-of-month storage is zero in all reservoirs, the *EAF* factors are applied.

Option 4 first computes incremental net evaporation in the same manner as option 1 but then multiplies the result by the factor from the *EF* record. If all the *EAF* factors on the *EF* record are 1.0, option 4 is the same as option 1 assuming either *EAL* is zero or *EAO* is either 3 or 4. In any month in which the beginning storage is below the limit *EAL* in *EF* record field 3, the computations either switch to option 2 (if *EAO* is 1 or 2) or the factors are set at 1.0 (if *EAO* is 3 or 4) depending on *EAO* in *EF* record field 2.

The *EAL* limit of *EF* record field 3 defines a beginning-of-period storage limit below which the *EAF* factors are no longer applied. The storage limit is computed as the storage capacity (*WS* record field 3) multiplied by *EAL* from *EF* field 3. The *EAO* option of field 2 specifies whether the limit is associated with the storage of each individual reservoir or the total sum of the storage of all the component reservoirs. With *EAO* = 1 or 3, application of the factors is curtailed any time the beginning-of-period storage of any one of the reservoirs falls below the *EAL* limit. With *EAO* = 2 or 4, the factors are no longer used if the total sum of the storage in all reservoirs falls below the *EAL* limit. With *EAO* options 1 and 2, whenever storage falls below the limit, the algorithm switches to allocating net evaporation based on beginning storage content, which is equivalent to *NEAF* option 2. With *EAO* options 3 and 4, which are applicable only with *NEAF* option 4, the *EAF* factors are set at 1.0 if storage falls below the limit

The optional *AF* record is motivated by situations in which multiple reservoir owners share the same priority. The priority system governs access to available stream flow as reflected in the water rights computation loop priority sequence. If two or more of the multiple reservoir owners actually have the same priority, allocation of available stream flow may be specified by the model-user through the *AF* record. The available stream flow is computed in the normal manner and then adjusted by the parameters from the *AF* record. Minimum *MIN* and maximum *MAX* adjusted flow availability volumes may be entered in fields 2 and 3. The multiplier factors *AF* for each reservoir in fields 4–23 are applied to available flow volumes exceeding the minimum. The *AF* record computational algorithm is essentially the same as the procedure activated by the parameters *XAX*, *XMIN*, and *XMIN* from the *PX* and *AX* records.

IN and EV Records in Standard Default Format**IN Record – Inflows, Naturalized Stream Flows 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 <i>IN</i> record repeated for multiple years
				blank,0	<i>IN</i> 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 stream flow for Month 1
6	25-32	INFLOW(cp,2)	F8.0	+	Naturalized stream flow for Month 2
7	33-40	INFLOW(cp,3)	F8.0	+	Naturalized stream flow for Month 3
8	41-48	INFLOW(cp,4)	F8.0	+	Naturalized stream flow for Month 4
9	49-56	INFLOW(cp,5)	F8.0	+	Naturalized stream flow for Month 5
10	57-64	INFLOW(cp,6)	F8.0	+	Naturalized stream flow for Month 6
11	65-72	INFLOW(cp,7)	F8.0	+	Naturalized stream flow for Month 7
12	73-80	INFLOW(cp,8)	F8.0	+	Naturalized stream flow for Month 8
13	81-88	INFLOW(cp,9)	F8.0	+	Naturalized stream flow for Month 9
14	89-96	INFLOW(10)	F8.0	+	Naturalized stream flow for Month 10
15	97-104	INFLOW(11)	F8.0	+	Naturalized stream flow for Month 11
16	105-112	INFLOW(12)	F8.0	+	Naturalized stream flow 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 <i>EV</i> repeated for multiple years
				blank,0	<i>EV</i> 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,4)	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

SIM

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 stream flow for Month 1
5	25-32	Q(2)	F8.0	+	Naturalized stream flow for Month 2
6	33-40	Q(3)	F8.0	+	Naturalized stream flow for Month 3
7	41-48	Q(4)	F8.0	+	Naturalized stream flow for Month 4
8	49-56	Q(5)	F8.0	+	Naturalized stream flow for Month 5
9	57-64	Q(6)	F8.0	+	Naturalized stream flow 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 stream flow for Month 7
5	25-32	Q(8)	F8.0	+	Naturalized stream flow for Month 8
6	33-40	Q(9)	F8.0	+	Naturalized stream flow for Month 9
7	41-48	Q(10)	F8.0	+	Naturalized stream flow for Month 10
8	49-56	Q(11)	F8.0	+	Naturalized stream flow for Month 11
9	57-64	Q(12)	F8.0	+	Naturalized stream flow 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.

Alternative Formats for IN and EV Records

Sequences of monthly flow volumes representing natural or some specified condition of river basin development are entered on inflow *IN* records. Sequences of monthly reservoir surface net evaporation less 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.

INEV in *JO* record field 2 specifies the manner in which the *IN* and *EV* records are organized. The standard default set of input files include a *FLO* (or *INF*) file for storing *IN* records and a *EVA* file for storing *EV* 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 used in early *WRAP* versions 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.

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 2002 will follow a similar set of records for all control points for the year 2001. Typically, developing a complete time series of *IN* and/or *EV* records covering all years of 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. A *SIM* simulation is performed chronological by year. 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 *IN* and *EV* records are read at the beginning of the simulation, requiring much more memory.

Grouping by Year			Grouping by Control Point		
IN	CP-1	2001	EV	CP-1	2001
IN	CP-2	2001	EV	CP-1	2002
IN	CP-3	2001	EV	CP-1	2003
IN	CP-1	2002	EV	CP-2	2001
IN	CP-2	2002	EV	CP-2	2002
IN	CP-3	2002	EV	CP-2	2003
IN	CP-1	2003	EV	CP-3	2001
IN	CP-2	2003	EV	CP-3	2002
IN	CP-3	2003	EV	CP-3	2003

IN and *EV* records are stored in text files. As an alternative, with option 6 specified for *INEV* in *JO* record field 2, the naturalized flows and net evaporation-precipitation depths are read from a binary *DSS* file with the filename *rootHYD.DSS* that can be created using *OF* record field 6.

Options for Organizing Monthly Naturalized Flows and Net Evaporation Depths

At least one *IN* record or equivalent DSS record is required to execute *WRAP-SIM*. However, *EV* records are not required. An entry of 0 or -2 for the *JO* record field 2 *INEV* switch activates a FLO file without a corresponding EVA file. The *INEV* options are as follows.

The organization and format of hydrology datasets can be conveniently converted using the program *HYD*. *WRAP-HYD* includes options for converting files with flows and evaporation-precipitation rates organized in either of the alternative formats to another selected option.

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 filename extensions FLO and EVA, respectively. The records are in the standard default format shown earlier. 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 filename root.HYD. Pairs of records with six months on each are in the format shown on page 110. 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.

Option 6: *INEV* = 6 in *JO* Record Field 2

Naturalized monthly stream flow volumes and net evaporation-precipitation depths are stored in binary format in a single DSS file with the filename rootHYD.DSS.

FD Record – Flow Distribution (FD Record for Flow Distribution Options 3, 4, 5, 6, 7, and 8)

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	+ -1	Number of gaged cps above ungaged site (blank = 0) Ungaged CP is downstream of source CP
5-no limit	25-no limit	UGID(I) I=1,MAXGAG	2x,A6	AN	Identifiers of upstream gaged control points No limit on the maximum number of identifiers.

FD Record – Flow Distribution (FD Record for Flow Distribution Option 10)

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	Identifier for control point in equation with coef=1.0
4	17-24	NG	I8	+	Number of additional control points (0, 1, 2, 3)
5-7	25-48	UGID(I) I=1,3	2x,A6	AN	Identifiers of control points with multiplier factors COEF1, COEF2, and COEF3 on FC record.

FC Record – Flow Distribution Equation Coefficients for Methods 3 and 10

field	columns	Variable	format	value	description
1	1-2	CD	A2	FC	Record identifier
2	3-8	COEF1	F6.0	+	Coefficient 1 (default = 0.0)
3	9-16	COEF2	F8.0	+ or -	Coefficient 2 (default 1.0 and 0.0 for options 3 & 10)
4	17-24	COEF3	F8.0	+ or -	Coefficient 3 (default = 0.0)

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

Explanation of FD, FC, and WP Records

FD, *FC*, and *WP* records are stored in a flow distribution file with filename extension DIS. 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. A DIS file always ends with an *ED* record. The end-of-data *ED* record is required as the final record in the DIS file.

A flow distribution DIS file is required and is automatically opened (activated) if one or more control point *CP* records in the DAT file specify an INMETHOD option in field 6 or EWA option in field 9 that requires *FD*, *FC*, and *WP* record information provided in the DIS file. Flow distribution options 3, 4, 5, 6, 7, 8, and 10 in *CP* field 6 require a DIS file. The evaporation-precipitation adjustment activated as a default in *JD* record field 10 or set for individual control points in *CP* record field 9 may also require information from *FD* and *WP* records.

The methods for distributing naturalized stream flows from gaged (known flow) to ungaged (unknown flow) control points and the evaporation-precipitation adjustment methodology are described in Chapter 3 of the *Reference Manual*. A *FD* record is required for each ungaged control point for which flows are synthesized. Flows are transferred from the source (gaged) control point (*FD* field 3 and auxiliary fields 4, 5, ...) to the ungaged location (*FD* field 2). *FD* records are also required if pertinent options are specified (*JD* field 10 and *CP* field 9) for computing adjustments to evaporation-precipitation depths for reservoir site runoff. Either *FD* record field 2 or 3 control points may be used for adjusting net evaporation-precipitation depths. Upstream control points (*FD* fields 5, ...) define incremental watersheds for either application.

A *FC* record follows the *FD* record if either flow synthesis option 3 or 10 is specified for this control point in *CP* record field 6. The *FC* record provides the coefficients *COEF1*, *COEF2*, and *COEF3* for the option 3 equation

$$Q_{\text{ungaged}} = (\text{COEF1}) Q_{\text{DSG}}^{\text{COEF2}} + \text{COEF3}$$

or option 10 equation

$$Q_{\text{ungaged}} = Q_{\text{DSG}} + (\text{COEF1}) Q_1 + (\text{COEF2}) Q_2 + (\text{COEF3}) Q_3$$

A watershed parameter *WP* record is provided for each gaged and ungaged control point involved in applying flow distribution methods 4 through 8 specified in *CP* record field 6. The watershed parameters are drainage area, curve number CN, and mean precipitation. Only those parameters required by the selected optional method specified on the *CP* record need to be provided on the *WP* records.

SIM uses drainage area units of square miles in performing computations within the model. The watershed drainage area entered in *WP* record field 3 is by default in units of square miles. However, if the area is entered in *WP* field 3 in units other than square miles, a conversion factor DAF, with default of 1.0, may be entered in *WP* field 6. The area on the *WP* record is multiplied by this factor to convert to square miles. The unit conversion multiplier DAF in *WP* field 6 applies to this and all subsequent *WP* records until a new DAF is entered on another *WP* record.

The watershed drainage area, curve number CN, and mean precipitation entered in *WP* record fields 3, 4, and 5 are by default for the total watershed above the control point identified in field 2. However, the parameter INWS in *CP* field 11 allows the three parameters to be assigned to the incremental watershed defined by the *FD* record rather than to the total watershed.

FA Record – Flow Adjustments

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

Adjustments to naturalized river flows are entered on *FA* records stored in a flow adjustment file with the filename extension FAD. The FAD file contains only *FA* records and optional **** and *ED* records. The *FA* record flow adjustments are positive or negative monthly volumes which are added to the stream flows. *FA* records may be entered for any number of control points.

Unlike the *CI* record, a different *FA* record is provided for each year, allowing the adjustments to vary between years. Constant inflow *CI* records in the DAT file provide a set of 12 monthly adjustments that are repeated for all years. The adjustments on either *CI* or *FA* records are entered at a specified control point and are cascaded downstream within *SIM* in the normal manner accounting for channel losses.

The FAD file is activated by the parameter FAD in *JO* record field 3. A choice of three alternative options for organizing and applying the *FA* record monthly flow volumes in the FAD file is controlled by the switch parameter FAD in *JO* record field 3.

FAD Option 1: Option 1 is the original FAD routine which was developed during 1999-2000 to model the effects of spring flow changes on stream flow. The *FA* record adjustments are added to naturalized flows each month at the beginning of the *SIM* simulation after the flow distribution routine and before the negative incremental flow adjustment routine. Individual adjustments from *FA* records may be negative or positive, but the total adjustment at a control point is not allowed to drop below zero. Adjustments are cascaded downstream subject to channel losses as naturalized flows at downstream control points are adjusted.

Option 1 has the peculiarity that positive amounts are entered at the next control point downstream of the control point indicated on the *FA* record. Negative *FA* record volumes are added to the naturalized flows at the *FA* record control point. Thus, positive values from the *FA* records enter the stream system one control point below negative adjustments.

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With options 1 and 3, the *FA* records are grouped in the FAD file by year. If records are included for more than one control point, the FAD file begins with *FA* records for all control points for the first year, followed by *FA* records for all control points for the second year, and ends with a set of *FA* records for all control points for the last year of the hydrologic period-of-analysis. The *FA* records must cover the entire period-of-analysis with a *FA* record provided for each year.

FAD Options 2 and 3: FAD options 2 and 3 are applied in the *SIM* simulation in the same manner as constant inflow *CI* record flow adjustments. *SIM* adds flows from the *FA* and *CI* records to the naturalized stream flows plus next-month return flows from the preceding month at the control point specified on the *FA* and *CI* records and, with adjustments for channel losses, at all downstream control points. *SIM* combines naturalized flows, next-month return flows from the previous month, *CI* record flows, and *FA* record flows at the beginning of each month after the flow distribution routine and negative incremental flow adjustment routine are completed. Outflows may be entered as negative values on *FA* records or *CI* records but are not allowed to reduce stream flows to below zero.

Differences: The only difference between FAD option 2 and option 3 is the organization of the *FA* records in the FAD file. FAD option 2 for *FA* records is equivalent to INEV option 2 for *IN* and *EV* records. FAD option 3 is equivalent to INEV option 1. With only one control point included in the FAD file the option 3 and option 4 arrangements of *FA* records are no different.

With option 2, the *FA* records are grouped by control point in the FAD file. All of the annual *FA* records for the first control point are grouped together before the records for the second control point. The file ends with the set of records for all years for the last control point. Unlike options 1 and 3, FAD option 2 allows *FA* records to be repeated for multiple years in the same manner as *IN* records by entering the first and last years in fields 3 and 4.

With FAD option 3, like FAD option 1 or INEV option 1, the records for all control points are grouped together by year. All the *FA* records for a year are followed by a complete set of *FA* records for the next year.

With FAD option 1, the naturalized flows recorded in the *SIM* output file includes the *FA* record adjustments. With FAD options 2 and 3, the naturalized flows recorded in the *SIM* output file do not include the *FA* record adjustments.

With FAD options 2 and 3, the error check parameter ICHECK option 6 in *JD* record field 4 will record the *FA* records as well as *IN* records in the message as read.

Extraneous records other than *FA* and **** records contained in the FAD file are handled differently with option 1 versus options 2 and 3. Option 1 simply ignores all records beginning with identifiers other than *FA*. Options 2 and 3 allow insertion of comment **** records any place in the FAD file and allow the end-of-data *ED* record to be placed after the last *FA* record. Any records placed after the *ED* record is not read. However, with FAD options 2 and 3, any records other than *FA* and **** records placed before the *ED* record result in error messages. The *ED* record is not required, but without the *ED* record, no other record or blank lines can follow the *FA* and **** records.

RU Record – Regulated-Unappropriated Flow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	RU	Record identifier
2	3-8	IDCP	A6	AN	Control point identifier
3	9-12	FYR	I4	+	First year for <i>RU</i> record repeated for multiple years.
				blank,0	<i>RU</i> record is for one year only; it is not repeated.
4	13-16	LYR	I4	+	Year (Year may be repeated as necessary.)
5	17-24	RUFA(1)	F8.0	+	Stream flow adjustment for month 1
6	25-32	RUFA(2)	F8.0	+	Stream flow adjustment for month 2
7	33-40	RUFA(3)	F8.0	+	Stream flow adjustment for month 3
8	41-48	RUFA(4)	F8.0	+	Stream flow adjustment for month 4
9	49-56	RUFA(5)	F8.0	+	Stream flow adjustment for month 5
10	57-64	RUFA(6)	F8.0	+	Stream flow adjustment for month 6
11	65-72	RUFA(7)	F8.0	+	Stream flow adjustment for month 7
12	73-80	RUFA(8)	F8.0	+	Stream flow adjustment for month 8
13	81-88	RUFA(9)	F8.0	+	Stream flow adjustment for month 9
14	89-96	RUFA(10)	F8.0	+	Stream flow adjustment for month 10
15	97-104	RUFA(11)	F8.0	+	Stream flow adjustment for month 11
16	105-112	RUFA(12)	F8.0	+	Stream flow adjustment for month 12

Flow adjustments on *RU* records are stored in a *SIM* input file with the filename extension RUF. The RUF file is activated by a non-zero RUFIN or RUF entered in *JO* record fields 13 or 14. The *RU* record format is the same as the standard default *IN* and *EV* records. *RU* records are included in the RUF file for control points at which adjustments are to be applied in one or more months. *SIM* assumes adjustments are zero for any control points not included in the RUF file. *RU* records may be provided for each and all years, or a single *RU* record can be repeated for any number of years having the same 12 monthly amounts in the same manner as *IN* and *EV* records.

RU records are grouped by control point in the RUF file. All *RU* records for all years for a particular control point are entered together as a group preceded and followed by the sets of *RU* records for other control points. The *RU* record sequencing is equivalent to INEV option 2 for *IN* and *EV* records. The RUF file ends with an end-of-data *ED* record.

Motivation for adding the optional regulated-unappropriated flow (RUF) file containing sequences of *RU* records to the set of *SIM* input files stemmed from the need to incorporate regulated flows in condensed datasets. The concept of a condensed dataset is described in the *Hydrology Manual*. However, although addition of the *RU* record and RUF file was motivated by this specific type of application, the generic new *SIM* modeling feature may be used for various other types of applications as well.

The flow volumes stored in a RUF file are applied within *SIM* to adjust stream flows. The *RU* record adjustments are somewhat similar but distinctly different than the flow adjustment *FA* and constant inflow *CI* records. The *RU* record adjustments are not cascaded downstream accounting for channel losses like the *FA* and *CI* record adjustments. The *RU* record monthly volumes are optionally added to *IN* record inflows or computed unappropriated flows at alternative stages of the *SIM* simulation as specified by the parameters *RUFIN* and *RUF* entered in fields 13 and 14 of

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the *JO* record. Thus, the *RU* record flow adjustments may be applied within the *SIM* simulation in alternative ways controlled by *JO* record *RUFIN* and *RUF* option selections.

The *RUFA*(month) on *RU* records are adjustments to monthly stream flow volumes (ΔF). The *SIM* input *RUF* file was originally designed specifically for incorporating regulated flows in a condensed dataset. With this application ($\Delta F = R - U$), the *RU* records containing regulated (*R*) flows less unappropriated (*U*) flows are created with program *HYD* from *SIM* simulation results. However, as a generic feature, *RUF* files may be developed and applied in various other ways for different applications. The *JO* record parameters *RUFIN* and *RUF* allow the user to select the following options for applying the ΔF (*RUFA* from *RU* records) within the *SIM* simulation.

The *RUFIN* switch in *JO* record field 13 provides the following options.

RUFIN Option 1 – The ΔF are added to the *IN* record inflows [*INFLOW*(cp) array] immediately after reading the flows from the *FLO* or *DSS* file. The adjusted inflows are then used in the *SIM* simulation. *RUFIN* option 1 is similar to applying *CI* records from the *DAT* file or *FA* records from a *FAD* file except the adjustments are not cascaded downstream.

RUFIN Option 2 – The ΔF are added to the *INFLOW*(cp) array just before the inflows are recorded in the *SIM* output file but have no effect on the simulation computations.

The *RUF* switch in *JO* record field 14 provides the following options. *RUF* options can be used in combination with *RUFIN* option 2 but can not be applied if *RUFIN* option 1 is activated. The *RUF* options are designed primarily for incorporating regulated flows in condensed datasets as discussed in the *Hydrology Manual*. If ΔF from the *RUF* file is zero, the regulated flow is computed in the conventional manner as if there is no *RUF* file. If ΔF is not zero, the regulated flow (*R*) is computed as a function of unappropriated flow (*U*) as follows.

RUF Option 1: The regulated flow (*R*) is set at the lesser of the following two alternative values.

$$R = U + \Delta F$$

R computed in the conventional manner

RUF Option 2: $R = U + \Delta F$

RUF Option 3: $R = U + \Delta F + \text{reservoir releases}$

The reservoir releases in option 3 are releases from upstream reservoirs associated with water right types 2 or 3 that pass through the control point at which the flow adjustments are applied.

The *RUF* options affect only computation of the regulated flows which are stored as the *REGFLOW*(cp) array. The *REGFLOW*(cp) quantities are computed at the completion of the water rights simulation sequence. Thus, *REGFLOW*(cp) has no effect on any simulation results other than the regulated flows recorded in the *SIM* output file, unless the second pass option is activated by *IFMETH*(wr) on an *IF* record or *PASS2* on the *JO* record. Regulated flows are set at *REGFLOW*(cp) for the second pass through the water rights loop for purposes of determining whether instream flow targets set by *IF* records are met. Without activation of the second pass feature, the *RUF* options affect no simulation results other than the recorded regulated flows.

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. *TABLES* provides flexible post-simulation 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. Though designed primarily for managing *SIM*, *SIMD*, and *SALT* simulation results, simulation input may also be displayed with *TABLES*.

This chapter covers the application of *TABLES* with *SIM* input data and simulation results. All *SIM*-related *TABLES* routines are covered here. Additional *TABLES* features associated with daily *SIMD* simulation results are covered in the *Daily Manual*. Salinity modeling capabilities including *TABLES* salinity-related tables are covered in the *Salinity Manual*.

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. The *TABLES* output file is the only *WRAP* input or output file that is not restricted to a standard filename extension. The default extension for the *TABLES* output file is *TOU*, but other three character extensions may be used instead. All files listed in Table 4.1 may have the same filename root. Optionally, the *TIN* and *TOU* files may have filename roots that are different from both each other and the *SIM* files.

The *TABLES* input *TIN* file specifies the tables and/or other types of information to be developed and stored in the *TABLES* output *TOU* file. This chapter focuses on the input records entered in a *TIN* 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, but various *TABLES* options 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. Thus, *TABLES* is very modular. Each input record entered in the *TIN* file builds a set of tables or data listings independently of the other records in the *TIN* file.

TABLES reads one record of the *TIN* input file (filename extension *TIN*); develops the set of tables specified; stores the tables in the *TOU* output file (extension *TOU*); and then goes on to the next record of the input file. The input records are handled in sequential order. Thus, erroneous

TABLES

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 from the message file trace the last record read. *TABLES* also writes various error and warning messages to the monitor and/or message TMS file to help in detecting and correcting blunders in the TIN file.

Table 4.1
TABLES Input and Output File Types

<u>TABLES Input Files Pertinent to this Manual</u>	
root3.TIN	required <i>TABLES</i> input file with specifications regarding tables to be developed
root1.DAT	<i>SIM/SIMD</i> input DAT file
root1.OUT	<i>SIM/SIMD</i> output OUT file
root1.HRR	<i>SIM/SIMD</i> output HRR file
root1.ZZZ	<i>SIM/SIMD</i> output ZZZ file
root2.DIS	<i>SIM/SIMD</i> input DIS file
root1.CRM	<i>SIM/SIMD</i> conditional reliability modeling output file
root1.SFF	storage-flow-frequency file created by 5CR1 record and read by 5CR2 record

<u>TABLES Output Files Pertinent to this Manual</u>	
root4.TOU	<i>TABLES</i> main output file (optional filename extension with default TOU)
root4.TMS	<i>TABLES</i> message file
root4.DSS	Hydrologic Engineering Center Data Storage System file created by <i>TABLES</i>

<u>Additional TABLES Input Files Addressed in the Daily and Salinity Manuals</u>	
root1.SUB	<i>SIMD</i> sub-monthly time step simulation results
root1.AFF	annual flood frequency file created by <i>SIMD</i> with peak flows and storage
root1.SAL	salinity simulation results file produced by program <i>SALT</i>

The types of *TABLES* input records 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 and data sets.

Some of the *TABLES* input records in the TIN file 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 and other simple arithmetic combining of data are involved. Other subroutines include more complex arithmetic or sorting operations. For example, a 1SRT record calls a subroutine containing a water rights sorting algorithm. A 1CPT record sorts control points in upstream-to-downstream order. A 2REL record computes period and volume reliabilities. A 2FRE record develops frequency statistics for naturalized, regulated, or unappropriated stream flow, reservoir storage, or instream flow shortages. A 2RES record activates a subroutine that develops reservoir drawdown-frequency and storage-reliability tables and storage tabulations with storage converted from volume units to percentages of storage capacity. A 2BUD record activates relatively extensive computations to develop water budgets for control points and the entire river basin.

Table 4.2
Input Records and Associated Tables

Miscellaneous Records

TITL – titles or headings	DATA – dataset transformation
COMM or **** – comments	IDEN – identifiers
PAGE – title page	UNIT – units for table headings
FILE – binary OUT file and DSS file	ENDF – end of input data file
TEST – checks of <i>SIM</i> output file	

Type 1 Records – Tables Developed from *SIM* Input DAT File

1REC – listing of specified input records
1SUM – water rights summary by control point, type of use, type of right, or group
1SRT – listing of water rights sorted by priority, type of use, control point, or water right type
1LEN – removes comments written to the right of column 128 of the input records
1CPT – listing of control point information in upstream-to-downstream order

Type 2 Records – Tables Developed from *SIM* Output OUT File

Time Series Tables in Optional Formats or HEC-DSS File

IDEN – control point, water right, reservoir, and water right group identifiers
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 at this control point from upstream reservoir releases
2CPI – control point inflows excluding secondary reservoir releases
2STO – reservoir storage
2EVA – reservoir evaporation-precipitation volume
2EVR – reservoir evaporation-precipitation rates
2EPD – adjusted reservoir evaporation-precipitation depth
2DEP – stream flow depletion
2TAR and 2SHT – diversion target and diversion shortage
2DIV – diversion
2RFL – return flow
2XAV – increase in available stream flow resulting from <i>PX</i> record cp limit option
2ASF – available stream flow
2IFT and 2IFS – instream flow target and instream flow shortage
2FSV and 2FSC – flow switch volume and flow switch count
2ROR – releases from other reservoirs
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

TABLES

Table 4.2
Input Records and Associated Tables (Continued)

2RAH – releases accessible to hydropower
2RNA – releases not accessible to hydropower
2WSE – reservoir water surface elevation
2RSC and 2RSD – reservoir storage capacity and drawdown

Reliability and Frequency Tables

2REL – reliability summary by control point, water right, water right group, or reservoir
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 and Water Budget 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(s)
2BUD – water budget for control points and/or the entire river basin(s)

Type 3 Records – Input Records Developed from SIM Output OUT File

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

Type 4 Records – Tables Developed from SIM HRR and ZZZ Files

4HRR – hydropower multiple-reservoir system reservoir releases from HRR file
4ZZF – frequency tables for flows from priority sequence flow ZZZ file
4ZZZ – times series tables or DSS records for flows from ZZZ file

Type 5 Records – Conditional Reliability Modeling Results from SIM CRM File

5CRM – conditional reliability modeling
5CR1 – develop flow-frequency or storage-flow-frequency relationship
5COR – correlation analysis

Other TABLES TIN File Record Types Covered in the Daily and Salinity Manuals

Type 6 – sub-monthly time step reliability and frequency tables from SIMD SUB file
Type 7 – flood frequency analyses from SIMD AFF file
Type 8 – salinity simulation results from SALT SAL file

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
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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	TARGET DIVERSION (AC-FT/YR)	MEAN SHORTAGE (AC-FT/YR)	**RELIABILITY** PERIOD (%)	VOLUME (%)	++++PERCENTAGE OF MONTHS++++ WITH DIVERSIONS EXCEEDING PERCENTAGE OF PERMITTED DIVERSION					-----PERCENTAGE OF YEARS-----						
					100%	95%	90%	75%	50%	25%	1%	100%	98%	95%	90%	75%

Table 4.6
Headings for Frequency Tables Specified by 2FRE Record
(Heading for first column may be either control point, water right, or reservoir.)

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%

Table 4.7
Headings for Monthly Summary Specified by 2SWR Record

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)
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Table 4.8
Headings for Annual Summary Specified by 2SBA Record

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

Input Records and Associated Tables

The tables or datasets to be developed are specified by records in an input file with the filename extension TIN. Each type of table is created with an input record that begins with a four-character record identifier, followed by parameters providing instructions for creating the tables or dataset. All records are optional; there are no required records. With the exception of TITL, IDEN, and DATA records, no limits are placed on the number or sequential order of the records.

Miscellaneous Records

TITL records provide titles or headings to be reproduced on the cover page and at the top of each type 2 or 3 table. Zero to five TITL records are placed at the beginning of the TIN file.

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

The FILE record indicates that the *SIM* OUT or CRM output file is in binary machine language. The formatted versus unformatted form of the *SIM* output file is controlled by *JD* record field 7. The FILE record also optionally creates and provides information for a DSS file.

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. Units pertain only to table headings, not actual computations. *TABLES* computations are manipulations of the *SIM* simulation results performed without reference to units.

The TEST record activates tests of the *SIM* output OUT file that are described in the *Reference Manual* Chapter 7. The TEST record is designed to be used only in rare instances in which *TABLES* is not able to read the OUT file for unknown reasons.

The DATA record converts simulation results to other datasets that are read by time series and frequency records. Options are provided for manipulating *SIM* and *SIMD* simulation output.

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, 1LEN, 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, 1LEN, 1CPT) signifying that the source of data is a *SIM* input DAT file. All four records create tables from data read from the main *SIM* DAT 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 are used to define records to be listed.

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. Other options consist of listing various sets of information from the *CP* records. Watershed area read from *WP* records in the *DIS* file may also be included in the tabulations.

Type 2 Records – Tables are developed from data from a SIM output OUT 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 5.3, 5.4, and 5.5 of the *Reference Manual*. 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.

Time Series Tables and Data Sets

The *SIM* simulation results described in *Reference Manual* Chapter 5 are tabulated as a standard set of time series tables by 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2RFR, 2URR, 2CPI, 2STO, 2EVA, 2DEP, 2DIV, 2TAR, 2SHT, 2RFL, 2XAV, 2ASF, 2ROR, 2IFT, 2IFS, 2HPS, 2HPE, 2RID, 2RAH, 2RNA, 2EPD, 2EVR, 2WSE, and 2RSC records. These *TABLES* input records all have the same format. The time series tables created by these records also all have the same format. The simulation results may be tabulated directly or optionally as moving averages or after other arithmetic adjustments. The time series are converted by *TABLES* to three optional formats:

- tables with annual rows and monthly columns with headings shown in Table 4.4
- tabulations in a columnar format designed for transporting to Microsoft Excel
- records in a HEC-DSS file designed to be read by HEC-DSSVue

TABLES

Reliability and Frequency Tables

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 reservoir/hydropower projects. Separate 2REL records would be used to obtain separate reliability summary tables for selected water rights, control points, and hydroelectric power reservoirs, respectively. Volume reliability is the mean volume supplied (or hydroelectric energy generated) divided by the corresponding mean target diversion volume (or target energy production), expressed as a percentage. Period reliability is the percentage of time during which either 100% or a specified percentage of the target demand is met. The 2REL 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 discussed in *Reference Manual* Chapter 5.

The 2FRE record determines the mean, standard deviation, and frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with specified control points, or the reservoir storage or instream flow shortage associated with specified water rights, or the storage or water surface elevation for specified reservoirs or DATA record data. The flow or storage amount is computed for each of the exceedance frequencies shown in Table 4.6 based optionally on relative frequency counts or the log-normal or normal probability distributions. The exceedance frequencies are measures of the percentage-of-time, probability, or likelihood that the flow or storage variable equals or exceeds the amounts shown in the table.

The 2FRQ record also develops an exceedance 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, or the storage or water surface elevation for specified reservoirs. The frequencies associated with up to seven user-specified flow or storage amounts are computed based on relative frequency counts.

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 2FRE and 2FRQ records may be found in the *Reference Manual* and *Fundamentals Manual*. Frequency analysis methods are discussed in Chapter 5 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 2RES 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.

Summary Tables

2SCP, 2SWR, 2SGP, and 2SRE records result in summary tables of key variables 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 a monthly summary table created by a 2SWR record is shown as Table 4.7. Each row of data in the table corresponds to a month in the hydrologic period-of-analysis.

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 stream flow 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 headings shown in Table 4.8. The naturalized, regulated, and unappropriated stream flows 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. A monthly table has an additional column for the month and 12 times as many rows as the annual table of Table 4.8.

Water Budget Tables

A 2BUD record develops a monthly control point water budget table and/or a period-of-analysis river basin water budget table. Monthly computations are performed for all control points in developing the total river basin water budget table. The water budgets are tabulations of the individual components of inflows to and outflows from the control point or river basin along with changes in reservoir storage. The following water budget equation is confirmed.

$$\text{sum of all inflows} - \text{sum of all outflows} = \text{change in storage}$$

The 2SCP, 2SWR, 2SGP, and 2SRE records described above tabulate simulation results from a *SIM* output file with only minor computations. The 2BUD routine uses *SIM* input and output data in the relatively extensive computations that are required to develop all components of a complete detailed monthly water budget for individual control points. The monthly data are also used to develop a period-of-analysis river basin water budget summary table.

TABLES

Type 3 Records – Input records are developed from data from a SIM output file.

Type 3 records instruct *TABLES* to read naturalized flows, regulated flows, unappropriated flows, stream flow depletions, and/or evaporation-precipitation depths from a *SIM* output file and convert these data to records in the format of *SIM IN* or *TS* records. The resulting time series 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 stream flows (3NAT record)
- regulated stream flows (3REG record)
- unappropriated stream flows (3UNA record)
- stream flow depletions (3DEP record)
- summation of stream flow 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 stream flow 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 stream flows.

A 3NAT record creates stream flow records in the format of *SIM* input *IN* or *TS* records containing the naturalized stream flows 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 stream flow depletions at each control point (3DEP record) are written on the records instead of naturalized stream flows (3NAT). A 3U+D record is the same as the others except the summation of unappropriated flows and stream flow 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 stream flow 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 stream flows from *SIM* simulation results as input to either *SIM* or another model. For example, regulated flows computed by *SIM* for a particular water management strategy may be treated as *TS* record instream flow requirements for other executions of *SIM*. Yield analyses at a single control point may be performed for previously computed unappropriated flows converted to *IN* records.

The *HYD OI* record described in the *Hydrology Manual* provides similar capabilities for converting *SIM* OUT file simulation results to input records. *HYD* also provides capabilities for cascading flows considering channel losses and various other flow volume and evaporation-precipitation depth manipulations involving simulation results read from the *SIM* output OUT file.

Type 4 Records – Tables are developed from data from either a SIM HRR or ZZZ file.

Type 4 records result in tables being developed from the data contained in the *SIM* special purpose HRR and ZZZ output files. The 4HRR record organizes data contained in a *SIM* hydropower and multi-reservoir system release file with filename extension HRR. 4ZZF and 4ZZZ records organize simulation results from a priority sequence flow file with filename extension ZZZ.

A 4HRR record tabulates monthly or annual hydroelectric energy targets and actual energy production and releases from all reservoirs associated with a water right. Reservoir releases for a given water right are listed as a line (record) in the HRR file for each month. The data in each line may include releases from multiple reservoirs associated with that water right along with reservoir identifiers. The 4HRR record reads the HRR file and creates tables with monthly hydropower targets, energy produced, and releases from each reservoir listed as columns. 4HRR record options include monthly or annual tables with or without inclusion of hydropower data. JO record field 4 of the *SIM* DAT file specifies whether or not *SIM* creates a HRR file is created. The same water rights are included in both the OUT and HRR output files.

A ZZ record in a *SIM* DAT file activates a feature described in *Reference Manual* Chapter 6 that tabulates regulated flows, available flows, and reservoir releases at specified control points in a ZZZ file as each water right is simulated in the priority sequence. The TABLES 4ZZF and 4ZZZ record routines read the flows from the ZZZ file. The 4ZZF record builds frequency tables similar to the 2FRE record. The 4ZZZ record organizes the flows as tables in the TOU file or DSS file records in the same manner as type 2 time series records.

Conditional Reliability Modeling

A conditional reliability CR record entered in a *SIM* or *SIMD* input file activates the CRM mode of modeling as described in Chapter 7 of the *Reference Manual*. As indicated in Table 5.2 of the *Reference Manual*, nine numbers are recorded in the 5th record of the *SIM* output file, with the last four being CR1, CR2, CR3, and CR4 from the CR record. *SIM/SIMD* simulation results are written to a file with the filename extension CRM. A 5CRM or 5CRM2 record entered in a TABLES input file causes the *SIM/SIMD* CRM output file (filename root.CRM) to be opened in preparation for activating the conditional reliability modeling (CRM) features of TABLES.

The 5CRM, 5CRI, 5CR2, and 5COR records are the only TABLES input records that are used solely for CRM. The other TABLES input records and associated tables are applicable for either CRM or conventional non-CRM simulations. The 5CRI and 5CR2 records activate the routines for assigning probabilities to simulation sequences in reliability and frequency analyses. Without these records, the equal-weight option is adopted by default. With the equal-weight option, the computations associated with the 2REL, 2FRE, 2FRQ, and 2RES records are the same with either a CRM or conventional modeling application. With the probability array option activated by a set of 5CRI and 5CR2 records, an array of probabilities associated with the simulation sequences is provided to the 2REL, 2FRE, 2FRQ, and 2RES record routines.

The sole purpose of a set of 5CRI records is to develop a flow-frequency (FF) or storage-flow-frequency (SFF) relationship from the results of a conventional long-term *SIM/SIMD*

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simulation. The purpose of a set of *5CR2* records is to develop an incremental probability (IP) array using the FF or SFF relationship previously created by *5CR1* records. The incremental probability array created with a *5CR2* record is used by the *2REL*, *2FRE*, *2FRQ*, and *2RES* record routines. A set of *5CR1* and *5CR2* records include a main *5CR1* record and main *5CR2* record along with supplemental *5CR1* and *5CR2* records listing pertinent control points, reservoirs, and initial storage. The parameters on the main *5CR1* and *5CR2* records refer to a series of intermediate computational steps in the procedure that produces the FF or SFF relationship (*5CR1* record) and the final incremental probability array (*5CR2* record).

The final product of a set of *5CR1* and *5CR2* records is an incremental probability (IP) array assigning probabilities to each hydrologic sequence of the CRM that is used as input to the reliability and frequency analysis routines activated by *2REL*, *2FRE*, *2FRQ*, and *2RES* records. The probability array remains in computer memory for use by any number of subsequent *2REL*, *2FRE*, *2FRQ*, and *2RES* records. If more than one *5CR2* record set is included in a *TABLES* input file, the IP array created by the last *5CR2* record set read will be in effect for those *2REL*, *2FRE*, *2FRQ*, and *2RES* records read after it. A *5CR2* record set applies to all records located after the *5CR2* records in the *TABLES* input file but before any subsequent set of *5CR2* records.

The main simulation results output file created by two different executions of *SIM/SIMD* are read by *TABLES*. These two files have filename extensions OUT and CRM. The *5CR1* record develops a FF or SFF relationship from the results of a conventional long-term *SIM* simulation read from an OUT file. The *5CR2* record develops an incremental probability (IP) array by combining the flow-frequency (FF) or storage-flow-frequency (SFF) array with storage and flow data from the CRM output file of a conditional reliability modeling (CRM) application of *SIM* or *SIMD*.

Format and Content of Input Records in TIN File

Program *TABLES* reads *SIM* input and output files and builds a set of user-specified tables and data listings which are written to the TOU output file. Another *TABLES* input file with the filename extension 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 *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 consist 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

TABLES may incorporate all water rights, control points, or reservoirs included in the *SIM* OUT file in its tables without having to list them on the TIN file records. Alternatively, several of the TIN file records include options allowing identifiers of water rights, groups of water rights, control points, or reservoirs to be listed in order to include a smaller sub-set of all those included in

the OUT file. Only eight identifiers (character variables) can be entered on one record, but records may be repeated allowing a total of up to 80 identifiers to be listed. 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.

Character variables (A format) input to Fortran programs are often right justified to prevent the trailing blanks from being read. However, the WRAP programs incorporate a read feature that 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.

Legend for Format Column of Following Tables

- A4 Alphanumeric (AN) label (character variable) in a field that is 4 characters wide.
- 8A8 Up to 8 alphanumeric labels in fields that are 8 characters wide.
- 2x Two blank spaces.
- 2x,A6 Two blank spaces , followed by a 6-character wide alphanumeric label.
- I8 Integer number right justified in field of 8 characters.
- I4 Integer number right justified in field of 4 characters.
- F8.0 Real number in field of 8 digits either right justified or with decimal included.

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Table 4.9 Quick Reference Chart for TABLES Input Records

columns											Page
4	8	12	16	20	24	28	32	36	40	44	
TITL											133
COMM											133
PAGE											133
ENDF											134
FILE OUTFOR DSSMES DSSMON											134
UNIT											135

Job Type 1 Records - Tables from SIM Input File Data

1REC	KK	NUM	REC	REC	REC	REC	REC	REC	REC	REC	136
1SUM	KK										136
1SRT	KK	IFF									136
1CPT	KK		OO		LIM		CPLIM				137

Job Type 2 Records - Tables from SIM Output OUT File Data

IDEN											145
DATA	DC2	ID	NUM	D(1)	D(2)	D(3)	D(4)	D(5)	D(6)	D(7)	147
2REL	MON	RFLAG	ID	NUM		TAR	VUL				150
2FRE	ID	MON	NUM	TABLE	METH	MAT	TIME		XF		152
2FRQ	ID	MONTH	NM		IDEN		QF(1)		QF(2)		154
2RES	TABLE	MONTH	NUM		IDEN		IDEN		IDEN		155
2SCP	MNAN	NUM		IDCP		IDCP		IDCP		IDCP	157
2SWR	MNAN	NUM				IDEN16				IDEN16	157
2SGP	MNAN	NUM		IDEN8		IDEN8		IDEN8		IDEN8	158
2SRE	MNAN	NUM		IDRES		IDRES		IDRES		IDRES	159
2SBA	MNAN										150
2BUD		CPBUD	YRF	YRL	ICP1	BEGST	NEGIN	CPOUT	BASIN		15-
2NAT	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2REG	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2UNA	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2CLO	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2CLC	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2STO	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2EVA	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2DEP	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2TAR	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2DIV	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2SHT	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2RFL	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2IFT	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2IFS	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2FSV	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2FSV	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2WRE	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141
2RSD	TA	PT	MORE	ID	NUM	DEC	MAT	TIME		XF	141

Job Type 4 Records - Tables from SIM Output HRR File Data

4HRR	HR	MNAN	NUM		IDEN		IDEN		IDEN		162
4ZZF	VAR	MON	TABLE	NUM							163
4ZZZ	TA	PT	MORE	VAR	NUM						164
4	8	12	16	20	24	28	32	36	40	44	Page

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 these 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

An optional cover page inserted at the beginning of the *TABLES* output TOU file provides miscellaneous information identifying the dataset but in no way affects the computations or any of the tables generated. The cover page is not written unless the TIN file contains type 2 records.

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 is used to check the OUT file only if *TABLES* terminates for unknown reasons that could be related to reading the OUT file. The TEST record activates a series of error checks of the *SIM* output OUT file which are described in the *Reference Manual* Chapter 8. The OUT file must be in the default text format, not the optional unformatted binary version.

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ENDF Record – End of Input File

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

Records placed after the optional ENDF record are not read. Multiple alternative sets of records separated by ENDF records can be stored in the same TIN file.

FILE Record – Binary *SIM* OUT Output File and *TABLES* DSS Output File Options

field	columns	variable	format	value	description
1	1-4	CD	A4	FILE	Record identifier
<i>Format of SIM OUT or CRM Output File</i>					
2	8	OUTFORM	I4	blank, 0 1	Default text file version of SIM OUT or CRM file. Binary machine language version of OUT or CRM file.
<i>DSS Message File Options</i>					
3	12	DSSMES	I4	-1 1 blank, 2 3 4 7 8 9	Messages are written only if <i>TABLES</i> is terminated due to some DSS related problem. Messages that DSS file has been opened or closed. Error or warning messages if DSS problems occur. Trace of all DSS records written to DSS files. Trace of all DSS records read from DSS files. Beginning level of debugging messages. Intermediate level of debugging messages. Maximum level of debugging messages.
<i>Label of First Month in DSS File</i>					
4	14-16	DSSMON	1x,A3	blank AN	Default is for first month to be January. First month in DSS file (JAN, FEB, MAR, ... , DEC)

OUT and/or DSS files may be used with *TABLES* without a FILE record. The OUT file is opened by any type 2 record. A DSS file will be created automatically even without a FILE record for the DSS options (PT = 4 or 5) in field 3 of the time series records (pages 141-143) or 4ZZZ record. A DSS output file is also activated similarly by sub-monthly time series and 8SAL records covered in the *Daily* and *Salinity Manuals*. The defaults for the FILE record parameters OUTFORM, DSSMES, and DSSMON will be adopted automatically without a FILE record.

Field 2: The formatted text versus unformatted binary form of the *SIM* OUT or CRM output file is controlled in *SIM* by *JD* record field 7. The FILE record is required as a flag that the OUT file is in binary machine language. If the *SIM* output file is in text format, the FILE record is not required.

Fields 3 and 4: FILE record fields 3 and 4 provide the same information for a *TABLES* DSS output file as *OF* record fields 7 and 8 provide for a *SIM* DSS input or output file. Information is provided for a Hydrologic Engineering Center (HEC) Data Storage System (DSS) output file created by *TABLES*. The beginning month in field 4 may alternatively be provided in the UNIT record field 4.

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 <i>UNIT</i> record, the default is AC-FT.
3	10-14	UNHP	A5	AN blank	Hydropower units printed in table headings. Without a <i>UNIT</i> 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:

$$\begin{aligned} \text{UNIT} &= \text{AC-FT} \\ \text{UNHP} &= \text{MW-HR} \end{aligned}$$

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.

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1REC Record – Listing of Specified Records from *SIM* Input DAT File

field	columns	variable	format	value	description
1	1-4	CD	A4	1REC	Record identifier
2	5-8	KK	I4	blank, 0 non-zero	List specified records 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 1 2 3 4	Summary by control point with only totals printed Summary by control point Summary by type of use Summary by water right type 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 1 2 3 4	Listing of rights in priority order Listing of rights by control point in priority order Listing of rights by type-of-use in priority order Listing of rights by water right type in priority order Listing of rights by GO record group in priority order
3	12	IFF	I4	blank, 0 1, +	Instream flow rights are not included in the table. Instream flow rights are included in the table.

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 *TOU* 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 1 2 3 4 5 6 7	Reproduction of CP records in rearranged order Listing of only control point identifiers, CPID(cp,1) Listing of cp and next downstream cp identifiers Listing of cp and next upstream cp identifiers Listing of INMETHOD and CL from CP records Option 4 listing with DA from WP records added data from options 2-5 combined: CPID(cp,1), INMETHOD, CL, DA, CPID(cp,2), NUP, upstream cps No written output. ICP(I) array for 2BUD record.
3	16	OO	I8	blank,0,1 2	Order based on listing cp before all downstream cp's Order based on full-length stream tributaries
4	17-24	LIM	I8	-1, - blank,0,+	List only control points with INMETHOD = 0 or 1 Include all control points in the output listing
5	25-32	CPLIM	2x,A6	AN blank	Include only cps located downstream of this cp 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 (<i>CP</i> record field 2)
INMETHOD	method for obtaining naturalized flows (<i>CP</i> record field 6)
CL(cp)	channel loss factor (<i>CP</i> record field 9)
DA(cp)	drainage area (<i>WP</i> record field 3)
CPID(cp,2)	identifier of next downstream control point (<i>CP</i> 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.

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Time Series of SIM Simulation Results in OUT File Read by TABLES

Program *TABLES* reads the *SIM* output OUT file that contains the monthly time series variables defined in detail in Chapter 5 of the *Reference Manual* and listed 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 the water right output records.

Table 4.10
SIM Output Record Fields Read by TABLES

Time Series Input Record	Control Point ID = 0	Water Right ID = 1	Reservoir/Hydropower ID = 2	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			
2CPI	field 10 – 13 + 6			
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
2XAV		WR field 14		
2ASF		WR/IF field 8		
2ROR		WR/IF field 9		
2IFT	CP field 14	IF field 11		
2IFS	field 14–field 10	IF field 12		
2FSV		IF field 13		
2FSC		IF field 14		
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	
2EVR			R/H field 11	
2WSE			R/H field 12	
2RSC			R/H field 13	
2RSD			R/H field 13 – field 5	

The following list consists of the *TABLES* input record identifiers tabulated in the first column of Table 4.10 and brief descriptions of the corresponding variables from the *SIM* simulation results output OUT file. All of these time series variables are of monthly amounts. All are monthly volumes with the exception of the 2EPD, 2EVR, 2WSE, and 2FSC record variables. The *TABLES* time series input record for each variable has the format outlined on pages 142-143.

- 2NAT** Naturalized stream flows read from *IN* records or computed with flow distribution methods.
- 2REG** Regulated stream flows computed by *SIM* as defined in the *Reference Manual* Chapter 5.
- 2UNA** Unappropriated stream flows as defined in the *Reference Manual* Chapter 5.
- 2CLO** Channel losses for the river reach below a control point.
- 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 and hydropower and *IF* releases 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.
- 2CPI** Inflow to control point excluding 2URR record reservoir releases.
- 2STO** End-of-month reservoir storage may be for an individual water right or reservoir or summation of storage for all reservoirs assigned to a same control point.
- 2EVA** Reservoir net evaporation-precipitation volume may be for an individual water right or reservoir or summation for all reservoirs assigned to that same control point.
- 2DEP** A stream flow depletion is the amount of water appropriated by a water right to meet diversion requirements and/or refill reservoir storage while accounting for net evaporation.
- 2TAR** Diversion (type 1, 2, 3), hydropower (type 5, 6), or storage (type 7) targets are set with *WR*, *UC*, *SO*, *TO*, *DI*, *FS*, *BU*, *TS*, and other *SIM* input records. For an *IF* record right with a storage option activated (*IFMETH* = 3 or 4), the target is a reservoir release target.
- 2SHT** For *WR* record right, amount of failure to meet diversion, energy, or storage target. Secondary energy is recorded as a negative hydropower shortage. For an *IF* record right, the shortage is the failure amount in meeting an *IFMETH* 3 or 4 reservoir release target.
- 2DIV** The actual diversion (type 1, 2, 3), hydropower production (type 5, 6), or storage refilling (type 7) amount is not included in the *SIM* output file but rather is computed by *TABLES* as the target minus the shortage. For *IF* record rights, release from an *IFMETH* 3 or 4 reservoir is reported. An intermediate target and shortage may be selected on *SO* record.
- 2RFL** Diversion return flow for water right is the volume returned to the stream system.
- 2XAV** Increase in available stream flow resulting from *PX* record control point limit option.
- 2ASF** The amount of stream flow 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.
- 2FSV** accumulated total volume of flow switch variable during *FS* record flow switch period

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- 2FSC** count of number of months that flow volume is within range defined by *FS* record bounds
- 2HPS** The hydroelectric energy shortage (positive number) or secondary energy (negative number) associated with the most junior hydropower right at the reservoir. Shortage is amount of failure to meet energy production target. Secondary energy is defined in *Reference Manual*.
- 2HPE** The accumulative total energy generated by the most junior right at the reservoir. The portion of the hydroelectric energy target that was supplied.
- 2RID** Stream flow depletions associated with a reservoir include all the water taken from stream flow 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 as defined by the parameter *LAKESD* on the *SIM WS* record.
- 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.
- 2EVR** *EV* record evaporation-precip depths prior to adjustments reflected in the 2EPD records.
- 2WSE** End-of-month reservoir water surface elevation from interpolation of *PV/PE* records.
- 2RSC** Reservoir storage capacity volumes set by *SIM* based on *WS*, *MS*, and *OS* records.
- 2RSD** Draw-downs are computed by subtracting contents (2STO) from capacities (2RSC).

Alternative Formats for TABLES Time Series Output

The *TABLES* input record types described on the following three pages convert the time series variables listed above to alternative formats. The time series data may be written to the tables in the TOU file and/or a DSS file directly as the variables defined above as read from the simulation results in the *SIM OUT* file. Optionally, moving averages or moving totals of the data for a user-specified number of months may be computed. The data or its moving averages or totals may be adjusted by multiplying by a specified factor and/or adding a given constant. The original or adjusted data is written to the TOU file and/or the DSS file in the following formats.

- A text file with the filename extension TOU 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 separate tables. This format is designed for report preparation and convenient viewing of simulation results.
- A text file with the filename extension TOU has each time series variable of interest tabulated as one column of a single table. This format is designed for convenient conversion to a Microsoft Excel spreadsheet for plotting or further computations. Either the monthly data or annual totals may be tabulated.
- A binary file with the filename extension 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. Either the monthly data or annual totals may be tabulated.

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/hydropower.

2NAT Record	– Naturalized Stream Flow (control points)
2REG Record	– Regulated Stream Flow (control points)
2UNA Record	– Unappropriated Stream Flow (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	– Upstream Reservoir Releases (control points)
2CPI Record	– Control Point Inflows excluding Secondary 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	– Stream Flow 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)
2XAV Record	– Increase in Available Stream Flow Resulting from <i>PX</i> Record CP Limit Option (water rights)
2ASF Record	– Available Stream Flow (water rights)
2ROR Record	– Releases from Other Reservoirs (water rights)
2IFT Record	– Instream Flow Target (instream flow rights, control points)
2IFS Record	– Instream Flow Shortage (instream flow rights, control points)
2FSV Record	– Flow Switch Volume (instream flow rights)
2FSC Record	– Flow Switch Count (instream flow rights)
2HPS Record	– Hydropower Shortage (+) or Secondary Energy (–) (reservoir/hydropower)
2HPE Record	– Energy Generated (reservoir/hydropower)
2RID Record	– Inflows to Reservoir from Stream Flow Depletions (reservoir/hydropower)
2RIR Record	– Inflows 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	– Adjusted Evaporation-Precipitation Depths (reservoir/hydropower)
2EVR Record	– Evaporation-Precipitation Depths from <i>EV</i> Records (reservoir/hydropower)
2WSE Record	– Reservoir Water Surface Elevation (reservoir/hydropower)
2RSC Record	– Reservoir Storage Capacity (reservoir/hydropower)
2RSD Record	– Reservoir Storage Drawdown (reservoir/hydropower)

TABLES

Time Series Records – Record Types Listed on Preceding Page

field	columns	variable	format	value	description
1	1-4	CD	A4	page 141 2DAT	Record identifier from the list of 33 identifiers on the preceding page or 2DAT to connect to a DATA record.
2	8	TA	I4	blank,0 1	Do not develop annual row/monthly column table. Develop table with annual rows and monthly columns.
3	12	PT	I4	blank,0 1 2 3 4 5 6	Do not activate either HEC-DSS or text file option. Develop columns of monthly data in TOU text file. Develop columns of annual quantities in text file. Develop columns of 12 monthly means in text file. Develop HEC-DSS monthly time series records. Develop HEC-DSS annual time series records. The mean for the entire simulation in TOU text file.
4	16	MORE	I4	0 1	Write columns; next record starts a new table. Add more columns to existing table or start first table.
5	20	ID	I4	0 1 2 3	Develop tables for default ID or for control points. Develop tables for water rights. Develop tables for reservoirs. Develop tables for water right groups.
6	24	NUM	I4	blank,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, rights, reservoirs, or right groups listed on a previous record. Number of control points, water rights, reservoirs, or water right groups to follow on IDEN records.
7	28	INPUT	I4	blank,0,1 2	Annual dataset from DATA record. Monthly or daily dataset from DATA record.
8	32	DECIMAL	3x,A1	blank 0,1,2,3,4	Standard number of digits. Number of digits to the right of the decimal.
9	36	MAT	I4	blank,0 1 2	Moving average/total option is not adopted. Moving averages are computed for TIME months. Moving totals are computed for TIME months.
10	37-40	TIME	I4	+	Number of months for moving averages or totals.
11	41-48	XF	F8.0	+, -, blank	Multiplier factor. Default multiplier factor = 1.0
12	49-56	AF	F8.0	+, -, blank	Addition factor. Default addition factor = 0.0

Explanation of Time Series Input Record Fields

Field 1: Variables are selected by this record identifier. One of the 33 alternative record identifiers, indicating variable selection, listed on page 141 may be entered in field 1. The equivalent daily time step (type 6) identifiers are described in the *Daily Manual*. Alternatively, the data array developed by a DATA record can be accessed by entering 2DAT or 6DAT for the field 1 *CD*. In this case, a DATA record is located ahead of the time series record in the input TIN file. The time series record will use the data array created by the DATA record.

Fields 2 and 3: The types of tables or datasets to be created are selected in fields 2 and 3. Program *TABLES* creates no output if fields 2 and 3 are both blank. Parameter *TA* in field 2 deals only with monthly data. Field 3 must be activated to deal with annual or daily data. Options selected by *PT* in field 3 are applicable with either annual, monthly, or daily data.

Field 2: A set of one or more tables with rows for years and columns for months and annual totals or means is created by entering the integer 1 in field 2. The tables are written to the *TABLES* output file which has a default filename extension TOU.

Field 3: Either columns of data may be written to the TOU file or HEC-DSS records may be written to the DSS file. The data may include either monthly, daily, or annual amounts. Annual amounts may be accessed from a DATA record array or annual means or totals may be computed directly from monthly quantities read from the *SIM* output OUT file.

A TOU file 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 convenient for transport to a spreadsheet program. The column may contain either the entire time series of monthly data (*PT*=1), annual totals or means for each year (*PT*=2), or a set of 12 means for each of the 12 months of the year (*PT*=3). The parameter *MORE* in field 4 controls whether another column is added to the current table or a new table is started.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a HEC-DSS file, accessible to graphing and other capabilities provided by HEC-DSSVue. 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 2REG, 2DIV, 2WSE, etc.
- D – date of the beginning of the time series such as 01JAN1938
- E – time interval = MON or YEAR for *SIM* results (*SIMD* includes sub-monthly.)
- F – CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

PT option 6 condenses the output to a single mean for the entire simulation for each specified control point, water right, or reservoir along with a total summation of the means.

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 *MORE* 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 *MORE* of zero in order to write the table.

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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 ($ID=3$) as indicated in Table 4.10. For 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 data for all water rights in a group ($ID=3$) may be tabulated by 2STO, 2EVA, 2DEP, 2TAR, 2SHT, or 2DIV records by entering a 3 in field 5.

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, *NUM* control points, water rights, reservoirs, or water right groups may be selected by listing identifiers on one to ten supplemental IDEN records. Water right groups may be selected only by listing them. A negative value for *NUM* may be entered in field 6 to indicate that the list read from a previous record is to be repeated. IDEN records are used if and only if *NUM* is a positive integer.

Field 7: A DATA record array is accessed by entering 2DAT in field 1. The DATA record manipulates monthly *SIM* or daily *SIMD* simulation results and may use these data to develop an annual dataset with one quantity per year. The field 7 default option 1 is to use the annual series.

Field 8: The data in the tables or tabulations created by *TABLES* may be recorded with either zero, 1, 2, 3, or 4 digits to the right of the decimal point. A blank field 7 results in a standard default number of digits that varies between variables and with the magnitude of the number.

The model-user will normally not want to record the simulation results in the *TABLES* output with more digits to the right of decimal than provided in the *SIM* output. *SIM* writes diversion targets and shortages in the OUT file with 3 digits to the right of the decimal (to nearest 0.001 unit). Net evaporation depths are recorded to the nearest 0.0001 unit. Reservoir water surface elevations in the *SIM* output file have three digits to the right of the decimal. Instream flow targets and shortages are recorded to the nearest 0.01 unit for instream flow rights and 0.1 unit for control points. The other variables in the OUT file have 2 digits to the right of the decimal (to nearest 0.01 unit). The format of the *SIM* output OUT file records and variables is described in Chapter 5 of the *Reference Manual*.

Fields 8 and 9: A non-zero *MAT* in field 8 results in the monthly time series data being converted to either moving averages or moving totals for *TIME* months, where the number of months *TIME* is entered in field 9. A moving total is the summation of amounts during the *TIME* most recent months including the current month. A moving average is the moving total divided by *TIME* months. The averages or totals are computed for the data in *TIME* months, including the current month and the *TIME*-1 preceding months. For the first *TIME* months of the time series, the moving totals or averages reach back to the beginning of the simulation. After totaling or averaging the data read from the OUT file, all other *TABLES* operations and the format of the output remain unchanged. A line is added to the heading for annual row/monthly column tables indicating that the data in the table are moving averages or totals.

Fields 10 and 11: The time series data are multiplied by *XF* (default $XF=1.0$) and added to *AF* (default $AF=0.0$) to serve various purposes. For example, *XF* may be a unit conversion factor. Reservoir storage may be converted to draw-down with $XF = -1.0$ and *AF* = storage capacity. The new variable X2 created from the original *SIM* simulation results variable X1 is computed as

$$X2 = (XF)(X1) + AF$$

IDEN Record – Type and Number of Identifiers (Used only if NUM is not already specified.)

field	columns	variable	format	value	description
1	1-4	CD	A4	IDEN	Record identifier
					<u>Type of Identifiers</u>
2	8	TID	I4	blank, 0	Control points
				1	Water rights
				2	Reservoirs
				3	Water Right Groups
3	11-12	NUM	I4	+	Number of identifiers on following IDEN records

IDEN Records – Identifiers of Control Points, Water Rights, Water Right Groups, or Reservoirs

field	columns	variable	format	value	description
1	1-4	CD	A4	IDEN	Record identifier
2-9	5-68	IDCP(I) IDRES(I) IDEN8(I)	8(2x,A6) 8(2x,A6) 8A8	AN	Identifiers of control points (ID=TID=0), reservoirs (ID=TID=2), water rights (ID=TID=1), water right groups (ID=TID=3). Used for positive NUM=NID.
	5-132	IDEN16(I) I = 1, NUM	8A16		Eight identifiers per record on up to ten records for a total of up to 80 identifiers.

If *NUM* is greater than zero on time series records listed on page 141, 2REL, 2FRE, or DATA records, the *NUM* identifiers are listed on one or more IDEN records following directly behind the referencing record. The supplemental IDEN records contain only the *CD* of IDEN and control point, water right, water right group, or reservoir identifiers (up to eight per record, up to 80 on ten records). IDEN records follow if and only if *NUM* is a positive non-zero integer.

If *NUM* is a positive non-zero integer, the control point, water right, group, or reservoir identifiers are listed directly on the end of 2SCP, 2SWR, 2SGP, and 2SRE records, with the fields before the identifiers left blank on the second and subsequent records if more than 8 identifiers are listed.

A negative value for *NUM* specifies that the identifiers read from previous records are to be repeated. The prior record or records supplying identifiers are either IDEN records or 2SCP, 2SWR, 2SGP, and 2SRE records. Identifiers entered once may be used any number of times.

The first form of IDEN record shown above providing values for *TID* and *NID* is not used if IDEN records with the identifiers follow directly behind a time series, 2REL, 2FREQ or DATA record providing values for *TID=ID* and *NID=NUM*. However, alternatively, a set of IDEN records for each pertinent type of identifier may be placed at the beginning of the TIN file or at least earlier in the TIN file than the time series, 2REL, 2FREQ, DATA, 2SCP, 2SWR, 2SGP, or 2SRE records, with *TID* and *NID* defined on an initial IDEN record. After identifiers are entered into computer memory, negative integers are entered for *NUM* on all later records using the identifiers.

TABLES

Identifiers of Control Points, Reservoirs, Water Rights, and Water Right Groups for Time Series (Page 141), DATA, 2REL, 2FRE, 2SCP, 2SWR, 2SGP, and 2SRE Records

Options for specifying the selection of water rights, reservoirs, and control points for inclusion in the *SIM* OUT file are outlined in Chapter 2. The *TABLES* input records contain default options for including in the *TABLES* output all control points, water rights, and/or reservoirs found in the *SIM* OUT file. Alternatively, subsets thereof may be selected for inclusion in the tables and datasets created and written by *TABLES* to the TOU or DSS files.

The time series records listed on page 141, the DATA record (page 147), and the 2REL, 2FRE, 2SCP, 2SWR, 2SGP, and 2SRE records share a common scheme for listing identifiers of selected control points (IDCP), reservoirs (IDRES), water right groups (IDEN8), or water rights (IDEN16) to be included in the tabulations created by *TABLES*. The variable *NUM* is the number of identifiers to be listed. The default *NUM* of zero results in inclusion of all control points, water rights, or reservoirs contained in the *SIM* output file. Alternatively, from one to 80 of the control points, water rights, or reservoirs may be selected for inclusion in the tables created by *TABLES*. Up to 8 identifiers may be entered on a single record. Up to 80 identifiers on ten records may be entered as a group. Any number of record groups may be included in the *TABLES* input TIN file.

Identifiers do not have to be repeated for multiple time series, 2REL, 2FRE, 2SCP, 2SWR, and/or 2SRE records. The last identifiers read during an execution of *TABLES* are stored in memory as the IDCP, IDRES, IDEN8, and IDEN16 arrays. Each of the four arrays contains the last set of identifiers of its type entered. A negative value for *NUM* specifies that the identifiers read from previous records are to be repeated. For example, a *NUM* of -45 tells *TABLES* to use the first 45 identifiers in the IDCP, IDRES, IDEN8, or IDEN16 array, as appropriate, from a previous TIN file input record. Identifiers may be listed on 2SCP, 2SWR, 2SGP, and 2SRE records, on IDEN records connected to time series (page 141), 2REL, or 2FRE records, or on IDEN records connected to an initial IDEN record providing the type and number of identifiers.

DATA Record

The data array created by a DATA record is accessed as input to the time series and frequency table routines. The water rights, reservoirs, and control points selected by the DATA record are used by the time series and frequency table routines that use the data array created by the DATA record. Any of the of the time series variables from the *SIM* or *SIMD* simulation results listed on page 141 and defined on pages 138-140 can be used with a DATA record. Thus, the frequency analysis routines activated by 2FRE, 2FRQ, 6FRE, and 6FRQ records can be applied to any of these variables or related transformed variables through use of a DATA record. The time series records can be used to tabulate the transformed datasets created with a DATA record in the same manner as the original simulation results.

Although also applicable to simulation results from a monthly *SIM* simulation, the DATA record is motivated largely by applications in analyzing instream flows from daily *SIMD* simulation results. The daily time series, 6FRE, and 6FRQ records are described in the *Daily Manual*. The term daily is used here to refer to all sub-monthly time steps, realizing that *SIMD* and *TABLES* also allow each month to be divided into sub-monthly time steps other than daily.

DATA Record – Data Transformation for Time Series and Frequency Tables

field	columns	variable	format	value	description
1	1-4	CD1	A4	DATA	Record identifier
2	5-8	CD2	A4	page 141	Time series identifier from page 141
3	12	DR(1) = ID	I4	0 1 2 3	Develop data for default ID or for control points. Develop data for water rights. Develop data for reservoirs. Develop data for water right groups.
4	13-16	DR(2) = NUM	I4	blank,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, rights, reservoirs, or right groups listed on a previous record. Number of control points, water rights, reservoirs, or water right groups to follow on IDEN records.
<i>Time Interval for Array to be Created</i>					
5	20	DR(3)	I4	blank,0,1 2 3	Annual. Monthly or sub-monthly (daily). Create both annual and monthly or daily arrays.
<i>Variable for Monthly or Sub-Monthly (Daily) Series</i>					
6	24	DR(4)	I4	blank,0 1 2	Original data from SIM/SIMD simulation results. Moving averages for DR(5) time steps. Moving totals for DR(5) time steps.
7	28	DR(5)	I4	blank,0 +	Default is one time step. Number of time steps.
<i>Variable for Annual Series</i>					
8	32	DR(6)	I4	blank,0,1 2 3	Total annual or seasonal summation. Minimum DR(4) volume occurring each year. Maximum DR(4) volume occurring each year.
<i>Specification of Season</i>					
9	35-36	DR(7)	I4	blank,0,+	First month of season. Default is month 1.
10	39-40	DR(8)	I4	blank,0,+	First day of first month of season. Default is 1.
11	43-44	DR(9)	I4	blank,0,+	Last month of season. Default is month 12.
12	47-48	DR(10)	I4	blank,0,+	Last day of last month of season. Default is last day.
<i>Arrays Written to Output File</i>					
13	52	DR(11)	I4	blank,0 1 2 3 4	Arrays are not recorded in message TOU file. Annual array recorded in message TOU file. Monthly or daily array recorded in TOU file. Both arrays recorded in TOU file. Annual array with dates recorded in TOU file.
<i>$X2 = (XF)(X1) + AF$</i>					
14	53-60	XF	F8.0	+, -, blank	Multiplier factor. Default multiplier factor = 1.0
15	61-68	AF	F8.0	+, -, blank	Addition factor. Default addition factor = 0.0

TABLES

The DATA record develops an annual, monthly, or daily (sub-monthly) data array stored in computer memory for use as input data for the time series records listed on page 141, the equivalent type 6 (daily) time series records covered in the *Daily Manual*, and 2FRE, 2FRQ, 6FRE, and 6FRQ records. *SIM* monthly or *SIMD* daily simulation results are converted to other related annual, monthly, or daily time series datasets. For example, daily flows might be converted to an annual series of the minimum 7-day flow occurring in each year.

Any of the time series variables from the *SIM* or *SIMD* simulation results listed on page 141 and defined on pages 138-140 can be used with a DATA record. Thus, the frequency analysis routines activated by 2FRE, 2FRQ, 6FRE, and 6FRQ records can be applied to any of these variables through a DATA record. The same frequency analysis computations can also be applied to any transformed dataset created with a DATA record by manipulating simulation results. The time series records can be used to tabulate the transformed datasets created with a DATA record or develop HEC-DSS files in the same manner as the original simulation results.

Any number of DATA records can be included in a TIN file. Their sequential placement in the TIN file controls their use by time series and frequency records. The one or two data array(s) created by only one DATA record are stored in memory. Each DATA record replaces the arrays created by the preceding DATA record. A particular time series or frequency record uses the array last created. Multiple time series and/or frequency records can use either the same or different DATA records depending on the order of placement of the records in the input file.

Time series and frequency records that read the one or two (annual and/or monthly/daily) arrays stored in computer memory by a DATA record must follow after the DATA record in the TABLES input TIN file. The entry 2DAT or 6DAT in the first field of a monthly (type 2) or daily (type 6) time series record signals use of the data array created by the preceding DATA record. A 9 (monthly/daily) or 10 (annual) is entered for the variable option in the 2FRE, 2FRQ, 6FRE, 6FRQ records to apply the data array created by the preceding DATA record.

DATA record operations consist of the following tasks performed in sequential order.

Step 1: *SIM* monthly or *SIMD* daily simulation results are read from an OUT or SUB file. Only data that falls within the annual season defined by DATA record fields 9-12 are read.

Step 2: The following equation with factors *XF* and *AF* from fields 14 and 15 converts the original data *X1* to a new *X2* which is subject to further manipulations in steps 3 and 5.

$$X2 = (XF)(X1) + AF$$

Step 3: Moving averages or totals (fields 6&7) of the volumes at the completion of step 2 in the *DR(5)* current and preceding time steps (*SIM* months or *SIMD* days) are computed.

Step 4: The monthly or daily dataset at the completion of step 3 is converted to an annual series consisting of the total volume for each year or the minimum or maximum in each year.

Step 5: The product is an annual array and/or monthly (*SIM*) or daily (*SIMD*) array stored in memory for use by time series and/or frequency analysis records.

Steps 2 and 3 are also options in the time series (page 141) and frequency (2FRE and 2FRQ) records. The steps 2 and 3 options can be applied to the original simulation results by a DATA record and then to the resulting dataset by time series or frequency records.

Explanation of DATA Record Fields

Fields 2, 3, and 4: The time series record identifiers listed on page 141 serve as variable identifiers in DATA record field 2. *ID* and *NUM* in fields 3 and 4 of the DATA record are the same as *ID* and *NUM* in fields 5 and 6 of the time series records. The use of the parameters *ID* and *NUM* along with the IDEN record is described on page 145. The control points (*ID*=0), water rights (*ID*=1), reservoirs (*ID*=2), and/or water right groups (*ID*=3) selected by the DATA record are used by the time series and frequency records that reference the DATA record.

Fields 5-14: Fields 5 through 14 provide specifications defining the new data series to be created by manipulating the original data series. The original *SIM* or *SIMD* simulation results data defined by fields 2, 3, and 4 are converted to a new data array defined by fields 5-14.

Field 5: The modified dataset stored in computer memory as an array may be either an annual series with one value for each year (default option 1) or contain a value for each month for a *SIM* monthly simulation (option 2) or each day for a *SIMD* daily simulation (option 3). In creating an annual series the size of the data series is reduced to the number of years in the simulation.

Field 6: The monthly or daily data series may be converted to moving averages (option 1) or moving totals (option 2) over *DR*(5) time steps. A moving total is the summation of volumes over the most recent *DR*(5) time steps. A moving average is the moving total divided by number of time steps *DR*(5). With the default of one time step, *DR*(4) options 0, 1, and 2 are the same.

Field 7: The input variable *DR*(5) is the number of time steps over which the volume is summed or averaged. With fields 6 and 7 blank (default *DR*(4) and *DR*(5)), the original data, optionally modified by factors *XF* and *AF*, is used without computing a moving total or moving average.

Field 8: With creation of an annual series, the number of values in the newly created annual dataset equals the number of years in the simulation. A year is defined as months 1-12. The new variable may be the summation over the year or subset of months (season) specified in fields 9-12. Alternatively, the annual quantity can be the minimum (*D*(6) option 2) or maximum (option 3) each year. The total, minimum, or maximum volume is based on the volumes for each month (*SIM*) or day (*SIMD*) of the season defined in fields 11-14 which by default is the entire year.

Fields 9-12: A season of the year is defined by beginning and ending dates (month and day). Only the data from the original data series that falls within this season is used in creating the new data series. The default is to define the season as being the entire year. The month (1, 2, 3, ..., 12) in field 9 and day (1, 2, 3, ..., 31) of that month in field 10 define the beginning of the season for which data from the original data series is used in creating the new data series. The month in field 11 and day of that month in field 12 define the last day of the season. Days are used only with a *SIMD* simulation. Only months are relevant with a *SIM* monthly simulation. A year is months 1 through 12 or one (May-Sep) or two (Jan-Feb and Oct-Dec) subsets thereof.

Field 13: The arrays can optionally be recorded in the TOU output file.

Fields 14 and 15: The optional multiplier (*XF*) and addition (*AF*) factors [$X2 = (XF)(X1) + AF$] have defaults of 1.0 and 0.0. The factors are applied to the original *SIM* or *SIMD* simulation results (*X1*) before any other changes. The time series and frequency records also include *XF* and *AF* factors applied to their input data which are the final data created by the DATA record.

TABLES

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	7-8	MON	I4	blank,0 +	All months are included in the computations. The month for which the analysis is performed.
3	12	RFLAG	I4	blank,0 1,+	N = number of months with non-zero targets $N = (\text{years})(12 \text{ months/year})$ for $R_p = (n/N) \times 100\%$
4	16	ID	I4	0 1 2 3	Table includes selected control points. Table includes selected water rights. Table includes selected hydropower reservoirs. Table includes selected water right groups.
5	19-20	NUM	I4	blank,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 on IDEN record(s). NUM identifiers from previous record are repeated.
6	21-28	TAR	F8.0	blank,0 + –1, –	Optional supplemental table is not created. Annual diversion or hydropower target. Adopt total of targets from SIM output file.
7	32	VUL	I4	≥ 1	Optional vulnerability and resiliency table is created.

Explanation of 2REL Record Fields

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

Field 3: Period reliability computations may be based either on using the simulation results from only the months with non-zero targets or using all months including those with zero target.

Field 4: TABLES reads the data for control points (ID=0) from the control point output records in the SIM OUT file. For control points, reliabilities are for the summation of the diversions for all the rights located at the control point. The data for water rights (ID=1) and water right groups (ID=3) are from water right records in the SIM OUT file. 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. The data for the hydropower reservoirs (ID=2) are from the reservoir/hydropower records.

Reliabilities are for either water supply diversions or hydroelectric energy production. Control point (ID=0) output records include only diversions. For hydropower reservoirs (ID=2), reliabilities are computed only for electric energy generation for the most junior right at the reservoir. For water rights (ID=1) and water right groups (ID=3), reliabilities may be computed for either water supply diversions or hydropower generation. However, inclusion of both diversions and hydropower in the same reliability table may be confusing and normally should be avoided.

If only one hydropower right is associated with a particular reservoir, the energy produced and associated reliability is the same for the water right and reservoir. However, if two or more hydropower rights are associated with the same reservoir, the reliability table reflects the total cumulative energy target and energy produced for the most junior right at the reservoir. Water right output records and corresponding reliability computations reflect the total cumulative energy target and energy production associated with an individual water right.

The 2REL record reliability table necessarily reflects target and shortage data from the simulation results read by *TABLES* from the *SIM OUT* file. The targets and shortage in the *SIM OUT* file may be affected by the parameter *ISHT* entered in *SO* record field 9. Hydropower rights may be included or excluded depending on the parameter *OUTWR* in *JD* record field 6.

Field 5: A blank or zero field 5 results in all of either the control points (ID=0 in field 4), water rights (ID=1), or reservoir/hydropower projects (ID=2) included in the *SIM* output file being included in the reliability table. The *all* option is not applicable for water right groups (ID=3).

Optionally, lists of control points, water rights, reservoir/ hydropower projects, or water right groups may be entered in IDEN records. Time series (page 141), 2REL, and 2FRE records employ IDEN records in identically the same way. With a positive non-zero *NUM*, one or more IDEN records follow immediately behind the time series, 2REL, or 2FRE record.

A negative value for *NUM* in field 5 indicates that the list read from previous records is to be repeated. The IDEN, 2SCP, 2SWR, 2SGP, and 2SRE records enter identifiers into memory in the same format that may be then used repeatedly with negative entries for *NUM*.

Any number of tables may be created using multiple 2REL records. Water right identifiers *IDEN16* are unique 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. Reliabilities for aggregated rights are determined using group *IDEN8* identifiers.

Field 6: A positive number entered for *TAR* in field 7 adds an extra 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 the total diversion target *TAR*. A -1 in field 7 also activates the supplemental table, but the summation of the pertinent targets from the *SIM* output file is adopted rather than a user-specified target *TAR*.

The supplemental 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*, *FS*, *BU*, *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/FS/BU/TS/DI* records. Thus, the supplemental table may be added.

Field 7: Another optional table with vulnerability, resiliency, and other shortage related metrics designed primarily for CRM is described in Chapter 7 of the *Reference Manual*.

TABLES

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

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRE	Record identifier
2	7-8	Variable	I4	1 2 3 4 -4 5 -5 6 -6 7 8 9 10 11	Naturalized flows (ID=0) Regulated flows (ID=0) Unappropriated flows (ID=0) Reservoir storage associated with control point (ID=0) Reservoir storage associated with a control point with only totals included in table (ID=0) Reservoir storage associated with a water right (ID=1) Reservoir storage associated with a water right with only totals included in table (ID=1) Reservoir storage associated with a reservoir (ID=2) Reservoir storage associated with a reservoir with only totals included in table (ID=2) Reservoir water surface elevation (ID=2) Instream flow shortage for an <i>IF</i> record right (ID=1) Instream flow shortage at a control point (ID=0) DATA record monthly or daily array. DATA record annual array (pages 146-149)
3	11-12	MON	I4	blank, 0 +	All months are included in the computations. The month for which the analysis is performed.
4	15-16	NUM	I4	0 + -	Include all control points, rights, or reservoirs in table. Number of control points, rights, or reservoirs. NUM identifiers from previous record(s) are repeated.
5	20	TABLE	I4	blank, 0, 1 2 3 4	Frequency table is created in standard row format. Frequency results are tabulated as columns. Abbreviated frequency results tabulated as columns. Quantities are expressed as a percentage of maximum.
6	24	METHOD	I4	blank, 0, 1 2 3	Relative frequency $P = (n/N) 100\%$ Log-normal probability distribution. Normal probability distribution.
7	28	MAT	I4	blank, 0 1 2	Moving average/total option is not adopted. Moving averages are computed for TIME months. Moving totals are computed for TIME months.
8	32	TIME	I4	+	Number of months for moving averages or totals.
9	33-40	XF	F8.0	+, -, blank	Multiplier factor. Default multiplier factor = 1.0
10	41-48	AF	F8.0	+, -, blank	Addition factor. Default addition factor = 0.0

A 2FRE record develops probability statistics including mean, standard deviation, and quantities associated with specified exceedance frequencies for the variables listed in 2FRE field 2 or through use of a DATA record for any of the simulation results variables or transformations thereof.

Explanation of 2FRE Record Fields

Field 2: Frequency tables are developed for the variable selected in field 2 which may be associated with either control points (ID=0), water rights (ID=1), or reservoirs (ID=2). Any number of control points, water rights, or reservoirs may be included in a frequency table. Storage frequency tables also include the total storage associated with each frequency for all the control points, rights, or reservoir included in the table. A -4, -5, or -6 specifies that only the storage totals are included in the table without listing the individual control points or rights.

Field 3: If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MON* in field 2, frequencies are computed for only the specified month. The default is to include is all months in the analysis.

Field 4: A blank or zero field 4 results in all of either the control points (variables 1, 2, 3, 4, -4, or 9 in field 2), water rights (variables 5, -5, or 8), or reservoirs (variables 6 or 7) being included in the frequency table. Optionally, lists of *NUM* control points, water rights, or reservoirs may be entered on IDEN records for inclusion in the frequency table. Identifiers shared by several record types are discussed on page 146. The parameter *NUM* is identical in 2FRE record field 4, 2REL record field 5, and field 6 of the time series records. *DR(2)=NUM* on the DATA record (2FRE field 2 variables 10 and 11) supersedes the *NUM* on the 2FRE record.

Field 5: Four alternative formats are available for the frequency tables. The option 2 columnar format contains a few more frequencies than option 1, is convenient for transport to a spreadsheet, and is limited to not exceed a maximum of 100 columns. Options 3 and 4 are shorter variations of option 2. Option 4 expresses volumes as percentages of maximum.

Field 6: Three alternative methods are available for computing flow or storage volumes or elevations (field 2 variable) associated with specified exceedance frequencies. Option 1 is based on sorting the *N* amounts in ranked order and applying linear interpolation and the relative frequency formula to assign exceedance frequencies (*P*) based on rank (*n*).

$$P = \frac{n}{N}(100\%)$$

For a specified exceedance 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.

Options 2 and 3 are based on the log-normal and normal probability distribution functions. The parameters are the mean and standard deviation of the data (normal distribution) or logarithms of the data (log-normal distribution). Frequency factors for the Gaussian (normal) probability distribution function for the selected exceedance frequencies are built into *TABLES*.

The 2FRE record log-normal and normal distribution options are not available with the 2FRQ record. The 2FRQ record frequencies are computed with the relative frequency formula.

Fields 7 and 8: 2FRE record fields 7 and 8 (*MAT* and *TIME*) are identical to fields 9 and 10 of the time series records. The moving total or moving average computations are identically the same for data used to develop frequency tables as applied to the data tabulated in time series tables.

Fields 9 and 10: The multiplier *XF* and addition *AF* factors in 2FRE record fields 10 and 11 are the same as *XF* and *AF* in fields 11 and 12 of the time series records described on pages 142-144.

TABLES

2FRQ Record – Frequency for Specified Flow or Storage

field	columns	variable	format	value	description
1	1-4	CD	A4	2FRQ	Record identifier
2	8	Variable	I4	1	Naturalized flows (ID=0)
				2	Regulated flows(ID=0)
				3	Unappropriated flows (ID=0)
				4	Reservoir storage associated with a control point(ID=0)
				5	Reservoir storage associated with a water right (ID=1)
				6	Reservoir storage associated with a reservoir (ID=2)
				7	Reservoir water surface elevation (ID=2)
				8	Instream flow shortage for an <i>IF</i> record right (ID=1)
				9	Instream flow shortage at a control point (ID=0)
				10	DATA record monthly or daily array
				11	DATA record annual array (pages 145-147)
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 <i>TABLES</i> 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 (field 2 variables 1-4), water water right (variables 5, 8), or reservoir (variables 6, 7)
6-12	25-80 33-88	QF(I) I=1,NM	7F8.0	+	Streamflow (variables 1,2,3), storage (variables 4,5,6), elevation (7), or instream flow shortage (variables 8,9)

A 2FRE record creates a frequency table with a set of pre-defined frequencies. A 2FRQ record frequency table contains computed frequencies for up to 7 specified flow, storage, elevation, or instream flow shortage amounts or the variable defined by a preceding DATA record.

Explanation of 2FRQ Record Fields

Field 2: Field 2 is the same in the 2FRQ and 2FRE records except the 2FRQ record does not include the total summation of reservoir storage. The variables recorded in the *SIM* water right, control point, and reservoir/hydropower output records are precisely defined in Chapter 5 of the *Reference Manual*. The DATA record is described on pages 146-149 of this *Users Manual*.

Field 3: Field 3 is identical for both the 2FRQ and 2FRE records. If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 2, frequencies are computed for only the specified month. The default is to include all months in the frequency analysis.

Fields 4, 5, and 6-12: A 2FRQ record frequency table contains computed frequencies for up to seven flow or storage amounts specified in fields 6, 7, 8, 9, 10, 11, and 12 for a single control point, water right, or reservoir specified in field 5. 2FRQ record field 5 can optionally be left blank if a DATA record is used. The number *NM* of flow or storage amounts is entered in 2FRQ field 4.

2RES Records – Reservoir Content, Draw-Down Duration, and Storage Reliability

First 2RES Record

field	Columns	variable	format	value	description
1	1-4	CD	A4	2RES	Record identifier
2	8	TABLE	I4	0 1 2 3 4	All three tables are created. Storage contents as a percentage of capacity table. Storage draw-down duration table is created. Storage reliability table is created. 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.

TABLES

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 in 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 1 2	Annual table Monthly table 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(I) I = 1,NUM	8(2x,A6)	AN	Identifiers of the selected control points for which to develop summary tables.

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 1 2	Annual table Monthly table 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(I) I = 1,NUM	8A16	AN blank	Identifiers of water rights for which to develop tables. 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. Time series, 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records enter identifiers into memory that may be repeated with a negative *NUM*.

Water right groups must be listed explicitly on the 2SGP record. *NUM* cannot be zero if tables are created for one or more water right groups.

TABLES reads the data for 2SCP and 2SBA tables from the control point records in the *SIM* output file. The data for the 2SWR and 2SGP tables are from the water right records in the *SIM* output file. The data for the 2SRE table are from the reservoir/hydropower records in the *SIM* output file.

TABLES

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 1 2	Annual table Monthly table 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(I) I = 1, NUM	8A8	AN blank	Identifiers of water right groups for which to develop tables. 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 1 2	Annual table Monthly table 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(I) I = 1, NUM	8(2x,A6)	AN blank	Identifiers of reservoirs for which to develop summary tables. 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 1 2	Annual table Monthly table Both annual and monthly tables

2BUD – Water Budgets for Control Points and the Entire River Basin System

field	columns	variable	format	value	description
1	1-4	CD	A4	2BUD	Record identifier
<u>Control Point Location</u>					
2	5-12	CPBUD	2x,A6	blank AN	Water budget is for the river basin outlet(s). Control point for the water budget.
<u>Time Period Covered by Water Budget</u>					
3	13-16	YRFIRST	I4	+ blank,0	First year of water budget computations. First year of <i>SIM</i> simulation is adopted.
4	17-20	YRLAST	I4	+ blank,0	Last year of water budget computations. Last year of <i>SIM</i> simulation is adopted.
<u>Approach for Sequencing Control Points</u>					
5	24	ICPI	I4	1 blank,0, -1	ICP(I) array is created by preceding 1CPT record. 1CPT record ICP(I) array is not used. Control points are in upstream-downstream order in <i>SIM</i> input file.
<u>Beginning-of-Computations Storage Volume</u>					
6	28	BEGSTO	I4	blank, zero 1 2	Beginning storage is zero or preceding end-of-year. <i>SIM</i> beginning reservoir storage BRS file is read. Storage is estimated from <i>SIM</i> output file variables.
<u>Adjustments for Negative Inflow</u>					
7	32	NEGINF	I4	blank,0,1 2 3	No adjustments are made to negative inflows. Adjustments based on beginning-of-period storage. Negative inflow volumes are set to zero.
<u>Water Budget Tables to be Written to TOU File</u>					
8	36	CPOUT	I4	blank,0,-1 1 2	Control point water budget table is not created. Water budget table is created for one control point. Water budget table is created for all control points.
9	40	BASIN	I4	blank,0,1 2 -1	River basin water budget table is created for outlet(s). Basin budget table for control point in field 2. River basin water budget table is not created.

The 2BUD record water budget computations performed by *TABLES* are described in Chapter 5 of the *Reference Manual*. Water budgets are developed by *TABLES* based on reading the simulation results from a *SIM* output OUT file containing output records for all control points included in the *SIM* DAT file. Additional information is also read from the *SIM* DAT file. The water budget computations are performed by control point in upstream-to-downstream sequence. Two different types of water budget tables may be developed, river basin and individual control point. Computations are performed for all control points in the process of developing the river basin water budget table. Results associated with individual control points are recorded in the individual control point water budget table. The computations step sequentially through time and, for each month, are performed by control point in upstream-to-downstream order. The resulting water budget tables include the variables defined in *Reference Manual Chapter 5*.

TABLES

Explanation of 2BUD Record Fields

Field 2: With field 2 blank, the default is to develop a river basin water budget for the one or more outlets defined by the *CP* records in the *SIM* DAT file. Thus, the default basin water budget is for the entire river system encompassing all of the control points in the *SIM* dataset. If a control point identifier is entered in 2BUD record field 9, the computations stop at that control point. All control points located downstream are omitted from the computations. Thus, the basin water budget is valid for a control point specified in field 9 only if all control points listed prior to that control point in the sequencing are located upstream. Depending on CPOUT in field 8, the optional control point water budget table may include either only the basin outlet specified by field 2 or all of the control points in the *SIM* dataset.

Fields 3 and 4: The time period covered by the water budget may be specified by first and last years. The default is to adopt the *SIM* period-of-analysis for the water budget. The water budget time period must be contained within the *SIM* simulation period-of-analysis but may be shorter.

Field 5: The *SIM* output file must contain all control points. The water budget computations are performed by control point in upstream-to-downstream sequence. A control point is considered only after computations are completed for all control points located upstream. A 1CPT record may be placed before the 2BUD record to create an ICP(I) array stored in computer memory that defines the upstream-to-downstream ordering of control points. The default option 1 is selected in 1CPT record field 3. If the control points are already in upstream-to-downstream order in the *SIM* DAT file, the 1CPT record is not needed.

Field 6: If the time period covered by the water budget starts after the start of the *SIM* simulation period, the end-of-year storage preceding the budget start year automatically provides the reservoir storage at each control point at the beginning of the water budget computations. Otherwise, the beginning-of-simulation storages from a BRS file created by *SIM* may be read. The other option is to compute the beginning storage volumes BSTO(cp) using end-of-month storage (ST), stream flow depletion (DEP), net evaporation-precipitation (EP), and diversion (DT-DS) volumes for the first month of the simulation read from the *SIM* output file as follows.

$$\text{BSTO}(\text{cp}) = \text{ST} - \text{DEP} + \text{EP} + \text{DT} - \text{DS}$$

In some cases, the beginning-of-simulation storage may depend upon other reservoir releases not included in the *SIM* output file and the above equation. The BRS file option is advantageous in this regard, since the BRS file will always contain the exact beginning storages from *SIM*.

Field 7: Negative values may result from the computation of the inflows flowing into a control point. The default option 1 carries the negative inflows forward in the computations without adjustment. Option 2 limits the adjustment of negative inflow loads to not exceed the volume in reservoir storage at the beginning of the month. The negative inflow volume is changed to zero or as close to zero as the storage volume allows. Option 3 consists of setting the negative inflow to zero, which has the effect of creating additional water volume.

Fields 8 and 9: Two types of water budget tables may be created and written to the TOU file, a river basin summary table and a control point table. The default is to develop only the budget for the entire river basin. Optionally, water budgets may be created for one or all control points.

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

field	columns	variable	format	value	description
1	1-4	CD	A4	3NAT 3REG 3UNA 3DEP 3U+D 3EPD	Record identifier for naturalized stream flows Record identifier for regulated stream flows Record identifier for unappropriated stream flows Record identifier for stream flow depletions Record identifier for summation of stream flow depletions plus unappropriated stream flows 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 1	Stream flow records grouped by control point Stream flow records grouped by year
4	13-20	INFAC	F8.0	blank,0 +	Default INFAC=1.0 Factor by which stream flows 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. The multiplier in field 4 may be a unit conversion factor or otherwise used to scale the flows.

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).

<u>Grouped by Control Point (<i>HEC</i> = 0)</u>		<u>Grouped by Year (<i>HEC</i> = 1)</u>	
CP1	1990	CP1	1990
CP1	1991	CP2	1990
CP1	1992	CP3	1990
CP2	1990	CP1	1991
CP2	1991	CP2	1991
CP2	1992	CP3	1991
CP3	1990	CP1	1992
CP3	1991	CP2	1992
CP3	1992	CP3	1992

The program *HYD OI* record provides more comprehensive capabilities serving this same purpose.

TABLES

4HRR Record – Hydropower and System Reservoir Release Table

field	column	variable	format	Value	description
1	1-4	CD	A4	4HRR	Record identifier
2	8	HR	I4	blank, 0, 1 2	Hydropower is not included in the table. Hydropower is included in the table.
3	12	MNAN	I4	blank, 0 1	Annual table Monthly table
4	16	NUM	I4	+	Number of water rights to follow (1 to 30)
5-9	17-96	IDEN(I) I=1,5	A16	AN	Water right identifiers for which to develop reservoir release tables (maximum of 5/record and six records)

The 4HRR record is the only *TABLES* record that results in data being read from a HRR file. Creation by *SIM* of a hydropower and system reservoir release HRR output file is activated by *JO* record field 4. The water rights included in a HRR file are system rights that also fall within the criteria specified in *JD* record field 6. The water rights included by *SIM* to the HRR file as well as *OUT* file are controlled by *OUTWR* in *JD* record field 6. The HRR file is further limited to system water rights, which includes hydropower (types 5 and 6), type 2 and 3 rights, and/or rights with multiple reservoirs.

The *TABLES* 4HRR record reorganizes the *SIM* simulation results from the HRR file as a series of columns. The first three columns are the year, month (for a monthly table), and water right identifier. With *HR* option 2 activated, the next two columns are the hydroelectric energy target and total energy produced. Reservoir releases and corresponding reservoir identifiers are tabulated in the next columns for all of the reservoirs associated with the water right. The rows of the table contain data for a month (*MNAN* option 1) or annual totals for a year (*MNAN* default option 0).

Hydroelectric energy targets, shortages (+) or secondary energy(-), and energy produced to meet targets are also tabulated with *2TAR*, *2SHT*, and *2DIV* records from data in the *OUT* file for either individual water rights or control point totals. The *2HPE* record tabulation of data from the *OUT* file reflects the total energy produced by the most junior right at a reservoir. For a reservoir with only one hydropower right, the energy production tabulated by the 4HRR record for a water right is the same simulation results variable that is displayed for a reservoir by the *2HPE* record. However, HRR file data are for individual rights. The *2HRR* table is for individual rights, not aggregated control point or reservoir totals. Energy production includes both form energy produced to meet the energy target and extra secondary energy produced with excess flows.

Releases from the individual secondary reservoirs tabulated by the 4HRR record from the HRR file are not recorded in the main *SIM* output file. The *2ROR* record releases from the *OUT* file are the summation of releases from all of the secondary reservoirs for the water right. The release for a water right type 1 or 5 primary reservoir is the diversion supplied by the water right.

A 4HRR 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. 4HRR fields 2, 3, and 4 are not read on the second and subsequent records.

4ZZF Record – Frequency Table for Flows in Water Rights Priority Loop

field	columns	variable	format	value	description
1	1-4	CD	A4	4ZZF	Record identifier.
2	8	VAR	I4	1 2 blank, 0, 3	Reservoir releases. Regulated flows. Available flows.
3	12	MON	I4	blank, 0 +	All months are included in the computations. The month for which the analysis is performed.
4	16	NUM	I4	blank, 0 – +	Tables for all control points included in ZZZ file. Develop tables for the NUM control points already listed with preceding record. Number of control points to follow on IDEN records.

The ZZ record activates a *SIM* feature described in Chapter 6 of the *Reference Manual* that tabulates regulated flows, available flows, and reservoir releases at specified control points in a ZZZ file as each water right is simulated in the priority sequence. Flows are tabulated each month at the beginning of the *SIM* simulation and after each water right is simulated in the priority sequence. TABLES 4ZZZ and 4ZZF record routines read the flows from the ZZZ file. The 4ZZF record builds frequency tables similar to the 2FRE record.

Frequencies are determined for flows at the beginning of the *SIM* simulation and after each water right is simulated in the priority sequence. The table created by a 4ZZF record includes all water rights recorded in any month for any control point found in the *SIM* ZZZ output file, but *SIM* ZZ record options allow limiting the water rights included in the ZZZ file. Flows for all ZZZ file rights are not necessarily recorded in any one month due to the ZZ record limit options. TABLES repeats flows for multiple rights until finding the next more senior right with recorded flows.

Explanation of 4ZZF Record Fields

Field 2: Each frequency table is developed for either reservoir releases (VAR=1), regulated flows (VAR=2), or available flows (VAR=3). One of the three variables is selected, with the default being available flows. Sets of two or three 4ZZF records may be included in the TIN file to build frequency tables for two or three variables. A separate table is created for each variable.

Field 3: If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for MON in field 2, frequencies are computed for only the specified month. The default is to include is all months in the analysis.

Field 4: 4ZZF field 4 is identical to 4ZZZ field 6. The default is to include tables for each of the control points found in the *SIM* ZZZ file. Optionally, NUM control points may be selected by listing control point identifiers on one to ten supplemental IDEN records. A negative value for NUM may be entered in field 6 to indicate that the list read from a previous record is to be repeated. IDEN records are used if and only if NUM is a positive integer. Each frequency table is for a single control point, with multiple tables created for multiple control points.

TABLES

4ZZZ Record – Flows in Water Rights Priority Loop

field	columns	variable	format	value	description
1	1-4	CD	A4	4ZZZ	Record identifier.
2	8	TA	I4	blank, 0 1	Do not develop annual row/monthly column table. Table with annual rows and monthly columns.
3	12	PT	I4	blank, 0 1 2 3 4 5	Do not activate either DSS or text file option. Develop columns of monthly data in text file. Columns of annual totals or means in text file. Develop columns of 12 monthly means in text file. Develop DSS monthly time series records. Develop DSS annual time series records.
4	16	MORE	I4	0 1	Write columns; next record starts a new table. Add columns to existing table or start first table.
5	20	VAR	I4	1 2 blank, 0, 3	Reservoir releases. Regulated flows. Available flows.
6	24	NUM	I4	blank, 0 – +	Tables for all control points included in ZZZ file. Develop tables for the NUM control points already listed with preceding record. Number of control points to follow on IDEN records.
7	25-40	RIGHT	A16	AN	Water right identifier entered any place in field. The term begin, Begin, or BEGIN is entered for flows at the beginning of the priority sequence.

The *SIM ZZ* record and associated *TABLES 4ZZZ* and *4ZZF* record routines discussed in *Reference Manual* Chapter 6 are designed to track the effects of each water right in a *SIM* dataset on the regulated flows and available (still unappropriated) flows at specified control points. *SIM* records the flows in a *ZZZ* file as each water right is simulated in the priority sequence. *TABLES* reads the *ZZZ* file. The *4ZZZ* record organizes the flows as tables in the *TOU* file or as *DSS* file records in a similar manner as the time series records described on pages 141-144.

Any number of *4ZZZ* records may be entered in the *TIN* file. Each *4ZZZ* record tabulates data from the *ZZZ* file for the single flow variable selected in *4ZZZ* record field 5 for flows which occur immediately after simulation of the water right specified in field 7 or at the beginning of the water rights priority simulation loop. Each table is for a specified control point (field 6).

Explanation of 4ZZZ Record Fields

Field 2: Types of tables to be created are selected in fields 2 and 3. There is no *TABLES* output if fields 2 and 3 are both blank. A set of one or more tables with rows for years and columns for months and annual totals is created in the *TOU* file by entering the integer 1 in *4ZZZ* field 2.

Field 3: Either columns of data may be written to the TOU file or HEC-DSS records may be written to the DSS file. The data may include either monthly flows, means, or annual totals.

A TOU file table activated by entering a 1, 2, or 3 in 4ZZZ record field 3 consists of a single column for each control point with multiple control points being included as separate columns in the same table. This format is designed to be read by spreadsheet programs for plotting or additional computational manipulations. The column may contain either the entire time series of monthly flow data (PT=1 in field 3), annual totals 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 *MORE* in field 4 controls whether another column is added to the current table or a new table is started.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a DSS file, accessible to graphing and other capabilities provided by HEC-DSSVue. The HEC-DSS data storage system 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 – control point identifier
- C – ZZ_RES_REL or ZZ_REG_FLOW or ZZ_AVAIL_FL
- D – date of the beginning of the time series such as 01JAN1938
- E – time interval = MON or YEAR for *SIM* results
- F – water right identifier from 4ZZZ record field 7

Field 4: Field 4 is relevant only if a columnar tabulation is activated by entering a 1, 2, or 3 for PT in field 3 and multiple control points are indicated by NUM in field 6. Each control point is tabulated as a single column in a table. The parameter *MORE* 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 control point columns up to a limit of 100 columns. At least one record must have a *MORE* of zero in order to write the table.

Field 5: One of three variables must be selected. The time series variable tabulated is either reservoir releases (VAR=1), regulated flows (VAR=2), or available flows (VAR=3). The default (blank field 5) is available flows (VAR=3). Multiple 4ZZZ records may be included in the TIN file to build tables for all three variables. Reservoir releases are a component of regulated flows.

Field 6: The default is to include tabulations for each of the control points found in the ZZZ file. Optionally, *NUM* control points may be selected by listing control point identifiers on one to ten supplemental IDEN records. A negative value for *NUM* may be entered in field 6 to indicate that the list read from a previous record is to be repeated. IDEN records are used if and only if *NUM* is a positive integer.

Field 7: The water right identifier is entered in field 7. The flows tabulated by *TABLES* are those at the field 6 control point occurring immediately after this water right was simulated by *SIM* in the water right priority sequence. Multiple 4ZZZ records may be included in the TIN file to build tables of flows occurring after multiple water rights, but each individual table is for a single water right. The flows at the beginning of the simulation each month prior to simulating any of the water rights are also included in the ZZZ file and are selected by entering the term *Begin*, *begin*, or *BEGIN* in 4ZZZ record field 7.

TABLES

5CRM Record – Conditional Reliability Modeling

field	columns	variable	format	value	description
1	1-4	CD	A4	5CRM	Record identifier
2	5-8	CRHEAD	I4	blank,0,+ -1	CRM headings are inserted at top of each table. CRM headings are not written.

Conditional reliability modeling (CRM) is covered in *Reference Manual* Chapter 7. A 5CRM or 5CR2 record results in opening a SIM CRM output file. Since a 5CR2 record also opens the SIM CRM output file, the 5CRM record is actually only required to open the CRM output file for the equal-weight option in which a 5CR2 record is not used. If preceded in the TIN file by a 5CRM or 5CR2 record, the time series, frequency, and reliability records use the SIM or SIMD simulation results from a CRM file for their analyses.

By default, four lines of information from the CR record and 5CR2 record are written on the cover page and at the top of the tables produced by the 2REL, 2FRE, 2FRQ, and 2RES records. A -1 entered for the parameter CRHEAD in 5CRM record field 2 prevents the CRM headings from being printed. The only reason to deactivate the heading is to reduce the size of the tables. Multiple 5CRM records may be used to turn the headings on and off for different tables.

5CR1 Record – FF or SFF Control Points and SFF Reservoirs (2nd and 3rd 5CR1 records)

field	columns	variable	format	value	description
1	1-4	CD	A4	5CR1	Record identifier
2	5-8	CD2	A4	FLOW STCP STRE	Control points for naturalized flows to be summed Control points for reservoir storage to be summed Reservoirs for storage to be summed
3-17	9-128	CPF(I) or CPS(I)	15(2x,A6)	AN	Control point or reservoir identifiers for summing flow (I = 1,NFLOW) or storage (I = 1,NSTOR)

The main (first) 5CR1 record is described on the next page. Supplemental 5CR1 records are added as specified by NFLOW and NSTOR in fields 2 and 3 of the first 5CR1 record.

Up to 15 control point or reservoir identifiers are listed in fields 3–17 of the two supplemental 5CR1 records as specified by fields 2 and 3 of the main 5CR1 record. The two supplemental 5CR1 records follow behind the main 5CR1 record.

If NFLOW in field 2 of the first 5CR1 record is non-zero, a 5CRIFLOW record is required to list the control points at which naturalized flows are summed for use in developing a SFF relationship.

If NSTOR in field 3 of the first 5CR1 record is non-zero, either a 5CRISTCP or 5CRISRES record is required to list the control points or reservoirs at which storage is summed.

If NFLOW or NSTOR in fields 2 and 3 of the initial 5CR1 record are blank or -1, the corresponding supplemental record is not entered.

5CR1 Record – Conditional Reliability Record to Develop a FF or SFF Relationship

field	columns	variable	format	value	description
1	1-4	CD	A4	5CR1	Record identifier
<u>Control Points or Reservoirs for Flow and Storage</u>					
2	5-8	NFLOW	I4	+ blank,0	Number of control points for naturalized flow Flow at all control points is summed
3	9-12	NSTOR	I4	+ blank,0 -1	Number of control points or reservoirs for storage Storage at all control points is summed Storage at all reservoirs is summed
<u>Annual or Monthly Cycle Options</u>					
4	13-16	TCR2	I4	+ blank,0	Starting month activates annual cycle option Monthly or non-annual option adopted by default
<u>Months Used to Sum Flows</u>					
5	17-20	FM	I4	+ blank,0	Number of months for naturalized flow volume Default is simulation length CR1 from CR record if a CRM file has been opened providing CR1.
<u>Option for Assigning Exceedence Frequencies</u>					
6	24	DIST	I4	blank,0,1 2	Weibull formula Log-normal distribution
<u>Regression Options for Storage-Flow Function</u>					
7	27-28	FIT	I4	blank,0 1, -1 2, -2 3, -3 4, -4	FF relationship developed without storage regression. Exponential regression for storage-flow function. Combined function used for storage-flow function. Linear regression used for storage-flow function. Power function used for storage-flow function. Note: -1, -2, -3, or -4 activates fields 9, 10, 11.
8	32	INTZERO	I4	blank,0 1	Intercept is not forced to zero Y-intercept (flow) is set at zero.
<u>Coefficients for $Q = a e^{S/b}$ or $Q = a + bS^c$</u>					
9	33-40	A	F8.0	+	Coefficient a
10	41-48	B	F8.0	+	Coefficient b
11	49-56	C	F8.0	+	Coefficient c
<u>Storage Interval</u>					
12	57-64	LOWLIM	F8.0	blank,0 +	No lower limit, or option is not applied. Lower storage limit defining flow sequence selection.
13	65-72	UPLIM	F8.0	+	No upper limit, or option is not applied. Upper storage limit defining flow sequence selection.
<u>Options for Writing Results to SFF and TOU Files</u>					
14	76	FILE2	I4	blank,0 1 2 3 4	Nothing is written to the SFF and TOU files. The probability array is written to the SFF file. Regression and correlation statistics to TOU file. Both probability array and statistics are written. Storage and flow volumes are tabulated in TMS file. Both probability array and statistics are written.

TABLES

Explanation of Fields of the Main 5CR1 Record

Field 2: If field 2 is blank, there is no listing of control point identifiers, and the naturalized flow at all control points included in the *SIM/SIMD* output file is summed. Otherwise, the naturalized flow used for the FF or SFF relationship is the total flows at the NFLOW control points listed on a supplemental *5CR1* record. FLOW is entered in field 2 of the supplemental *5CR1* record. The number of control point identifiers read is specified by field 2 of the initial *5CR1* record and cannot exceed 15.

Field 3: If field 3 is blank, there is no listing of control point or reservoir identifiers, and the storage from all control point output records included in the *SIM/SIMD* output file is summed. A -1 results in use of all reservoir records in the *SIM/SIMD* output file. Otherwise, the reservoir storage is the total of the reservoir storage at the NSTOR control points or reservoirs listed on a supplemental *5CR1* record. STCP or STRE is entered in field 2 of the supplemental *5CR1* record. The number of identifiers on the supplemental *5CR1* record is specified by field 3 of the initial *5CR1* record and cannot exceed 15.

Field 4: Entering a starting month ranging from 1 to 12 activates the annual cycle option. The monthly cycle option is activated by default by a blank field 4. The same information is provided by CR2 on the *CR* record and recorded in the fifth line of the CRM file. However, field 4 specifies the option used to develop the SFF or FF array from the results of a long-term non-CRM *SIM/SIMD* simulation.

Field 5: The storage and flow are summed over the first FM months of each simulation sequence. If a CRM file is opened by a 5CRM or 5CR2 record, the default FM is the simulation period CR1, which is set by *CR* record field 2 and included in the 5th record of the *SIM* output CRM file.

Field 6: The two alternative options for assigning exceedance probabilities to $Q_{\%}$ (defined by *Reference Manual* Eq. 7.8) in developing the SFF relationship or to flow volume in developing the FF relationship are based on the log-normal probability distribution (Eq. 7.19) and Weibull formula (Eq. 7.20).

Field 7: The following regression equations may be used to relate flow Q to storage S for a SFF relationship.

FIT Option 1	Exponential:	$Q = a \times e^{S/b}$	Eq. 7.9 in <i>Reference Manual</i>
FIT Option 2	Combined:	$Q = a + bS^c$	Eq. 7.12
FIT Option 3	Linear:	$Q = a + bS$	Eq. 7.11
FIT Option 4	Power:	$Q = bS^c$	Eq. 7.10

A blank field 7 indicates that a FF relationship is being developed without considering storage. Developing a SFF relationship requires selection of a regression method. With options 1, 2, 3, and 4, regression analysis are performed within *TABLES* to determine the coefficients a , b , and c . With FIT options -1, -2, -3, and -4, the coefficients are read from fields 9, 10, and 11 rather than activating the regression analysis computations.

Field 8: The coefficient a representing the y-intercept (flow for zero storage) in the linear and combined regression equations (*Reference Manual* Equations 7.12 and 7.11) may be set equal to zero.

Fields 9, 10, and 11: These fields are used to enter values for the regression coefficients if option -1, -2, -3, or -4 is selected for the variable FIT in field 7.

Fields 12, and 13: Lower and upper limits define a range of reservoir storage contents from which the corresponding naturalized flow sequences are adopted for use in developing the FF or SFF relationship.

Field 14: The SFF or FF array is stored in active computer memory but may also be written to a SFF file to be read by the *5CR2* record routine. Regression and correlation statistics may be written to the TOU file. The basic storage and flow volume data may be tabulated in the TMS file.

5CR2 Record – Conditional Reliability Record to Build the Incremental Probability Array

field	columns	variable	format	value	Description
1	1-4	CD	A4	5CR2	Record identifier <i>Control Points or Reservoirs for Flow and Storage</i>
2	5-8	NFLOW	I4	+ blank,0	Number of control points for naturalized flow. Flow at all control points is summed.
3	9-12	NSTOR	I4	+ blank,0 -1	Number of control points or reservoirs for storage. Storage at all control points is summed. Storage at all reservoirs is summed.
4	13-16	READINI	I4	blank,0 +	<i>Starting Reservoir Storage Condition</i> Initial storages read from 2CP2INIT record. Initial storages read from BRS file.
5	17-20	FM	I4	+ blank,0	<i>Months Used to Sum Flows</i> Number of months for naturalized flow volume. Default is simulation length CR1 from CR record.
6	24	FIT	I4	blank,0 1 2 -1 -2	<i>Regression Options for Storage-Flow Function</i> FF relationship is created without storage regression. 1 Exponential (Eq. 7.9) coefficients from 5CR1 record. 2 Combined (Eq. 7.12) coefficients from 5CR1 record. -1 Exponential (Eq. 7.9) coefficients in fields 10, 11, 12. -2 Combined (Eq. 7.12) coefficients in fields 10,11,12.
7	28	FILE1	I4	blank,0,1 2	<i>FF or SFF Relationship</i> SFF or FF is created with preceding 5CR1 record. SFF or FF relationship is read from SFF file.
8	32	FILE2	I4	blank,0 1	<i>Option to Write Probability Array to SFF File</i> Nothing is written to the SFF file. 1 The probability array is written to the SFF file.
9	40	MFACTOR	F8.0	+ blank,0	<i>Multiplier Factor</i> Multiplier factor for storages on 2CP2INIT record default=1.0
10	41-48	A	F8.0	+	<i>Coefficients for $Q = a e^{S/b}$ or $Q = a + bS^c$</i> Coefficient a
11	49-56	B	F8.0	+	Coefficient b
12	57-64	C	F8.0	+	Coefficient c

Explanation of Fields of the Main 5CR2 Record

Field 2: If field 2 is blank, there is no listing of control point identifiers, and the naturalized flow at all control points included in the SIM/SIMD output file is summed. Otherwise, the flow used to build the incremental probability (IP) array is the total of the naturalized flows at the NFLOW control points listed on a supplemental 5CR2 record. FLOW is entered in field 2 of the supplemental 5CR2 record. The number of control point identifiers read from the supplemental 5CR2 record is specified by field 2 of the initial 5CR2 record and cannot exceed 15.

TABLES

Field 3: If field 3 is blank, there is no listing of control point or reservoir identifiers, and the storage from all control point output records included in the *SIM/SIMD* output file is summed. A -1 results in use of all reservoir records in the *SIM/SIMD* output file. Otherwise, the reservoir storage used to build the probability array is the total of the reservoir storage at the NSTOR control points or reservoirs listed on a supplemental *5CR2* record. STCP or STRE is entered in field 2 of the supplemental *5CR2* record. The number of identifiers read from the supplemental *5CR2* record is specified by field 3 of the initial *5CR2* record and cannot exceed 15.

Field 4: If field 4 is blank, the starting reservoir storage volumes used in developing the probability array are provided on a *5CR2INIT* record. A positive integer entered in field 4 activates the option of reading the starting storages from a BES file created by *SIM/SIMD*.

Field 5: The storage and flow are summed over the first FM months of each simulation sequence. If field 4 is blank, the default is to sum the storage and flow for the entire simulation period CR1, which is set by *CR* record field 2 and included in the 5th record of the main *WRAP-SIM* output file.

Field 6: Field 6 is blank if a flow-frequency (FF) relationship is used to construct the incremental probability (IP) array without considering storage. The following regression equations may be used to relate flow *Q* to storage *S* if a storage-flow-frequency (SFF) relationship is used to construct the IP array. A positive 1 or 2 in field 6 indicates that *Reference Manual* Eq. 7.9 or Eq. 7.10 is used with coefficients determined by the previous *5CR1* record. Negative integers -1 or -2 in *5CR2* record field 6 activate the option of reading coefficients from fields 10, 11, and 12. If the coefficient *b* is 1.0, the linear equation is used. The power equation is specified by a value for *b* other than 1 with a coefficient *c* of zero. The combined equation has a non-unity *b* and non-zero *c*.

Exponential (Eq. 7.9)	$Q = a \times e^{S/b}$
Power (Eq. 7.12):	$Q = bS^c$
Linear (Eq. 7.11):	$Q = a + bS$
Combined (Eq. 7.10):	$Q = a + bS^c$

Field 7: The default is to use the SFF array developed by the previous *5CR1* record that is in active computer memory. The second option is to read a SFF array from a previously created SFF file. Only the first SFF array will be read from the previously created SFF file even if the file contains multiple SFF arrays.

Field 8: The incremental probability array is stored in active computer memory for use by *2REL*, *2FRE*, *2FRQ* and *2PER* record routines. The probability array may also be written to a SFF file if the model-user wants to see the numbers.

Field 9: All starting storage volumes are multiplied by the factor entered in field 9 with a default of 1.0. MFACTOR serves the same function as *CR4* on the *CR* record.

Fields 10, 11, and 12: These fields are used to enter values for the regression coefficients *a*, *b*, and *c* of Equations 7.9 or 7.12 of Chapter 7 of the *Reference Manual* if specified by a -1 or -2 entered in *5CR2* record field 6 for the parameter FIT.

5CR2 Record – Control Points and Reservoirs (2nd, 3rd, and 4th 5CR2 records)

field	columns	variable	format	value	description
1	1-4	CD	A4	5CR2	Record identifier
2	5-8	CD2	A4	FLOW STCP STRE INIT	Control points for naturalized flows to be summed Control points for reservoir storage to be summed Reservoirs for storage to be summed Initial storage volumes for storage control points
3-17	9-128	CPS(I) CPF(I)	15(2x,A6)	AN	Control point or reservoir identifiers for summing flow (I = 1,NFLOW) or storage (I = 1,NSTOR)
3-17	9-128	IS(I)	15(F8.0)	+	Initial storage volumes for CD2=INIT (I=1,NSTOR)

Supplemental 5CR2 records are included in the input file only as specified by fields 2, 3, and 4 of the initial 5CR2 record. Up to 15 control point or reservoir identifiers are listed in fields 3–17 of the two supplemental 5CR2 records as specified by fields 2 and 3 of the main 5CR2 record. Initial reservoir storage volumes are entered on a third 5CR2 record if specified by field 4 of the main 5CR2 record. The three supplemental 5CR2 records follow behind the main 5CR2 record.

If NFLOW in field 2 of the main 5CR2 record is non-zero, a 5CR2FLOW record is required to list the control points at which naturalized flows are summed for use in developing a SFF relationship.

If NSTOR in field 3 of the main 5CR2 record is not zero or –1, either a 5CR2STCP or 5CR2SRES record is required to list the control points or reservoirs at which storage is summed.

If READINI in field 4 of the main 5CR2 record is non-zero, a 5CR2INIT record is required for the starting storage volumes for each of the control points or reservoirs listed on the 5CR2STCP or 5CR2SRES record.

TABLES

5COR Record – Correlation Coefficients

field	columns	variable	format	value	description
1	1-4	CD	A4	5COR	Record identifier
<u>Control Points or Reservoirs for Flow and Storage</u>					
2	5-8	NFLOW	I4	+ blank,0	Number of control points for naturalized flow. Flow at all control points is summed.
3	9-12	NSTOR	I4	+ blank,0 -1	Number of control points or reservoirs for storage. Storage at all control points is summed. Storage at all reservoirs is summed.
<u>Annual or Monthly Cycle Options</u>					
4	13-16	TCR2	I4	+ blank,0	Starting month activates annual cycle option. Monthly or non-annual option adopted by default.
<u>Months Used to Sum Flows</u>					
5	17-20	FM	I4	+ blank,0	Number of months for naturalized flow volume. Default is CR1 from CRM file if opened.

5COR Record – Correlation Coefficients (second and third 5COR records)

field	columns	variable	format	value	description
1	1-4	CD	A4	5COR	Record identifier
2	5-8	CD2	A4	FLOW STCP SRES	Control points for naturalized flows to be summed. Control points for reservoir storage to be summed. Reservoirs for storage to be summed.
3-17	9-128	CPF(I) or CPS(I)	15(2x,A6)	AN	Control point or reservoir identifiers for summing flow (I = 1,NFLOW) or storage (I = 1,NSTOR)

Up to 15 control point or reservoir identifiers are listed in fields 3-17 of the two supplemental 5COR records as specified by fields 2 and 3 of the main 5COR record. The two supplemental 5COR records follow behind the main 5COR record.

If NFLOW in field 2 of the first 5COR record is non-zero, a 5CORFLOW record is required to list the control points at which naturalized flows are summed for use in developing correlation coefficients.

If NSTOR in field 3 of the first 5COR record is non-zero, either a 5CORSTCP or 5CORSRES record is required to list the control points or reservoirs at which storage is summed.

If NFLOW or NSTOR in fields 2 and 3 of the initial 5COR record are blank or -1, the corresponding supplemental record is not entered.

5COR Record Continued

The *5COR* record activates a routine that reads reservoir storage volumes and naturalized stream flow volumes from the OUT file produced by a long-term *SIM* simulation and aggregates the volumes as specified by *5COR* record fields 2, 3, 4, and 5. A table of statistics is produced that includes the mean, standard deviation, and range of storage and flow volumes and the linear correlation coefficient and Pearson rank correlation coefficient for flow volumes versus storage volumes.

The creation of the statistics table is the only function of the *5COR* record. The same statistics table is also included as a *5CRI* record option. The optional *5CRI* record statistics table is the same as the *5COR* table. The *5COR* record is designed for correlation studies to support consideration of alternative modeling strategies. With multiple *5COR* records or multiple executions of *TABLES*, correlation coefficients may be computed for alternative combinations of naturalized flow volumes covering different periods of months at alternative control point locations and preceding storage contents in various reservoirs or combinations of reservoirs. These correlation coefficients may be used to support judgments regarding selection of control points and time periods to be adopted in the conditional reliability modeling (CRM) studies.

Explanation of Fields in the Main 5COR Record

Field 2: If field 2 is blank, there is no listing of control point identifiers, and the naturalized flow at all control points included in the *SIM/SIMD* output file is summed. Otherwise, the naturalized flow used to build correlation coefficients is the total of the flows at the NFLOW control points listed on a supplemental *5COR* record. FLOW is entered in field 2 of the supplemental *5COR* record. The number of control point identifiers read from the supplemental *5COR* record is specified by field 2 of the initial *5COR* record and cannot exceed 15.

Field 3: If field 3 is blank, there is no listing of control point or reservoir identifiers, and the storage from all control point output records included in the *SIM/SIMD* output file is summed. A -1 results in use of all reservoir records in the *SIM/SIMD* output file. Otherwise, the reservoir storage used to compute correlation coefficients is the total of the reservoir storage at the NSTOR control points or reservoirs listed on a supplemental *5COR* record. STCP or STRE is entered in field 2 of the supplemental *5COR* record. The number of identifiers read from the supplemental *5COR* record is specified by field 3 of the initial *5COR* record and cannot exceed 15.

Field 4: Entering a starting month ranging from 1 to 12 activates the annual cycle option. The monthly cycle option is activated by default by a blank field 4. The same information is provided by CR2 on the *CR* record. However, field 4 specifies the option used to develop correlation coefficients from the results of a long-term non-CRM *SIM/SIMD* simulation.

Field 5: The flow is summed over the first FM months of each simulation sequence. If field 5 is blank and CRM file is opened, the default is to sum the storage and flow for the entire simulation period CR1, set by *SIM CR* record and included in the 5th record of the CRM file.

TABLES

