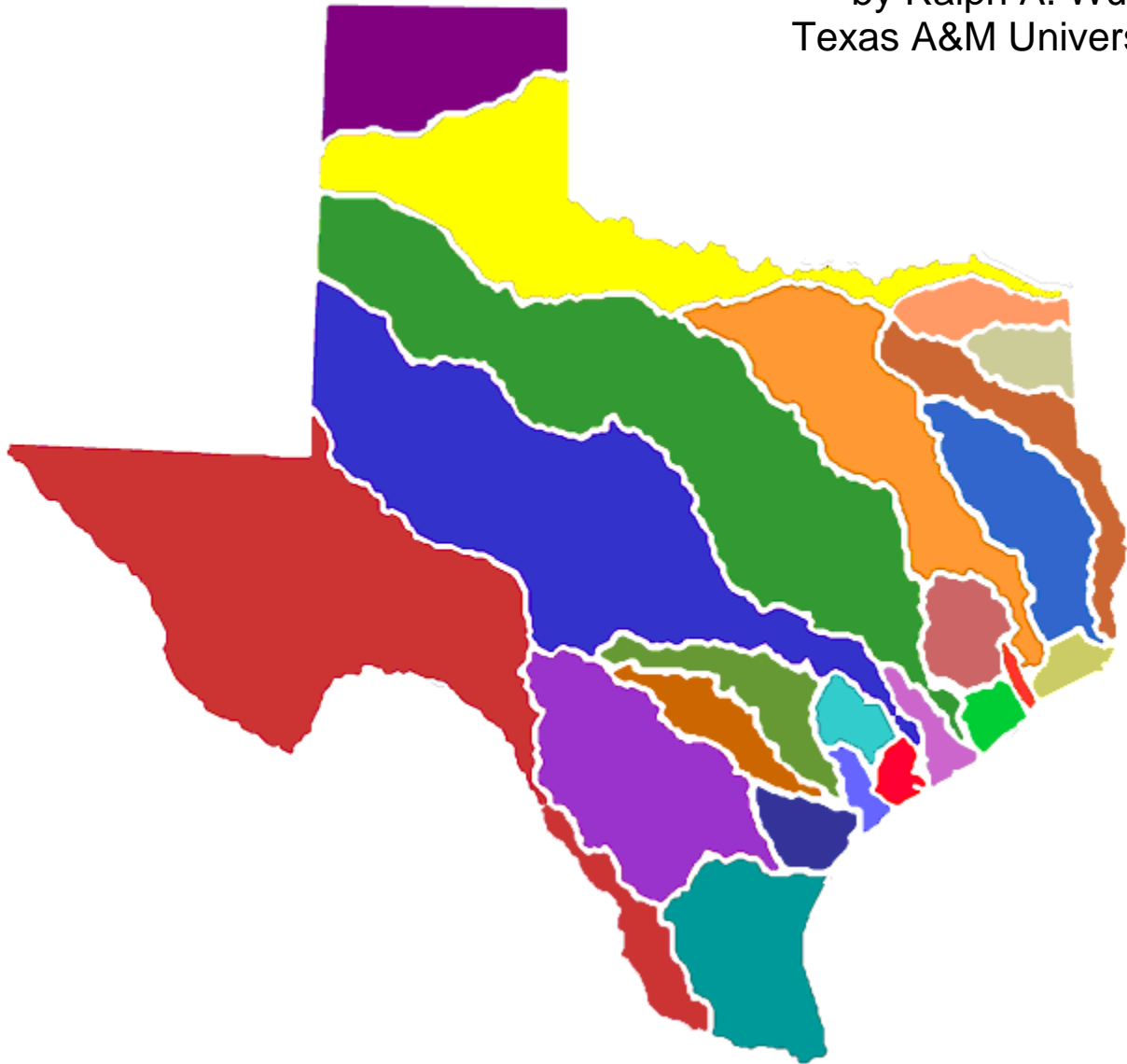# Water Rights Analysis Package (WRAP) Modeling System Users Manual

by Ralph A. Wurbs
Texas A&M University

Texas Water
Resources Institute
make every drop count

Water Rights Analysis Package (WRAP) Modeling System Users Manual

by

Ralph A. Wurbs
Texas A&M University

12th Edition
May 2019

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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 features. The *Reference Manual* provides an overview description of the modeling system, outlines the purposes served by each of the manuals, and explains in detail the methods employed in the monthly WRAP. The *Daily Manual* covers the additional capabilities provided by the daily version of the modeling system. This *Users Manual* provides the operational logistics for applying the WRAP programs *SIM*, *SIMD*, and *TABLES* by explaining the organization of input and output files and the content and format of input records. Application of the Hydrologic Engineering Center program *HEC-DSSVue* with WRAP is also covered in this *Users Manual*.

WRAP Programs

This *Users Manual* and companion *Reference*, *Daily*, and *Fundamentals Manuals* document the following WRAP 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 based on a monthly time step for input sequences of naturalized flows and net evaporation rates.

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

TABLES develops frequency metrics, reliability indices, and various user-specified tables for organizing, summarizing, and displaying *SIM* and *SIMD* simulation results.

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

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

The *Daily Flows* and *Daily Hydrographs* programs assist in developing daily hydrology input for *SIMD* including calibrated routing parameters.

SALT reads a *SIM* simulation results 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.

Covered in this Manual		Covered in Supplemental Manuals	
Monthly Simulation	SIM.exe	Monthly Hydrology	HYD.exe
Daily Simulation	SIMD.exe	Daily Hydrology	DAY.exe
TABLES	TAB.exe	Daily Hydrology	DAYH.exe
WinWRAP	WinWRAP.exe	Salinity Simulation	SALT.exe

Chapter 1 WRAP

WinWRAP facilitates running the WRAP programs within Microsoft Windows in an integrated manner along with use of Microsoft programs and _HEC-DSSVue_ to access and manage input and output 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 files. _WinWRAP_ is described briefly here and explained in greater detail in the _Fundamentals Manual_. The _WinWRAP_ menu structure provides the user the options shown in Table 1.1.

Table 1.1
WinWRAP User Interface

Files by Type	WRAP Programs	MS Programs	Information	Aids	Exit
All Files	SIM-TAB	NotePad	WinWRAP Instructions		Clear Screen
All WRAP Files	SALT-TAB	WordPad	WinWRAP Version		Exit
Main Input Files	HYD		WRAP Documentation		
Main Output Files	DAY				
Hydrology Files	---------------		TAMU WRAP Website		
Special Files	Terminate		TCEQ WAM Website		
Message Files			TWRI Website		
DAT Files			HEC Website		
TIN Files					
TOU Files					
DSS Files					

Microsoft WordPad, NotePad, or other software is used to view and edit data files. The "_Files by Type_" menu provides access to data files through a Microsoft Windows window. The pull-down menu allows browsing through directories with only files shown of the selected type (first column of Table 1.1). Clicking a file activates a user-selected program such as WordPad or NotePad which opens the file. The Windows operating system provides mechanisms 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 automatically opens _HEC-DSSVue_. The _MS Programs_ pull-down menu is also designed for opening the Microsoft programs listed in Table 1.1. However, the _Files by Type_ menu with pre-assigned filename extensions is a quicker way to edit existing data files.

The WRAP programs optionally record _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_. Assuming that _HEC-DSSVue_ has been loaded on the computer, _HEC-DSSVue_ can be executed by clicking a DSS file as well as by other normal alternative methods for employing software. The _HEC-DSSVue_ software and documentation are available for download at the Hydrologic Engineering Center website.

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. The browser is used to locate the directory of the input files and open a file. A mouse clicks repeats the same filename root in multiple boxes quicker than employing the browser for each box. *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.

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 reference to the WRAP manuals. *TAMU WRAP*, *TCEQ WAM*, *TWRI*, and *HEC* refer to websites for latest the WRAP software and documentation available at Texas A&M University (TAMU), the Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) System, the Texas Water Resources Institute (TWRI), and the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC).

The optional aids for creating input data files previously accessed through the *Aids* menu are now obsolete. An optional set of interactive dialog boxes may be used to create *TABLES* input files. However, *TABLES* input files are more conveniently created and edited using the same Microsoft editors as used for the other input files rather than this built-in *WinWRAP* editor. The *TABLES* input file editor has not been updated in recent years for new and revised *TABLES* input records.

SIM Monthly Simulation Model

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 monthly stream flow volumes 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 a 936-month 1940-2017 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 WordPad or NotePad and/or any other editor, spreadsheet, *HEC-DSSVue*, or other software.

SIMD Daily Simulation Model

SIMD expands the monthly *SIM* simulation model to employ daily computational time steps, flow forecasting and routing, pulse flow environmental instream flow targets, and flood control reservoir operations. The *Daily Manual* supplements the *Reference Manual* in documenting the *SIMD* simulation model and corresponding daily features of *TABLES*.

TABLES Post-Simulation Program

TABLES creates 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. Though dealing primarily with simulation results, options are also provided for analyzing simulation input data. *TABLES* is covered in Chapter 7 of the *Reference Manual* and Chapter 5 of this *Users Manual*. The *Fundamentals Manual* provides an introductory condensed coverage of *WinWRAP*, *SIM*, and *TABLES* and their integrated application.

Other WRAP Programs

The Monthly Hydrology (*HYD*), Daily Flows (*DAY*), Daily Hydrographs (*DAYH*), and Salinity (*SALT*) programs are covered in the *Hydrology*, *Daily*, and *Salinity Manuals*. *HYD* is a set of computational options designed to facilitate developing or updating sequences of monthly naturalized stream flows (*IN* records) and reservoir net evaporation-precipitation rates (*EV* records) for *SIM* input files. *DAY* and *DAYH* documented in the *Daily Manual* are used to develop routing parameters and other daily flow data for *SIMD*. 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*.

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.

A simulation is performed with *SIM* or *SIMD* using input files of water rights and hydrology data provided by the model user. *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*, *DAYH*, 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*, *SIMD*, and *TABLES* are discussed throughout this *Users Manual*. Files associated with *DAY*, *HYD*, and *SALT* are covered in the other manuals.

Filenames are in the format "*root.extension*". The combined directory pathname and filename root is limited to a maximum length of 70 characters for DSS files and 116 characters for the other files. Certain files used in a single execution must have the same filename root, and all of the files may have the same root. Either shared or different filename roots may be assigned to files as follows.

- The same root may be used for the filename of all files for all programs associated with a particular modeling project or different roots can be used with different programs. The filename extension differentiates the different types of data contained in the files.

- Assigning a different root for the *SIM* input files other than the DAT file may be convenient though not required in the common situation in which the DAT file is varied in multiple simulations to reflect alternative plans or scenarios while the other files remain unchanged.

- Different roots for *TABLES* input and output files may be convenient though not required.

- Programs *HYD* and *DAY* input and output files may have either the same or different roots. *HYD* and *DAY* automatically add the term OUT to the root of certain output filenames.

Table 1.2
Input and Output Files
_____

Simulation Model (SIM.exe and SIMD.exe) Input Files

root1.DAT required main input file containing all input *dat*a, except the voluminous hydrology
related data contained in the following files
root2.FLO inflow *IN* records with naturalized stream *flo*ws (optional filename root.INF)
root2.EVA *eva*poration *EV* records with net evaporation-precipitation rates
root2HYD.DSS *hyd*rology DSS file with naturalized flows and evaporation-precipitation rates
root2.DIS flow *dis*tribution *FD* and *FC* and watershed parameter *WP* records
root2.HYD *IN* and *EV* records provided in a single *hyd*rology file instead of FLO and EVA files
root2.TSF target series *TS* records can be placed in either a TSF file or the DAT file
root2.FAD *f*low *ad*justment *FA* records for adjusting naturalized stream flows
root2.HIS hydrologic index series on *HI* records
root1.BES *b*eginning and/or *e*nding *s*torage listing activated by *JO* record field 5
root2.RUF *r*egulated-*u*nappropriated *RU* flow adjustment records activated by *JO* field 12 or 13
root2.DIF *d*aily *i*nput *f*ile with routing parameters and other optional daily data read by *SIMD*

Simulation Model (SIM.exe and SIMD.exe) Output Files

root1.MSS *m*ess*ages reporting simulation progress and input data errors
root1.OUT main simulation results *out*put file read by *TABLES* and *SALT*
root1.SOU main *s*imulation results *ou*tput file in columnar format
root1.DSS simulation results output file in HEC-DSS (*d*ata *s*torage *s*ystem) binary format
root1.HRR *h*ydropower and *r*eservoir *r*elease file read by *TABLES*
root1.YRO *y*ield-*r*eliability *o*utput table presenting the results of a *FY*-record analysis
root1.CRM *c*onditional *r*eliability *m*odeling simulation results read by *TABLES*
root1.ZZZ changes in stream flow availability in water rights sequence activated by *ZZ* record
root1.BES *b*eginning and/or *e*nding *s*torage listing activated by *JO* record field 5
root1.BRS *b*eginning *r*eservoir *s*torage listing activated by *JO* record field 6
root1.SUB *SIMD* *sub*-monthly time step simulation results
root1.SMM *SIMD* sub-monthly messages and supplemental reports
root1.AFF *SIMD* *a*nnual *f*lood *f*requency file with annual series of peak flow and storage

Salinity Simulation Model (SALT.exe) Input Files

root.SIN required *s*alinity *in*put file with concentrations or loads of entering flows
root.DAT required main *SIM/SIMD* input file from which *CP* records are read
root.OUT required main *SIM/SIMD* *out*put file with simulation results
root.BRS *b*eginning *r*eservoir *s*torage file created by *SIM/SIMD* and read by *SALT* to provide
beginning reservoir storage if specified by *JC* record field 8
root.BRC *b*eginning *r*eservoir *c*oncentration file created by *SALT* and also read by *SALT*

Salinity Simulation Model (SALT.exe) Output Files

root.SAL *sal*inity simulation results read by *TABLES*
root.SMS *s*alinity *me*ssage file with simulation trace, error and warning messages, and
intermediate and summary simulation results tables
root.BRC *b*eginning *r*eservoir *c*oncentration file created and read by *SALT*

_____

Table 1.2 (continued)
Input and Output Files

_____

TABLES (TAB.exe) Input Files

root.TIN	required *TABLES in*put file with specifications regarding tables to be developed
root.DAT	*SIM/SIMD* input DAT file
root.OUT	*SIM/SIMD* output OUT file
root.DSS	any DSS file containing any monthly, daily, or annual time series data
root.ZZZ	*SIM/SIMD* output ZZZ file
root.HRR	*SIM/SIMD* output HRR file
root.DIS	*SIM/SIMD* input DIS file
root.AFF	*SIMD a*nnual *f*lood *f*requency output file with annual series of peak flow and storage
root.CRM	*SIM/SIMD c*onditional *r*eliability *m*odeling output file
root.SFF	*s*torage-*f*low-*f*requency file created by *5CR1* record and read by *5CR2* record
root.SAL	*SALT* output SAL file

TABLES (TAB.exe) Output Files

root.TOU	*TABLES ou*tput file with the tables developed by the various routines
root.TMS	*TABLES m*es*s*age file with tracking the computations and reporting input data errors
root.DSS	Hydrologic Engineering Center *D*ata *S*torage *S*ystem file read by *HEC-DSSVue*
root.SFF	*s*torage-*f*low-*f*requency file created by *5CR1* record and read by *5CR2*

Monthly Hydrology Program (HYD.exe) Input Files

root.HIN	*H*YD file with all *in*put data not included in the following hydrology files
root.FLO	inflow *IN* records with stream *flo*ws
root.EVA	*eva*poration *EV* records with net evaporation-precipitation rates
root.DIS	flow *dis*tribution *FD & FC* and watershed parameter *WP* records
root.HYD	*IN* and *EV* records in single *hyd*rology file in modified format
root.DSS	*D*ata *S*torage *S*ystem file of stream flows and evaporation-precipitation depths
Precipitation.PPP	statewide precipitation dataset maintained by TWDB
Evaporation.EEE	statewide evaporation dataset maintained by TWDB

Monthly Hydrology Program (HYD.exe) Output Files

rootOUT.HOT	file with all output not included in the following files
rootOUT.HMS	*H*YD *m*es*s*age file tracking the computations and reporting input data errors
rootOUT.FLO	inflow *IN* records with naturalized stream *flo*ws
rootOUT.EVA	*eva*poration *EV* records with net evaporation-precipitation rates
rootOUT.DSS	*D*ata *S*torage *S*ystem file of stream flows and evaporation-precipitation depths

Daily Hydrology Programs (DAY.exe) Input and Output Files

root.DIN	main *DAY in*put file
root.DMS	*D*AY *m*es*s*age file
root.DAY	*DAY* output file
root.FLO and rootOUT.FLO	input or output file of monthly *flo*ws
root.DCF and rootOUT.DCF	input or output file of *d*aily *f*lows
root.DSS and rootOUT.DSS	input or output file of flows in DSS binary format

_____

Table 1.3 Matrix of Input and Output Files and Programs

File Name	File Function	WRAP Programs					
		SIM	SIMD	SALT	TABLES	HYD	DAY
	Main Required Input File for Each Program						
DAT	*SIM* and *SIMD* input data file	input	input	input			
SIN	*SALT* input file			input			
TIN	*TABLES* input file				input		
HIN	*HYD* input file					input	
DIN	*DAY* input file						input
	Hydrology Input Data						
FLO	*IN* record naturalized flows	input	input			in & out	in & out
EVA	*EV* record net evaporation	input	input			in & out	
DSS	DSS file with various data	input	input		input	in & out	in & out
DIS	flow distribution parameters	input	input			input	
HIS	hydrologic index *HI* record series	input	input				
FAD	flow adjustments	input	input				
	Main Simulation Results Output File for Each Program						
OUT	*SIM* and *SIMD* main output file	output	output	input	input	input	
CRM	conditional reliability model file	output	output		input		
SOU	results in columnar tables	output	output				
SUB	*SIMD* sub-monthly time step file		output		input		
SAL	*SALT* main output file			output	input		
TOU	*TABLES* main output file				output		
DSS	DSS file with simulation results	output	output		output		
DAY	*DAY* main output file						output
	Message File for Each Program						
MSS	*SIM* and *SIMD* message file	output	output				
SMM	*SIMD* message file		output				
SMS	*SALT* message file			output			
TMS	*TABLES* message file				output		
HMS	*HYD* message file					output	
DMS	*DAY* message file						output
	Special Purpose Files						
HRR	hydropower and reservoir release	output	output		input		
YRO	yield reliability output	output	output				
ZZZ	priority sequence flows	output	output		input		
BES	beginning/ending storage	in & out	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		
DIF	optional daily input data		input				

The user-assigned filename root is specified by the model-user through the beginning-of-execution log-in procedures managed by *WinWRAP*. The 3-character extension designates the type of data contained in the files, using naming conventions incorporated in the WRAP programs. Microsoft Windows allows selection of an editor, such as WordPad, to automatically open files having a particular extension. Programs and files are connected by *WinWRAP* with user-supplied filename roots when the programs are executed.

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*, *SIMD*, and *TABLES* are defined in Chapters 3, 4, and 5, respectively, of this manual. *SIM* and *SIMD* input records begin with one of the two-character record identifiers listed in Tables 3.1 and 4.1. *TABLES* records begin with the four-character identifiers listed in Table 5.2.

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

The record description tables in this manual reflect the recommended default option of standard fixed-width fields. The Fortran format specifications found in the fourth column of the record description tables 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.

Fields on *SIM* and *TABLES* input records with real number entries have a width of eight characters (F8.0 specification). Most record fields for integer entries are either four (I4) or eight (I8) characters wide. Some of the alphanumeric entries such as control point and reservoir identifiers have six-character fields (A6); others have 8-character fields (A8). Water right identifies may contain up to 16 characters (A16). Various fields also have other widths.

Variables with integer (I4 or I8) format specifications should be right-justified in the appropriate field with no decimal. Trailing blanks are read as zeros. Real variables (F8.0) should either be right justified or include the decimal. Input values for Fortran character variables (alphanumeric (A) specification) can be 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 entries 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,A6,2I4,12F8.0) as described by the *IN* record description table in Chapter 3 of this *Users Manual*.

```
IN  CP1    2012   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 follows.

```
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, day, or 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.

Hydrologic 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.

SIM, *HYD*, and *SALT* employ a monthly computational time step. *SIMD* (D for daily) performs the simulation using a daily time step while combining daily and monthly input data. February is divided into 28 or 29 days (leap year) and the other months have 30 or 31 days.

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 8 of the *Reference Manual*.

Dataset Size, Memory Requirements, and Execution Times

A *SIM* or *SIMD* input 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. Programs *SIM* and *SIMD* perform 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. Dimension limits for most arrays are set based on the information obtained from the initial reading of data files, but several minor limits are fixed at specified sizes which are noted at appropriate places in this manual. *TABLES*, *HYD*, *DAY*, and *SALT* are structured somewhat differently than *SIM* and *SIMD*. 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 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. A flow extension model calibration option in *HYD* can also have execution times of multiple hours.

HEC-DSS and HEC-DSSVue

The HEC-DSS Data Storage System was developed and is maintained by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE). A DSS file is a direct access binary file that can be read only by HEC-DSS software such as *HEC-DSSVue*, HEC simulation models, or other non-HEC software that contain DSS capabilities. The WRAP programs are linked at compilation with a HECDSS library of routines allowing them to read input data from DSS files and store simulation results as DSS files.

The HEC-DSS Visual Utility Engine (*HEC-DSSVue*) is a graphical user interface program for viewing, editing, and manipulating data in DSS files. *HEC-DSSVue* provides capabilities for graphical displays of WRAP input data and simulation results and computational routines that are pertinent to analysis of WRAP quantities. Data can be conveniently exchanged between WRAP programs, *HEC-DSSVue*, and Microsoft Excel. The public domain *HEC-DSSVue* software and documentation may be downloaded from the HEC website: http://www.hec.usace.army.mil

WRAP applications of HEC-DSS and *HEC-DSSVue* are covered in detail in Chapter 6 of this *Users Manual* and discussed throughout this manual and the other WRAP manuals. *HEC-DSSVue* is documented in detail in its user's manual available at the HEC website along with the *HEC-DSSVue* software. The HEC Data Storage System (DSS) references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. Pathnames vary for different types of WRAP input data and simulation results, as described by Tables 6.5, 6.6, and 6.7 in Chapter 6, but are generally in the following format.

A – filename root of WRAP input or output file
B – control point identifier
C – identifier of variable such as IN, EV, DF, FA, HI, or TS for simulation input or NAT, REG, UNA, STO, DEP, DIV, or IFT for simulation results
D – range of record blocks encompassing period-of-analysis
E – 1DAY, 1MON, or 1YEAR indicating the time interval
F – Blank (not used) for simulation input file. Water right or reservoir identifier for long-term simulation or CRM sequence for conditional reliability modeling output file

DSS files are used in WRAP for managing time series of simulation input data and time series simulation results. Differences and similarities between DSS files and all of the other WRAP file types listed in Table 1.2 are as follows.

- All of the file types are identified by their filename extensions which are listed in Table 1.2. DSS files have the filename extension DSS.

- DSS files are in a binary format that can be read only by software with DSS capabilities. The other files are all in a text file format readable by WordPad, NotePad, Microsoft Word, Microsoft Excel, and other popular software.

- Data records in DSS files are organized based on a pathname structure designed for efficient organization and accessibility of time series data including extremely large datasets. The other WRAP input and output files are text files containing records which are explained in this *Users Manual* and the other WRAP manuals.

- Input records for the WRAP programs are labeled by two-character identifiers such as *IN*, *EV*, *CP*, *WR*, *IF*, placed in the first two columns of each of the records in the text files. These record type identifiers are placed in Part C of the DSS record pathnames.

- The format for DSS error/warning messages is different than the other WRAP messages.

- *HEC-DSSVue* provides useful capabilities for storing, organizing, searching, viewing, tabulating, plotting, and manipulating DSS data records and performing mathematical operations and statistical analyses. *HEC-DSSVue* works only with DSS files.

Other Auxiliary Software

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 and analyzing simulation results. *HEC-DSSVue* data management, graphics, and analysis capabilities employed with DSS datasets are noted above and discussed in Chapter 6. Microsoft Office and ArcGIS software are noted below.

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, and Word, 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

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 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. Both standardized display features and customization are provided.

CHAPTER 2
WRAP-SIM FILES

Applying WRAP involves working with computer programs, data files, and data records. The input and output files for program *SIM* described in this chapter are also used by *SIMD*. Additional files of daily data relevant only for *SIMD* are described in Chapter 4. The content and format of *SIM* (*SIM/SIMD*) and *SIMD*-only input records are explained in Chapters 3 and 4.

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* and *SIMD* Input and Output Files
_____

Input Files Read by Both SIM and SIMD

DAT	all input data except the hydrology data	required
FLO	inflow *IN* records with naturalized stream flows	*JO* record field 2
EVA	evaporation *EV* records with net evaporation depths	*JO* record field 2
DSS	time series *IN*, *EV*, *FA*, *RU*, *HI*, *TS* records	*JO* record fields 2,4-7
DIS	flow distribution watershed parameters	*CP* record fields 6, 9
FAD	*FA* record adjustments to naturalized flows	*JO* record field 3
TSF	*TS* record target series	*TS* record field 3
HIS	*HI* record hydrologic index sequences	*HC*, *TO*, *FS*, *CV, JO* 6
BES	input/output file for beginning-ending storage options	*JO* record field 8
HYD	alternative to FLO and EVA hydrology files	*JO* record field 2
DSS	DSS file as alternative to FLO and EVA hydrology files	*JO* record field 2
RUF	*RU* record regulated-unappropriated flow adjustments	*JO* record fields 17,18

Output Files Created by Both SIM and SIMD

MSS	trace messages and error and warning messages	automatic
OUT	simulation results	default
DSS	simulation results in DSS (data storage system) file	*OF* record
CRM	conditional reliability modeling simulation results	*CR* record
SOU	simulation results in columnar format	*JD* record field 7
YRO	yield-reliability table with firm yield	*FY* record
ZZZ	stream flow availability in rights priority sequence	*ZZ* record
HRR	hydropower production and reservoir releases	*JO* record field 10
BES	input/output file for beginning-ending storage options	*JO* record field 8
BRS	beginning reservoir storage used by *TABLES* conditional reliability modeling routine and program *SALT*	*JO* record field 9

Daily Data Files Relevant only to SIMD and Described in the Daily Manual

DIF daily input file and message SMM and simulation results SUB and AFF output files
_____

The input files provided by the model-user as input for *SIM* are comprised of the records described in Chapter 3. The DAT file (filename root.DAT) is the only absolutely required *SIM* input file. DSS or FLO and EVA files are standard input files 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 listed in Table 2.1 each serve a specific purpose.

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 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 message MSS file. Supplemental output related to multiple-reservoir system releases and hydroelectric energy generation is written to the optional HRR file. A yield-reliability and firm yield analysis option writes a table to an YRO output file. BES, BRS, and ZZZ output files serve special purposes noted later in this chapter.

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 5. 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*.

Main Input Data (DAT) File

All input other than the *IN*, *EV*, *FD*, *FC*, *WP, FA,* and *TS* records are stored in the main *SIM* input file with filename extension DAT. Optionally, *TS* records and the *IN* and *EV* records may also be included in the DAT file. 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. Optional target series *TS* records may be included in either the DAT file or a TSF file.

Hydrology (FLO, EVA, DSS) Input Files

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 by INEV option 3 in *JO* record field 2, the *IN* and *EV* records may be included in the DAT file. *I*NEV option 5 combines the *IN/EV* records in a HYD file (filename root.HYD) in a format developed for the original version of the model but now never 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 (INEV option 6 in *JO* record field 2) 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. DSS files are discussed in Chapter 6.

Options for storing flow adjustment *FA*, and hydrologic index *HI*, regulated-unappropriated flow adjustment *RU*, and target series *TS* records as DSS records in the DSS hydrology input file are activated by parameters on the *JO* record. The DSS hydrology input file is employed instead of FLO, EVA, FAD. RUF, HIS, and/or TSF files if specified on the *JO* record in the DAT file.

Flow Distribution (DIS) Input File

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) primary control points to ungaged (unknown flow) secondary control points. Watershed areas from the DIS file can also be used by the routine that adjusts net evaporation-precipitation volumes for reservoir site runoff. A DIS file is opened automatically if flow distribution options that use the DIS file data are specified on one or more *CP* records (fields 6 or 9). The DIS file is also opened automatically by selection in *JD* record field 10 of the net evaporation-precipitation adjustment option that uses watershed areas from the DIS file.

Flow Adjustment (FAD) Input 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. The *FA* record and FAD file were originally developed to adjust naturalized flows for spring flows associated with specified groundwater conditions. However, the quantities entered on *FA* records can be any adjustments to naturalized flows for any purpose. *FA* record sequences can be provided for any number of control points. All *FA* records are contained in a single FAD file.

Hydrologic Index Series (HIS) Input File

The hydrologic index series HIS file contains hydrologic index *HI* records. The *HI* record and *HIS* file were initially motivated by environmental flow standards specified as a function of the Palmer hydrologic drought index. However, the quantities entered on *HI* records can be time series of any index of interest. The optional hydrologic index is used in the *SIM* simulation in setting water right targets. *HI* records can be stored in either a HIS or DSS file.

The *HI* record indices are referenced by *HC*, *TO*, *LO*, *CV*, and/or *FS* records in the process of setting environmental instream flow or water right diversion targets. Control point identifiers entered on *HC*, *TO*, *LO*, *CV*, and *FS* records connect to the control point identifier on the *HI* records. *HI* record sequences can be provided for any number of control points. All *HI* records for a *SIM* or *SIMD* input dataset are contained in a single HIS file. The HIS file is activated by *HCV* option *HI* on a hydrologic condition *HC* record, TOTARGET option 16 on a *TO* or *LO* record, and/or one or more *FS* or *CV* records with option 12 selected in field 2.

Target Series (TSF) Input File

Target series can be provided for any number of *WR* or *IF* record water rights. Series of monthly diversion, instream flow, or hydropower targets can be input to *SIM* on target series *TS* records in either the DAT file or a TSF file or as DSS records in the DSS hydrology file. Daily environmental flow targets or other water right targets may be computed in a daily *SIMD* simulation and aggregated to monthly totals for inclusion in a DSS, DAT, or TSF input file for a monthly SIM simulation. The *SIM* input TSF file of *TS* records or the *TS* records in a DSS file are activated by a single *TS* record in the DAT file.

Regulated-Unappropriated Flow Adjustment (RUF) Input File

The RUF file was designed for developing condensed datasets as described in Chapter 3 of the *Hydrology Manual*. However, *RU* records in a RUF or DSS file may be used for other purposes as well. The RUF file stores *RU* records containing regulated-unappropriated flow adjustments. The RUF file is activated by a non-zero entry in *JO* record fields 17 or 18.

Simulation Results Output (OUT) File

The *SIM* OUT file (filename extension OUT) is created as a formatted text file by default, but, though not recommended, can optionally be created as an unformatted binary file as specified by *JD* record field 8. 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. These advantages are also achieved with DSS, which is the recommended approach to binary files. 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 8. *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. The model-user specifies in the DAT file which water rights, control points, and/or reservoir/hydropower projects to include in the OUT file. *OR* record DSS(1) option 2 lists rights, control points, and reservoirs in the OUT file without simulation results.

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

WR 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 Output (SOU) File

Simulation results are tabulated in columns in the SOU file for either direct viewing or export into MS Excel. All, none, or any combination of OUT, DSS, and SOU output files may be created with the *JD* and *OF* records. Control points, water rights, and reservoirs are selected for the SOU file in the same manner as for the OUT file. Unlike the OUT file, the SOU file cannot be read by *TABLES*.

Data Storage System (DSS) Output File

The DSS data storage system and *HEC-DSSVue* program for managing DSS files are noted in Chapter 1 and discussed in detail in Chapter 6. DSS and its *HEC-DSSVue* interface was developed by the USACE Hydrologic Engineering Center (HEC). DSS files storing time series data of *SIM* simulation results can be created with either *SIM*, *SIMD*, or *TABLES*. *HEC-DSSVue* is employed to read the DSS files, plot, tabulate, manipulate, or transform the data, and/or perform statistical analyses. The DSS file is in a direct access binary format designed to be read only by *HEC-DSSVue*. The DSS output file is controlled by selections on the DSS file options *OF* record.

Differences between creating a DSS file directly with *SIM* versus creating a DSS file with *TABLES* from the data read from an OUT file created with *SIM* are as follows. The *TABLES* time series options provide capabilities for various manipulations of the data read from the OUT file with the transformed data then being recorded as tables in a TOU file or DSS records in a DSS file. The DSS file created directly by *SIM* is limited to the actual simulation results as computed by *SIM* with no post-simulation arithmetic manipulations.

The DSS file created directly by *SIM* is particularly useful for conditional reliability modeling (CRM). Each DSS record in a DSS file created by *TABLES* covers the entire hydrologic period-of-analysis. The DSS file created directly by *SIM* has separate records for the multiple CRM simulation sequences. The DSS features of *TABLES* are designed for a 12-month year. DSS records created with *SIM* can contain CRM sequences of any integer number of months.

Conditional Reliability Modeling (CRM) Output File

The conditional reliability modeling (CRM) file is 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 8.

Message (MSS) Output 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 in *Reference Manual* Chapter 9.

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 *RG* record has an option for listing water right information to the MSS file. The flow switch *FS* and cumulative volume *CV* records include options for recording intermediate computational results in the MSS file.

Hydropower and Reservoir Release (HRR) Output 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; hydroelectric energy target and quantity of energy actually generated; and 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 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.

The releases included in the HRR file plus additional data for tracking multiple-reservoir system operations are recorded in the DSS output file by DSS(2) in *OF* record field 3

Priority Sequence Stream Flow Availability (ZZZ) Output 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 (YRO) Output File

The firm yield *FY* record activates a routine described in Chapter 6 of the *Reference Manual* that executes the simulation model multiple times in an iterative search for the firm or safe yield and develops 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) Input and Output File

The beginning-ending storage (BES) file is the only file that may serve as both a *SIM* input and *SIM* output file. The beginning-ending storage 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. By default, *SIM* sets the beginning-of-simulation storage contents at capacity. The BES file is used to apply the alternative approach of setting beginning-of-simulation storage contents equal to the end-of-simulation storage contents. Beginning of simulation storage contents for all reservoirs are read from a BES file, and ending storages are written to the BES file. A BES file is opened automatically if a pertinent beginning-ending-storage option is activated in *JO* record field 5.

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) Output 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 BRS file may also be useful for general information.

Selection of Control Points, Water Rights, and Reservoirs to Include in Output

WRAP-SIM simulation results are written to the OUT, CRM, SOU, and DSS output files in the form of the following three sets of time series output records covering each month of the hydrologic period-of-analysis: (1) water right output records including both *WR* and *IF* record rights, (2) control point output records, and (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 <u>all</u> control points, <u>all</u> water rights, or <u>all</u> reservoirs in *TABLES* refers to <u>all</u> 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 covered in Chapter 3 controlling creation of the OUT file and by *TABLES* input parameters discussed in Chapter 5 governing reading the OUT file.

*S*imulation results may be very 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 (or CRM), 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. The use of these output control devices is explained in Chapter 5 of the *Reference Manual*.

Control points, water rights, and reservoirs may be labeled "artificial" using parameters on the *CO* and *WO* record described in Chapter 3. The "artificial" classification does not affect simulation computations but rather is designed for organizing simulation results. Artificial control points, water rights, and reservoirs used for special water accounting schemes are not included in the *SIM* output files unless specifically specified on the *JD and RO* records. The use of artificial control points and water rights is described in Chapter 4 of the *Reference Manual*.

Locating Errors in the Input Data Files

The WRAP programs all create message files that track the progress of reading input files, performing computations, and creating output files. Information recorded in the message files facilitates detecting and locating blunders and inconsistencies in input data. Errors associated with DSS records are discussed further in Chapter 6.

Trace, Warning, and Error Messages

All of the WRAP programs contain similar features for detecting missing and erroneous records in the input files, which are described in Chapter 9 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 9 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 Chapter 9 of the *Reference Manual* may be consulted as needed to better understand and respond to the messages.

No Tabs or Formatting Characters or Blank Records Allowed

WRAP input files must be text files with no formatting. WRAP input files are created and saved as text files. Microsoft programs (and most other programs) use the default filename extension *txt* for the initial creation of unformatted text files. The extension *txt* is easily changed to the filename extensions used by WRAP.

The WRAP programs cannot read tabs, indents, and formatting characters. Characters inserted into documents by word processing or spreadsheet programs to control formatting may be either hidden or visible to the human user of the software. Either way, such characters will prevent the WRAP programs from executing.

SIM input records begin with a two-character identifier. *TABLES* input records begin with a four-character identifier. Blank or undefined identifiers result in termination with error messages.

Blank spaces must be entered with the space bar on the keyboard. Tabs and other formatting characters are not allowed. For example, in editing a DAT file using WordPad, the tab key is erroneously used rather the space bar in entering spaces between the data entries. Execution of *SIM* with this DAT input file results in the execution being terminated with the following information written in the MSS message file.

```
        WRAP-SIM MESSAGE FILE

    *** Starting to read file fundexam.DAT

      ERROR: Fortran IOSTAT error occurred reading an
             input record with CD identifier of JD
             IOSTAT status variable =     64
             Stopped from Subroutine READDAT due to error.

    The first 82 characters of each of the last two records read are as follows:
    **   NYRS     YRST   ICHECK    CPOUT    OUTWR OUTFILE  ADJINC
    JD   74     1940        1       -1       -1              4

        *** Execution of SIM terminated due to an input error.
        *** IOSTAT status variable (error code) =    64
        *** JD record contains data in wrong format.
```

The first trace message indicates that *SIM* started to read the file FundExam.DAT. An error message indicates that an error was encountered in reading the *JD* record. The *JD* record contains data in an unacceptable format. The last two records read by *SIM* before execution was termination are reproduced along with the error message. The hidden tab character between JD and 74 must be deleted, and blank spaces inserted using the space bar on the keyboard. Although Microsoft Word optionally allows the tabs and indents in a document to be shown, WordPad does not. Since in WordPad the tab character cannot be seen in the DAT file, the user may not immediately recognize why the data on the *JD* record has the wrong format.

ICHECK Options

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 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 resorting to the *ICHECK* options 2 through 12 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.

Several simulation features apply linear interpolation to input data tables. Warning messages are always printed if the maximum value in a table is exceeded. If an interpolated table is exceeded by more than 1.0% and ICHECK=1, *SIM* is terminated with an error message.

The *ICHECK* options are defined in *Reference Manual* Chapter 9. *ICHECK* options 1 and 9 control the number of warning and error routines that are activated. Options 2-7 and 11 reproduce specific types of input records as an aid in checking for errors. Option 8 writes information to the MSS file developed by the *PX* record dual simulation. The other ICHECK options provide information about specific aspects of the 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* record flow adjustments which are described in the *Hydrology Manual*. *ICHECK* option 12 lists instream flow targets. Options 13 and 14 deal with iterative evaporation-precipitation computations for nearly empty reservoirs.

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

ICHECK = −1 All error and warning check routines are deactivated.
ICHECK = 0   Some error checks and most warning messages are deactivated.
ICHECK = 1   All error and warning routines are in effect.
ICHECK = 2   All *UC* and *RF* records are written as read.
ICHECK = 3   All *CP* records are written as read.
ICHECK = 4   All *WR* and *IF* records are written as read.
ICHECK = 5   All *SV* and *SA* records are written as read.
ICHECK = 6   All *IN* and *EV* records are written as read.
ICHECK = 7   All *FD*, *FC*, and *WP* records written as read.
ICHECK = 8   All dual simulation information.
ICHECK = 9   Most error checks are in effect.
ICHECK = 10 CRM trace written to MSS file for conditional reliability modeling.
ICHECK = 11 All *RU* records are written as read.
ICHECK = 12 Instream flow targets are recorded.
ICHECK = 13 Warning message alert that wrong-sign evap-precip was changed to zero.
ICHECK = 14 Wrong sign net evaporation-precipitation volume is not changed to zero.

Locating Errors in the SIM Simulation Results 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.

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 5 of this *Users Manual* along with the other *TABLES* input records. The tests activated by the TEST record are described in Chapter 9 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. The organization of *SIM* time series records in the DSS hydrology input file is discussed in Chapter 6. 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 63 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 optional *T1*, *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

_____

<u>Basic Input File (filename extension DAT)</u>

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*
OF   *Options for DSS input and output Files*
WO, GO, CO, RO *Water right, Group, Control point and Reservoir/hydropower Output*
CR   activation switch and specifications for *Conditional Reliability* modeling
FY   *Firm or safe Yield and yield-reliability table*
ZZ   special feature for tracking stream flow availability in water rights priority sequence
XL   multiplication factors and parameter *Limits*
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* right requirements
ES/HC   *Environmental flow Standards for Hydrologic Conditions*
HP   *Hydroelectric Power* parameters
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 (TS* records may be in DAT, TSF. or DSS files.)
PX/AX   *Priority sequence circumvention options*
WS   *Water right reservoir Storage*
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*

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Table 3.1 (Continued)
Types of SIM Input Records

_____

Hydrology Files (filename extensions FLO and EVA or DSS)

IN   *IN*flows to the system (naturalized or otherwise defined monthly stream flows)
EV   *EV*vaporation (reservoir monthly net evaporation less precipitation depths)

Flow Distribution File (filename extension DIS)

FD   *F*low *D*istribution specifications for transferring flows from gaged to ungaged sites
FC   *F*low distribution *C*oefficients for certain flow distribution options
WP   *W*atershed *P*arameters used in the flow distribution computations
ED   *E*nd of *D*ata

Other Hydrologic Time Series Files (filename extensions FAD, RUF, HIS, DSS)

FA   *F*low *A*djustments to be added to the stream flows (FAD or DSS file)
RU   *R*egulated-*U*nappropriated flow adjustments (RUF or DSS file)
HI   *H*ydrologic *I*ndex referenced by *HC*, *TO*, *LO*, *FS*, and *CV* records (HIS or DSS file)

Data Storage System (DSS) Hydrology Input File

The quantities recorded on IN, EV, FA, RU, HI, and TS records in FLO, EVA, FAD, RUF, HIS, TSF, and DAT files alternatively can all be recorded in binary format as DSS records in a single DSS file with filename rootHYD.DSS which is called the *SIM* hydrology DSS input file. Identifiers on *FA*, *RU*, and *HI* records in the DAT file connect to the records in the DSS 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 8 of the *Reference Manual*.

*Optional Files **OF** Record*.- The *OF* record controls options for the DSS and SOU 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.

Table 3.2
Input Records Associated with Component Features of SIM

_____

Organization of the Simulation

file activation	JO, 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

Hydrology Features (Chapter 3 of Reference Manual)

naturalized stream flows	IN, JO field 2, CP fields 4, 7, 8, 12
net reservoir evaporation-precipitation	EV, JO field 2, CP fields 5, 9
net evaporation-precipitation adjustment	FD, WP, CP 10, JD 11
stream flow distribution to ungaged sites	FD, FC, WP, CP fields 7, 8, 12
stream flow adjustments	FA, JO field 3
channel losses	CP field 11
watershed flow option	SO field 2
negative incremental stream flow options	JD fields 9, 10

Water Management Features (Chapter 4 of Reference Manual)

water supply diversions and return flows	WR, UC, SO, PX, TO, RF, ML, TS
instream flow requirements	IF, ES, HC, UC, TO, CV, FS, 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 12, 14
backup right	BU

_____

*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.

*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.

*Environmental Flow Standard **ES** and Hydrologic Condition **HC** Records*.- *ES* and *HC* records are used with *IF* records to model environmental instream flow standards in Senate Bill 3 format.

*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.

*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.

*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*.- Water right diversion, instream flow, or hydropower targets or streamflow depletion limits may be entered on *TS* records in a TSF file, DAT file, or DSS file. 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.

*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 and corresponding water surface elevations are entered on these records for use in 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.

*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 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.

Records in the Hydrology Files (Filename Extensions DSS or 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.

Other Time Series Input Data (Filename Extensions DSS or FAD, RUF, and HIS)

*Stream Flow Adjustment **FA** Record*.- Sequences of adjustments on *FA* records 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 referenced by *HC*, *TO*, *LO*, *FS*, and *CV* records.

Time series data may be stored in FAD, HIS, RUF, and/or TSF files or alternatively in a DSS file and referenced by identifiers provided on *FA*, *HI*, *RU*, and/or *TS* records in the DAT file.

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 two-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 is a series of tables and accompanying explanations providing instructions regarding the format and content of each type of *SIM* input record. *SIM* time series input data recorded as DSS records in a DSS file are further discussed in Chapter 6.

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	JD record is required. JO, OF, FA, RU, HI, CO, RO, WO, GO, XL, CR,
JO	Job Options	FY, ZZ, and RG records are optional. These records are placed between
OF	Optional Files	the T1/T2/T3 records and UC records in any order, except records of the
FA,RU,HI	DSS Input File IDs	same type (FA, RU, HI, CO, RO, WO, or GO) must be grouped together.

CO	Control Point Output	All CO records are grouped together.
RO	Reservoir Output	All RO records are grouped together.
WO	Water Rights Output	All WO records are grouped together.
GO	Water Right Groups	All GO records are grouped together.

XL	Multiplication Factors
CR	Conditional Reliability
FY	Firm Yield
ZZ	Flow Availability
RG	Rights Group

UC	Use Distribution	Set of all UC records follows the records listed above.
UP	Use Priority	Set of all UP records follows set of all UC records.
RF	Return Flow Factors	Set of all RF records follows UC and precedes CP records.

CP	Control Point	All CP records grouped together in any order; at least one.
CI	Constant Inflows	Set of all CI records in any order follows set of all CP records.

IF	Instream Flow	IF and WR records are grouped together in any order, with the set of SO,
WR	Water Right	WS/HP/OR, ML, BU, TO, LO, CV, FS, ES, HC, TS, and PX records
SO	Supplemental Options	following the corresponding WR or IF record.
ML	Monthly Limits	WS, SO, ML, BU, TO, LO, TS, and PX/AX records may be in any order,
BU	Back-up Right	but the complete set must immediately follow their WR or IF record.
TO,LO	Target/Limit Options	CV and FS records are also included with the sets of WR/IF and
CV	Cumulative Volume	auxiliary records. However, CV and FS records included with one right
FS	Flow Switch	may also be connected to one or more other water rights.
ES,HC	Environmental Standards	
TS,TSR	Target Series	
PX,AX	Priority Circumvention and Stream flow Allocation Factors	

WS	Reservoir Storage	WS, HP, and OR records are included in the set of water right auxiliary
HP	Hydroelectric Power	records listed above. HP and OR records follow a WS record.
OR	Operating Rules for a Multiple-Reservoir System	

SV	Storage Volume	Set of all SV-SA tables grouped together in any order, with
SA	Surface Area	each SA immediately following corresponding SV.
PV	Storage Volume	Set of all PV-PE tables grouped together in any order, with
PE	Surface Elevation	each PE immediately following corresponding PV.

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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
TE	Tailwater Elevation	each TE immediately following corresponding TQ.

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
IS/IP	Index Storage/Percentage	must be followed by an IS record followed by an IP record.

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

ED	End of Data	Last record in DAT file except optionally for IN/EV records.

Flow Distribution File (filename root.DIS)

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

Flow (root.FLO) and Evaporation-Precipitation (root.EVA) or Hydrology (rootHYD.DSS) Files
FLO, EVA, and DAT file IN and EV record format options is selected by INEV in JO record field 2.
DSS file organization is described in Chapter 6.

IN	Inflows	IN records of naturalized monthly flows in DSS, FLO, or DAT file.
EV	Evaporation	EV records of evaporation-precipitation depths organized same as IN records.

Other Time Series Files (filename rootHYD.DSS, root.FAD, root.RUF, root.HIS, or root.TSF)

FA	Flow Adjustment	Set of all FA records in FAD or DSS file.
RU	Regulated-Unappropriated Flow Adjustment	Set of all RU records in RUF or DSS file.
HI	Hydrologic Index	Set of all HI records in HIS or DSS file.
TS	Target Series	TS records in TSF, DAT, and/or DSS file.

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* Records and *JD, JO, OF, FA, HI, RU,
CO, RO, WO, GO, XL, CR, FY, ZZ*, and *RG* Records in the DAT File**

A DAT file begins with the optional *T1*, *T2* and *T3* records, if used, followed by *JD*, *JO*, *OF*, *FA*, *HI*, *RU*, *CO*, *RO*, *WO*, *GO*, *XL*, *CR*, *FY*, *ZZ*, and *RG* records in any sequential order as noted in Table 3.3. The *JD* record is required. Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries on the *JD* record. All of the other records in this group are optional.

JD Record – Simulation Job Control Data

field	columns	variable	format	value	description
1	1-2	CD	A2	JD	Record identifier
2	3-8	NYRS	I6	+	Number of years in the simulation period-of-analysis.
3	9-16	YRST	I8	+	First year of simulation. All *IN* and *EV* records before year YRST will be skipped.
					Level of Error Checks and Traces
4	24	ICHECK	I8	blank,0	Normal trace, reduced error, and no warning checks.
				1	Normal trace and complete error and warning checks.
				2-14	ICHECK options are defined in Table 2.3 on page 26.
					Simulation Results Output
5	25-32	OUTCP	I8	blank,0	Control point output is specified only by *CO* records.
				1	Control point data is output for all control points except artificial control points.
				2	Control point data is output only for cps with *IN* records plus those cps listed on *CO* records.
				3	Output only for artificial control points.
				4	All control points including artificial control points.
				≥5	Control point output is limited to first OUTCP control points plus those cps listed on *CO* records.
6	33-40	OUTWR	I8	blank,0	WR output is specified only by *WO* and *GO* records.
				1	Water rights data is output for all *WR* and *IF* record rights except hydropower rights and artificial rights.
				2	All *WR* and *IF* record rights with no exceptions.
				3	Only non-hydropower *WR* record rights are output.
				4	Only *IF* record instream flow rights.
				5	Only hydroelectric power rights are output.
				6	Only artificial water rights are output
				≥7	Water right output is limited to first OUTWR rights in input file plus those listed on *WO* and *GO* records.
7	44	SOUF	I4	1, 2	Optional SOU file is created. Default is no SOU file.
8	48	OUTFILE	I4	2	Binary output file is created. Default is not binary.
					Negative Incremental Naturalized Flow Options
9	56	ADJINC	I8	blank,0,6	Option 6 defined in *Reference Manual* is the default.
				1,2,3,–3,4,–4,5,7,8	Options described in *Reference Manual* Chapter 3.
					Negative Incremental Flow Adjustments to MSS File
10	64	NEGINC	I8	blank,0,1	No adjustments written.
				2	Downstream adjustments written to MSS file.
				3	Upstream adjustments written to MSS file.
				4	Only summary table written to MSS file.
				5	Summary table and control point list.
					Default for Evaporation-Precipitation Adjustment
11	72	EPADJ	I8	blank,0	No adjustment unless specified on *CP* record
				–1	Adjustments based on ungaged CP (*FD* field 2)
				–2	Adjustments based on gaged CP (*FD* record field 3)

JD Record – Simulation Job Control Data (Continued)

field	columns	variable	format	value	description
					Dimension Limit for IS/IP, SV/SA, PV/PE, and TQ/TE Records
12	80	TL	I8	Blank, ≤12	Default maximum limit = 12 pairs of values in tables.
				≥13	Maximum limit on number of entries in tables.
					Alternate Water Right Identifiers in WR Record Fields 12-14 and 15-17
13	88	IDSET	I8	blank,0,1	First set of identifiers on *WR* input records are used.
				2	Second set of identifiers on *WR* records are used.

Explanation of JD Record Fields

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

Output Control: *JD* record fields 5, 6, and 13 and *CO, RO, WO,* and *GO* records control which control points, water rights, and reservoirs are included in the simulation results OUT, CRM, DSS, SOU, and HRR output files. Reservoir output is specified only by use of *RO* records.

Field 5: Control point output records are selected by OUTCP in *JD* record field 5 or the control points with simulation results to be included in the output may be listed on *CO* records. If *JD* field 5 is blank or zero and there is no *CO* record, the simulation results output files include no simulation results stored as control point output records. The older alternative format of denoting options 1, 2, 3, 4 with negative −1, −2, −3, and −4 rather than positive integers also still works.

If a 1 (or −1) is entered in *JD* record field 5, all control points will be output except those designated as artificial. OUTCP option 4 outputs all control points including artificial. A 2 in *JD* field 5 specifies output of just those control points for which *INMETHOD* in field 7 of the *CP* record is 0, 1, or 2, excluding artificial control points. These are primary control points for which naturalized stream flows are entered on *IN* records rather than being synthesized.

OUTCP also allows the first any number of control points ≥ 5 in the DAT file to be selected. For example, entering the integer 38 in field 5 results in output records for the first 38 control points in the order that the *CP* records are found in the *SIM* input DAT file. *CO* records may be used in combination with this *JD* field 5 option.

Field 6: OUTWR allows selection of either no water rights, (1) all rights excluding hydropower and artificial rights, (2) all rights, (3) non-hydropower *WR* record rights, (4) instream flow rights, (5) hydropower rights, or (6) artificial rights. OUTWR also allows the first number of water rights ≥ 7 in the input file to be selected. For example, entering the integer 74 in *JD* record field 6 results in output records for the first 74 water rights in the order that the *WR* records are entered in the *SIM* input DAT file. Alternatively, water rights may be selected for inclusion in the output files by listing water right identifiers or group identifiers on *WO* and *GO* records.

Field 7: The optional SOU file includes the default simulation results variables listed on page 47 with SOUF=1 and all the variables on page 47 with SOUF=2. The first two columns of each table in a SOU file are the year and month and the subsequent columns are the values for each output variable. With CRM, default control point tables include simulation sequence information. The SOU file is a text file which can be read with any editor but not by *TABLES*.

Field 8: By default, the OUT file is in text format readable with editors such as WordPad as well as by *TABLES*. Creating the OUT file in binary machine language format (OUTFILE option 2) readable only by *TABLES* reduces run-time and file size and increases precision. With the integration of DSS in WRAP, the old OUTFILE=2 binary option is now essentially obsolete.

Field 9: The term "*negative incremental flow*" refers to situations in which naturalized flow at an upstream location is greater than the naturalized flow further downstream in a particular month. The conceptual implications of negative incremental flows and computational options for dealing with negative incremental flow are explained in detail in Chapter 3 of the *Reference Manual*. *ADJINC* in *JD* field 9 controls the choice of negative incremental flow option to be adopted in the simulation computations. Option 4 or 6 is the default recommended standard for most applications with a monthly *SIM* simulation. 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   *NEGINC* 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.

Field 11: Methodologies for correcting the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir are explained in the *Reference Manual* Chapter 3. *EPADJ* in field 11 sets a default. The option specified in the *JD* record field 11 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 10 of a *CP* record supercedes the default set in field 11 of the *JD* record.

Field 12: 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 12.

Field 13: Two alternative sets of three water rights identifiers may be included in the last six fields of the *WR* records. Only one of the two sets is read in a single execution of *SIM*. Input variable *IDSET* in *JD* record field 13 specifies whether the first or second set of three identifiers on the *WR* records is adopted in a particular model run.

<div align="center">

Sequencing of *JD, JO, OF, FA, HI, RU, CO, RO, WO,*
<u>*GO, XL, CR, FY, ZZ* and *RG* records in the DAT File</u>

</div>

SIM reads the *JD, JO, OF, FA, HI, RU, CO, RO, WO, GO, XL, CR, FY, ZZ*, and *RG* records as the section of the DAT file that follows the *T1/T2/T3* records and precedes the *UC* records. These records must all be inserted between the *T1/T2/T3* records and *UC* records but can otherwise be in any order, except multiple *FA, HI, RU, 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. All of these records are optional except the required *JD* record.

Relationships between the *FA*, *RU*, and *HI* records described on page 48, which are stored in the DAT file, and the *FA*, *RU*, and *HI* records described on pages 127-131, which are stored in DSS, FAD, RUF, and HIS files, are discussed on page 122. *TS* records are also discussed on page 122.

JO Record – Simulation Job Options

Field	columns	variable	format	value	description
1	1-2	CD	A2	JO	Record identifier
					Organization of IN and EV Records
2	8	INEV	I6	blank,0,1	Grouped by years in FLO and EVA files.
				−1	Grouped by years in FLO file. No EVA file.
				2	Grouped by control points in FLO and EVA files.
				−2	Grouped by control points in FLO file. No EVA file.
				3	Grouped by years in DAT file.
				4	Grouped by control points in DAT file.
				5	Grouped by years in HYD file in HYD file format.
				6	DSS hydrology input file.
					Flow Adjustment Options in FAD File
3	16	FAD	I8	blank,0	FAD file is not used.
				1	Explanations of options 1, 2, and 3 for organizing and
				2	applying flow adjustments from FAD file *FA* records
				3	are provided later with the *FA* record description.
					FA, HI, RU, and TS Records in DSS File
4	20	DSSFA	I4	1, −1	Flow adjustments (FA records) read from DSS file.
5	24	DSSRU	I4	1, −1	Reg-Unapp adjustments (RU records) from DSS file.
6	28	DSSHI	I4	1, −1	Hydrologic index (HI records) read from DSS file.
7	32	DSSTS	I4	1, −1	Target series (TS records) read from DSS file.
					Beginning-Ending Storage (BES) Options
8	36	BES	I4	blank, 0	Feature is not used and BES file is not created.
				1	Ending storages written to BES file.
				2	Beginning storages read from BES file.
				3	Both beginning read and ending written to BES file.
				4	Cycling with BES file automatically created/read.
				5	Cycling without use of a BES file.
				6	Information-only table with water rights data added.
					Beginning Reservoir Storage (BRS) File
9	40	BRS	I4	1	Optional BRS output file is created.
					Hydropower and Reservoir Release (HRR) File
10	44	SYSOUT	I4	1	Optional HRR output file is created.
					Multiple-Reservoir System Release Options
11	48	STOFLG	I4	blank,0	End-of-period storage used for system release rules.
				1	Beginning-of-period storage is used for system rules.
					Drought Index Reservoir Storage Timing
12	56	STODI	I8	blank,0	Beginning-of-period storage used for drought index.
				1	End-of-period storage is used for drought index.
				2	Average of beginning and ending storage is used.
					Alternative Water Right Priority Schemes
13	64	NPOPT	I8	1	Automated natural upstream-to-downstream priority.
				2	Priorities are set by sequencing of *WR* & *IF* records.
				3	Priorities are set by sequencing of *CP* records.

JO Record – Simulation Job Options (Continued)

field	columns	variable	format	value	description
					Defaults for IFM(IF,3), RFMETH, and DUAL
14	72	PASS2	I8	blank,0,1	*IFM(IF,3)* in *IF* field 8 controls 2nd pass option.
				2	Second pass is activated for all months regardless.
15	76	RFD	I4	blank,0,+	Default for *RFMETH* options in *WR* record field 2.
16	80	DUALD	I4	blank,0,+	Default for *DUAL* options in *PX* record field 2.
				−1	Deactivate dual simulation.
					Options for Applying RU Record Adjustments
17	84	RUFIN	I4	1	Adjustments added to inflows at beginning.
				2	Adjustments added to inflows at end of simulation.
18	88	RUF	I4	1	Option 1 for *RU* record regulated flow adjustments.
				2	Option 2 for *RU* record regulated flow adjustments.
				3	Option 3 for *RU* record regulated flow adjustments.

Explanation of JO Record Fields

Field 2: The options for organizing the *IN* and *EV* records in the default FLO and EVA files or the DAT file or optional HYD file activated by INEV=1,2,3,4,5 are outlined later in this chapter accompanying the description of the *IN* and *EV* records. With INEV option 6, the naturalized flows and net evaporation-precipitation depths are input as DSS records in a DSS hydrology file.

Field 3: This field activates use of flow adjustments read from a FAD file. The flow adjustments consist of adding quantities read from *FA* records to naturalized stream flows. Options for organizing and applying the adjustments are described later with the FAD file *FA* records.

Fields 4-7: *FA, HI, RU,* and *TS* time series records can be stored in FAD, HIS, RUF, and TSF files, respectively. Alternatively, these time series can be stored as DSS records in a single DSS input file. An entry of 1 for the switch parameters DSSFA, DSSHI, DSSRU, and DSSTS in *JO* record fields 4-7 specify that the *FA, HI, RU,* and *TS* time series, respectively, are read from a single DSS file. Blank fields or entries of zero mean that these time series either are not used or, if used, are read from FAD, HIS, RUF, and TSF files. For time series input data stored in the DSS hydrology input file, control point or water right identifiers must be entered on DAT file *FA, HI, RU,* and/or *TS* records. DSS is explained in Chapter 6 of this *Users Manual*.

FA, HI, RU, and *TS* time series can be read from FAD, HIS, RUF, and/or TSF files, respectively, and stored in a single DSS file with the filename rootHYD.DSS. An entry of −1 for the switch parameters DSSFA, DSSHI, DSSRU, and DSSTS in *JO* record fields 4-7 specify that the *FA, HI, RU,* and *TS* time series, respectively, are read from the appropriate text file and moved to the DSS file. Likewise, *IN* and *EV* records are read from FLO and EVA files and stored in the DSS file if activated by DSS(5) on the *OF* record. This file conversion feature is solely for creating the hydrology DSS file and storing these selected time series data in the DSS file. The *SIM* simulation is not performed. The file with filename rootHYD.DSS is created by one or more of either of the parameters DSS(5), DSSFA, DSSHI, DSSRU, or DSSTS.

Field 8: 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 9: The beginning reservoir storage file (filename extension 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 10: *SYSOUT* activates the optional hydropower and multiple reservoir system release output file (filename extension HRR) which is reorganized with the *TABLES* 4HRR record.

Field 11: 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 12: A drought index is defined by *DI*, *IS*, and *IP* records. *STODI* in *JO* record field 12 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 13: 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 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 14: *PASS2* over-rides the *IFM(IF,3)* 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 15: The return flow method selected by the parameter *RFMETH* in *WR* record field 7 over-rides the default *RFD* in *JO* record field 15. *RFMETH* option 1 is the default for *RFD*.

Field 16: 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 DUALD for all water rights can be set in *JO* record field 12 subject to being replaced for individual water rights by *PX* record field 2 or *SO* record field 14. Entering a −1 for DUALD in *JO* field 16 deactivates the dual simulation specified on *PX* or *SO* records.

Fields 17 and 18: The *RU* record options are described later with the *RU* time series record. Regulated-unappropriated flow *RU* adjustments can be stored in either a DSS or RUF input file. If the time series data are read from in a DSS input file, control point identifiers must be listed on DAT file *RU* records as explained on the next page.

OF Record – Options for Data Storage System (DSS) Input and Output Files

field	columns	variable	format	value	description
1	1-2	CD	A2	OF	Record identifier
2	8	DSS(1)	I6	1	Conventional OUT or CRM output file is activated.
				2	OUT file listing water rights, reservoirs, and cpts.
3	12	DSS(2)	I4	1	Multiple-reservoir system results in DSS output.
				blank,0	System water right tracking option is not activated.
4	16	DSS(3)	I4	1	DSS output file with *SIM/SIMD* monthly results.
				2	Both daily and monthly results in *SIMD* DSS file.
				3	DSS output file contains only *SIMD* daily results.
5	17-20	DSS(4)	I4	blank,0	Page 47 default set of variables in DSS output file.
				−1	All variables are included in the DSS output file.
				1,2,...,43	Number of variables listed on 2nd *OF* record.
6	24	DSS(5)	I4	1	FLO and EVA files converted to DSS.
				blank,0	Option is not activated.
					DSS Message MSS File Options
7	28	DSS(6)	I4	1	Messages that DSS files are opened or closed.
				blank,0,2	Error and warning messages (default).
				3	Pathnames to MSS file as DSS records are written.
				4	Pathnames to MSS file as DSS records are read.
				7	Beginning level of DSS debugging messages.
				8	Intermediate level of DSS debugging messages.
				9	Maximum level of DSS debugging messages.
8	30-32	DSS(7)	I4	1	DSS output records with all zeros are omitted.
				blank,0	Option to check for all zeros is not activated.
9	33-36	DSSMONTH	1x,A3	AN	First month in DSS files (JAN, FEB, MAR, ... , DEC).
				blank	The default first month label is JAN.
10	37-44	DSSUNITS(1)	A8	AN	DSS volume units. Default = AC-FT
11	45-52	DSSUNITS(2)	A8	AN	DSS evaporation-precip units. Default = FEET
12	53-60	DSSUNITS(3)	A8	AN	DSS daily pattern flow units. Default = AC-FT
13	61-92	DSSROOT	A32	blank	Default is the same filename root as the other files.
				AN	Root of filename for DSS input file (without HYD).

Auxiliary OF Record with List of DSS Output Variables (Page 47) for Non-Zero DSS(4)

field	columns	variable	format	value	description
1	1-4	CD	A2, 2x	OFV	Record identifier for second *OF* record.
2-44	5-172	DSSV(I) I=1,DSS(4)	43I4	+	Integer identifiers of variables from page 47.

The *OF* record creates a DSS output file and/or provides information for both/either DSS input and/or output files. An auxiliary *OF* record simulation results variable list follows the initial *OF* record if and only if a positive non-zero integer is entered for DSS(4) in *OF* field 5. Otherwise, the default (DSS(4)=0) lists or complete (DSS(4)= −1) lists of control point, water right, and reservoir simulation results variables listed on page 47 are included in the simulation results DSS output file. The extra *OF* record allows DSS(4) output variables to be selected from the list on page 47 for inclusion in the *SIM* output DSS file. *OF* record options are discussed in Chapter 6.

Explanation of OF Record Fields

Fields 2-4: Without an *OF* record, *SIM* simulation results are written to an OUT or CRM file to be read by *TABLES*. The *OF* record records the simulation results a DSS output file. Simulation results variables are defined in *Reference Manual* Tables 5.1-5.5, referenced in *Users Manual* Table 5.8, and listed here on page 47. Control points, reservoirs, and water rights for which to include simulation results in the output files are selected on *JD*, *CO*, *RO*, *WO*, and *GO* records.

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. An option 2 OUT file contains only lists of selected water rights, reservoirs, and control points with pertinent basic information but without including the *SIM* simulation results.

Field 3: DSS(2) records the following variables in the DSS output file for multiple reservoir system water rights: releases from each reservoir, storage contents of each reservoir in acre-feet and as a percent of capacity, and, for reservoirs with *PV/PE* records, water surface elevations and drawdowns. The purpose of this information is to facilitate tracking of *OR* record operations. The recorded quantities are monthly in a *SIM* simulation and daily in a daily *SIMD* simulation.

Field 4: The DSS output file contains the same simulation results as the OUT and CRM files but in a format that can be read by *HEC-DSSVue*. The default is no DSS output file. Daily results as well as monthly totals from a daily *SIMD* simulation can be recorded in the DSS file.

Field 5: If *OF* record field 5 is blank, the default set of variables listed on the following page is included in the DSS output file. With a −1 entered for DSS(4) in field 5, the DSS file contains all of the variables. With a DSS(4) of 1 or greater, the DSS output file is limited to the first DSS(4) variables listed on the auxiliary *OF* (or *OFV*) record using the 43 integer identifiers on page 47. The list of integer numbers can be in any order but only the first DSS(4) integer numbers are read. The labels shown in parenthesis on page 47 are identifiers in DSS pathnames and correspond to the *TABLES* time series record identifiers in Table 5.8.

Field 6: DSS(5) converts FLO and EVA files to a hydrology input DSS file with the filename rootHYD.DSS. With the DSS(5) option activated, *SIM* does nothing but create the hydrology file; the simulation is not performed. *IN* and *EV* records are read from FLO and EVA files and written to a DSS file automatically created by *SIM*. *JO* record parameters convert FAD, TSF, HIS, and RUF file records to this same DSS file. The DSS file is read by *SIM* as simulation input. INEV option 6 in *JO* record field 2 specifies reading of hydrology data from a previously created DSS file for the *SIM* simulation. *JO* record fields 4-7 control the other data.

Field 7: DSS(6) sets the level of DSS messages to be written to the message MSS 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 output records containing all zeros can optionally be omitted from the output file.

Fields 9-12: DSS specifications include 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 stored in the DSS files of hydrology input data or simulation results output data. Units included in the DSS labels are specified in fields 10-12, with defaults of AC-FT, FEET, and AC-FT.

Field 13: DSS input filename root without the appended HYD. Default is DAT or DIS file root.

Simulation Results Variables

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) Not Equal to Zero

1. naturalized stream flow (NAT)
2. regulated stream flow (REG)
3. unappropriated stream flow (UNA)
4. channel loss credits (CLC)
5. channel losses (CLO)
6. return flows returned here (RFR)
7. upstream reservoir releases (URR)
8. control point inflows (CPI)
9. end-of-month reservoir storage (STO)
10. reservoir net evaporation volume (EVA)
11. stream flow depletions (DEP)
12. diversion target (TAR)
13. diversion shortage (SHT)
14. diversion amount (DIV)
15. instream flow target (IFT)
16. instream flow shortage (IFS)

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

Default for WR Record Water Rights

diversion target (TAR)
diversion shortage (SHT)
end-of-month reservoir storage (STO)
stream flow depletion (DEP)
diversion or energy amount (DIV)

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

Variables 1 − 24 apply to both *WR* and *IF* record rights.
Variables 25 and 26 apply only to *WR* record rights.
Variables 27, 28, 29, 30, and 31 apply only to
   IF record rights.

Complete List for DSS(4) Not Equal to Zero

17. reservoir storage volume (STO)
18. reservoir net evaporation volume (EVA)
19. stream flow depletion (DEP)
20. diversion or hydropower target (TAR)
21. diversion or energy shortage (SHT)
22. diversion or energy amount (DIV)
23. available stream flow (ASF)
24. releases from secondary reservoirs (ROR)
25. return flow (RFL)
26. available increase (XAV)
27. instream flow IF record target (TIF)
28. combined instream flow IF right target (IFT)
29. instream flow IF right shortage (IFS)
30. instream flow IF right *FS* record flow (FSV)
31. instream flow IF right *FS* record count (FSC)

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) Not Equal to Zero

32. end-of-month reservoir storage (STO)
33. net evaporation-precipitation volume (EVA)
34. power shortage or secondary energy (HPS)
35. hydroelectric energy generated (HPE)
36. inflows from stream flow depletions (RID)
37. inflows from reservoir releases (RIR)
38. releases accessible to hydropower (RAH)
39. releases not accessible to hydro (RNA)
40. adjusted evaporation-precipitation depth (EPD)
41. net evaporation depths (EVR)
42. reservoir water surface elevation (WSE)
43. reservoir storage capacity (RSC)

FA, RU, and HI Identifier Records – Identifiers for Time Series in the DSS Input File

field	columns	variable	format	value	description
1	1-2	CD	A2	FA, RU, HI	Record identifier
2	3-8		6x		Field is not used. Warning message if not blank.
3-17	9-128	ID (1,15)	A8	AN	Control point identifiers assigned to the time series records in the DSS file.

SIM may read any or all of the following types of period-of-analysis monthly time series data as described on page 122.

> naturalized flows as *IN* records from the FLO or DSS file (page 123)
> net evaporation-precipitation depths as *EV* records from the EVA or DSS file (page 123)
> naturalized flow adjustments as *FA* records from the FAD or DSS file (page 127)
> regulated-unappropriated flow adjustments as *RU* records from the RUF or DSS file (129)
> hydrologic indices as *HI* records from the HIS or DSS file (page 131)
> water right target series as *TS* records from the DAT, TSF, or DSS file (page 132)

SIM reads a single hydrology input DSS file with the filename rootHYD.DSS that may contain any of the types of time series data listed above. The time series variable is labeled as IN, EV, FA, RU, HI, or TS in DSS pathname part C. Each of these variables is included in the DSS file only if specified by INEV, DSSFA, DSSRU, DSSHI, or DSSTS on the *JO* record.

FA, *RU*, and *HI* record identifiers are assigned automatically if the time series data are read from FAD, HIS, and RUF files and thus the identifier records described here are not needed. However, if the *FA*, *RU*, and *HI* record time series quantities are read from the DSS file, control point identifiers must be listed on the DAT file *FA*, *RU*, and *HI* records described here. The identifiers are found in the DSS file as pathname part B of the time series records.

FA, *RU*, and *HI* records in the DAT file lists control point identifiers for the time series read from the DSS file. Control point identifiers for *IN* and *EV* record quantities are assigned automatically from information from the control point *CP* records. *TS* record time series quantities in the DSS file are referenced by identifiers from the *TS* records read with *IF* and *WR* records, which by default are the water right control point identifiers but may be other identifiers.

The *FA*, *RU*, and *HI* records described here provide a list of all of the control points for which time series data are to be read from the DSS file. These records are placed in the DAT file anyplace after the T1, T2, T3 records but before the *UC* records. All records of each type are grouped together. For example, all *FA* records are grouped together and so forth.

Any number of control points up to a maximum of 15 can be listed on each *FA*, *RU*, or *HI* record. Any number of *FA*, *HI*, and/or *RU* identifier records may be used. As an example, assume flow adjustment *FA* record series are to be read from the DSS file for 25 control points. Two *FA* records can be included in the DAT file with 15 control points listed on the first and ten on the second. Alternatively, five control points could be listed on each of five *FA* records in the DAT file or 12 and 13 control points could be listed on the first and second records. The identifiers consisting of up to six characters are entered any place in the 8-column fields.

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	ARTIF	A6	ARTIF	Artificial control points as described on page 51.
3-14	9-104	CPOUID(J) J=1,12	12A8	AN	Identifiers of control points for which *SIM* simulation results will be included in output files.

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	blank,0	Only the reservoirs listed on *RO* records are included.
				–1	All except artificial reservoirs are in output files.
				–2	All reservoirs are included in output files.
				–3	Only artificial reservoirs are included in output files.
3-14	9-104	REOUID(J) J=1,12	12A8	AN	Identifiers of reservoirs for which simulation results will be included in output files.

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	ARTIF	A6	ARTIF	Artificial water rights as described on page 51.
3-14	9-200	WROUT(J) J=1,12	12A16	AN	Identifiers of water rights for which simulation results will be included in output files.

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	3-8	GOUC	I6	blank,0	Water right use type identifier option is not used.
				1	UC identifiers assigned as first group identifiers.
				2	UC identifiers assigned as 2nd group identifiers.
				3	Output all rights with non-blank first identifiers.
				4	Output all rights with non-blank 2nd identifiers.
				5	Either 1st or 2nd group identifiers are not blank.
3-14	9-104	GROUP(J) J=1,12	12A16	AN	Identifiers of water right groups for which water right simulation results will be included in the output files.

Explanation of CO, RO, WO, and GO Record Fields

Any number of *CO*, *RO*, *WO*, and *GO* records are used along with *JD* record fields 5 and 6 to select data to include in the simulation results written to the OUT, CRM, SOU, and/or DSS files. The optional *CO*, *RO*, *WO*, and *GO* records are placed as a group between the title 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.

Any number of control points, reservoirs, water rights, and water right groups may be listed on any number of *CP*, *RO*, *WO*, and *GO* records with any number up to 12 of identifiers on each record. For example, any number of control point identifiers may be provided on any number of *CO* records, with zero to 12 identifiers on each record. For example, 53 control point identifiers could be listed on 11 *CO* records with five identifiers on each of ten records and three on the eleventh record. Alternatively, the 53 control point identifiers could be listed on five *CO* records with 12 identifiers on any four of the *CO* records and five identifiers on the other *CO* record. Any of the identifiers can occupy any of the columns of their 8-column or 16-column fields, without being either left-justified or right-justified.

The *RO* record provides the parameter NREOUT options of including all reservoirs, either with or without artificial reservoirs, or only artificial reservoirs in the simulation results. Parameters CPOUT and OUTWR in *JD* record fields 5 and 6 provide similar options for control points and water rights.

Water right output records are selected by matching identifiers WROUT(J) on *WO* records with the identifier WRID(wr) on the *WR* or *IF* records or alternatively by matching *GO* record group identifiers GROUP(J) with either of the two group identifiers [WRIDS(wr,1) and WRIDS(wr,2)] on the *WR* or *IF* records. Output records are included in the output files for all *WR* or *IF* record rights for which *GO* record group identifiers GROUP(J) are matched with either of the two group identifiers [WRIDS(wr,1) and WRIDS(wr,2)] on either the *WR* or *IF* records.

The identifiers WRIDS(wr,1) and WRIDS(wr,2) are included on the OUT file records read by *TABLES* for *WR* record rights but not on *IF* water right output records. Both *WR* and *IF* rights record the water right identifier WRID(wr) on the OUT file output records.

The water right use type option is activated by entering the integer 1 or 2 for GOUC in *GO* record field 2. This option treats water use type identifiers connecting *UC* and *WR* or *IF* records as *WR* record first (GOUC=1) or second (GOUC=2) group identifiers WRIDS(wr,1) and WRIDS(wr,2). The *GO* record identifiers GROUP(J) are matched with USEID in *UC* record field 2 and *WR* or *IF* record field 4. The specified either first or second group identifiers on the *WR* and *IF* records are ignored. Thus, all water rights with the same monthly water use coefficients are in a specified group for which simulation results are included in the output files if the *UC* record USE identifiers are included as in the GROUP(J) list on the *GO* records. Use identifiers and regular group identifiers can be included on the same *GO* records.

If GOUC option 3 is selected in *GO* record field 2, output records for all *WR* or *IF* record water rights that have a non-blank WRIDS(wr,1) are included in the output file. Likewise, GOUC of 4 selects all rights with non-blank WRIDS(wr,2), and GOUC of 5 includes both group identifiers.

CO and WO Record Field 2 Designation of
Artificial Control Points, Water Rights, and Reservoirs

The *CO* and *WO* records described on page 49 serve the additional auxiliary purpose of designating control points, water rights, and reservoirs as being *"artificial"*. Entering ARTIF in *CO* or *WO* record field 2 activates the optional artificial designation feature. The 5-character label ARTIF can be entered either left or right justified in the 6-character field.

Any number of the control points, record water rights, and reservoirs in a *SIM* input DAT file can be classified as artificial. Control points, water rights, and reservoirs are designated as artificial as follows.

- All control points listed on *CO* records with the label ARTIF in field 2 are designated as being artificial. This is the only way to assign control points the artificial designation.

- Either of the following two alternative mechanisms can be employed to designate a water right as being artificial. All water rights assigned to an artificial control point by their control point identifier in *WR* or *IF* record field 2 are automatically made artificial. Water rights can also be designated as artificial by listing their WRID(wr) identifiers (from *WR* record field 14 or *IF* record field 11) on *WO* records that have ARTIF entered in field 2. This second option allows artificial water rights to be located at regular non-artificial control points.

- All reservoirs located an artificial control point are automatically artificial. This is the only mechanism for designating a reservoir as artificial.

Thus, all water rights and reservoirs located at artificial control points are automatically labeled artificial. Water rights can also be labeled artificial using *WO* records.

Designation of control points, water rights, and reservoirs as being *"artificial"* does not affect the *SIM* simulation computations. The sole purpose of the artificial classification scheme is to exclude certain quantities from the simulation results output OUT, CRM, SOU, and DSS files. Quantities for artificial control points, water rights, and reservoirs are included in the *SIM* output files only if certain output options controlled by the *JD* record parameters CPOUT or OUTWR or *RO* record parameter NREOUT are selected.

Reiterating, the optional artificial labeling feature does not affect the *SIM* simulation computations or regular ″non-artificial″ simulation results. Reservoir storage volumes, diversion and return flow volumes, and all other quantities associated with artificial control points, water rights, and reservoirs are separated from quantities associated with regular control points and water rights for purposes of recording output records in the OUT, CRM, SOU, and DSS files. As *SIM* writes control point, reservoir, and water right output records, those labeled artificial are omitted unless otherwise specifically specified.

Although the artificial feature can be generically used whenever convenient for various purposes, a primary motivation for its addition to *SIM* is to deal with artificial or ″dummy″ control points and related model components have been incorporated in several of the TCEQ WAM System *SIM* input datasets for purposes of various accounting computations. Accounting diversions and storage serve computational purposes but do not represent actual physical facilities.

XL Record – Multiplication Factors and Parameter Limits

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

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 11 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*.

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 months
3	9-16	CR2	I8	+ blank,0,−	Starting month (1, 2, .. , 12) for annual cycle option. Monthly cycle option is activated.
4	17-24	CR3	I8	blank,0 + −1	CRM file is limited to last 12 months of sequence. CRM file includes 12 months starting with CR3. All months are included in CRM file. CR3 is applicable only if CR1 > 12 months.
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	Cyclic repetition of months if CR1>12 and CR2>0. No repetition or cycling of months of hydrology. CR5 is applicable only if CR1 > 12 months.

The simulation model *SIM* can be executed in either the conventional long-term simulation mode or short-term CRM mode. The *CR* record activates the CRM mode and is the only additional record added to the *SIM* input dataset to convert from conventional to CRM.

Conditional reliability modeling (CRM) is described in Chapter 8 of the *Reference Manual*. The *CR* record activates the CRM simulation mode and is the only *SIM* input record associated specifically with CRM.   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 extension CRM) which replaces the OUT file. CRM simulation results can also be recorded in the optional SOU and DSS files created by *SIM*.

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. Chapter 7 of the *Reference Manual* documents *TABLES* methodologies and input records for conditional reliability analyses. *TABLES* input records designed specifically for CRM as well as those input records that are applicable for either CRM or conventional long-term simulation results are included in Chapter 5 of this *Users Manual.*

The required *JD* and optional *JO, FA, RU, HI, CR, XL, OF, ZZ, CO, RO, WO, GO,* and *RG* records must all be placed between the title (T1, T2, and T3) records and *UC* records but can otherwise be in any order. The *CR* record can be inserted anyplace in this group of records.

FY Record – Firm Yield, Safe Yield, and Yield-Reliability Table in YRO File

field	columns	variable	format	value	description
1	1-2	CD	A2	FY	Record identifier
2	3-8	FYIN(1)	F6.0	+	Fraction (0.0-1.0) of monthly target that must be met. Applied as specified by FYC(1) in field 10.
				blank,0	Default = 1.0
					Specification of Increments for Iterative Algorithm
3	9-16	FYIN(2)	F8.0	+	Initial value for the annual target amount. (Must be greater than zero.)
4	10-24	FYIN(3)	F8.0	+	Incremental decrease for first level of decreases for iterative simulations. (Must be greater than zero.)
5	25-32	FYIN(4)	F8.0	+	Incremental decrease for second level of decreases.
				blank,0	Optional second level is not used.
6	33-40	FYIN(5)	F8.0	+	Incremental decrease for third level of decreases.
				blank,0	Optional third and fourth levels are not used.
					Water Right or Water Right Group
7	41-56	FYWRID	A16	AN	Water right identifier for *FY* record rights.
8	57-64	FYGROUP	A8	AN	Water right group identifier for *FY* record rights.
9	68	MFY	I4	blank,0,1	Proportional to amounts in *WR* record field 3.
				2	Based on priorities in *WR* record field 5.
					Water Supply Safe Yield Criteria
10	72	FYC(1)	I4	blank,0	FYIN(1) in field 2 applies only to period reliability.
				+, −	FYIN(1) also applies to determination of safe yield and FYC(1) is the number of consecutive months.
11	76	FYC(2)	I4	blank,0	Reservoir storage reserve option is not applied.
				1, −1	Storage reserve based on diversions.
				2, −2	Storage reserve based on diversions and evaporation.
				3, −3	Storage reserve based on storage drawdown.
				4, −4	Storage reserve is specified as FYIN(6) in field 13.
12	80	FYC(3)	I4	+	Number of months of water supply storage reserve. FYC(3) is applicable for FYC(2) options 1, 2, and 3.
13	88	FYIN(6)	F8.0	+	Required storage reserve plus inactive storage. FYIN(6) is applicable only for FYC(2) option 4.
					Optional Output to OUT File
14	92	SIM3	I4	blank,0	OUT file is not employed. No results to OUT file.
				non-zero	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 *T1/T2/T3* records and *UC* records.

The *FY* record automates the search for a firm yield (fields 3-8) or safe yield (fields 2-13) by controlling repeated multiple simulations with the annual diversion target of one or multiple water rights incrementally decreased in each consecutive simulation. Results from each of the iterative simulations are recorded in a yield-reliability table created in the YRO output file. The table ends with the last line reflecting the firm or safe yield. A message is printed in the YRO file table in cases in which no non-zero firm or safe yield is possible.

For purposes of the *FY* record routine, firm yield is defined as the maximum annual *WR* or *IF* record field 3 annual target amount (annual diversion, hydropower, or instream flow target) that can be supplied with a volume reliability of 100.0 percent. Firm yield is computed by the iteration algorithm controlled by the parameters FYIN(2), FYIN(3), FYIN(4), and FYIN(5) in *FY* record fields 3, 4, 5, and 6. Safe yield is an expanded version of firm yield defined by the optional additional parameters FYIN(1), FYC(1), FYC(2), FYC(3), and FYIN(6) in *FY* record fields 2, 10, 11, 12, and 13. The example in Chapter 3 of the *Fundamentals Manual* computes a simple conventional firm yield. An example in Chapter 6 of the *Reference Manual* computes safe yield by activating the additional input parameters FYC(1), FYC(2), and FYC(3).

Each line in the YRO table represents a complete hydrologic period-of-analysis simulation for a specified annual water supply diversion target that replaces the annual amount otherwise entered in *WR* record field 3. The safe yield version of the YRO file table with three additional columns is created if non-zero safe yield criteria parameters are entered for FYC(1) and/or FYC(2) in *FY* record fields 10 and 11. The data tabulated in each column of the table are defined below. The last three columns are omitted in the FYC(1)=FYC(2)=0 version of the YRO file table.

Iteration (I) – Integer counter of the hydrologic period-of-analysis *SIM* simulations.

Level (L) – Integer counter of incremental decreases in annual target amounts defined by FYIN(2), FYIN(3), FYIN(4), and FYIN(5) in *FY* record fields 3, 4, 5, and 6.

Annual Target (acre-feet/year) – annual diversion target for the single water right or summation of annual diversion targets for the multiple water rights specified in *FY* fields 7 and 8.

Mean Shortage (acre-feet/year) – Annual mean of shortages in supplying the monthly targets.

Mean Actual (acre-feet/year) – Annual means of monthly diversion volumes reflecting target volumes minus shortage volumes. Monthly volumes are aggregated to annual means.

Volume Reliability (%): $R = (v/V)(100\%)$ where v is volume supplied and V is target volume.

Periods without Shortage (n) – integer number of months during the hydrologic period-of-analysis simulation for which at least $(1.0 - FYIN(1))$ of the monthly target is supplied.

Period Reliability (%): $R = (n/N)(100\%)$ where N is the number of months in the simulation.

Maximum Shortage Months – The maximum number of consecutive months with shortages continuously exceeding FYIN(1) of the monthly targets.

Storage Reserve (acre-feet) – The volume for the FYC(3) months preceding the end of the month with the minimum end-of-month storage contents computed in accordance with the criteria specified by FYC(2), FYC(3), and FYC(4). If the exact same value for minimum storage contents occur in multiple months, the first occurrence is selected to compute the storage reserve from quantities in the preceding FYC(3) months.

Minimum Storage (acre-feet) – The minimum end-of-month storage contents occurring during the simulation in the reservoir filled by a single water right or the summation of concurrent storage contents of multiple reservoirs filled by multiple water rights.

Explanation of FY Record Fields

Fields 2 and 10: FYIN(1) in field 2 is the fraction of the monthly target that must be supplied to meet the criterion defined by FYC(1) in field 10. For example, an entry of FYIN(1)=0.95 defines a non-shortage period as any month in which at least 95% of the diversion target is supplied (shortage of less than 5% of target). With the default FYC(1) (blank field 10), FYIN(1) is used only for counting non-shortage periods and computing period reliabilities tabulated in the last two columns of the YRO table. With FYC(1)≥1, FYIN(1) is also used to determine the firm or safe yield which means defining stop criteria for the iterative algorithm.

Fields 3, 4, 5, 6: FYIN(2), FYIN(3), FYIN(4), and FYIN(5) are specifications controlling the iteration algorithm that repeats the *SIM* simulation multiple times. The first simulation has an annual diversion target of FYIN(2) which is reduced by the amounts FYIN(3), FYIN(4), and FYIN(5) in each simulation in the iteration search for the firm or safe yield.

Fields 7, 8, 9: The *FY* record yield analysis may be applied to a water right FYWRID identified in *FY* record field 7 (*WR* record field 12) and/or to a set of any number of rights identified by FYGROUP in field 8 of the *FY* record which connects to the group identifiers in fields 13 and 14 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.

Fields 2 and 10: FYIN(1) in field 2 is used the define shortage and non-shortage periods for the period reliabilities in the last column of the YRO table the same regardless of the entry for FYC(1) in field 10. A positive integer in field 10 employs the parameter FYIN(1) in defining safe yield and represents the allowable number of consecutive months with diversions above FYIN(1) of the monthly target but below 100.0% of the monthly target. A negative FYC(1) results in quantities being included in the YRO table without affecting the iterative search.

Fields 11, 12, 13: FYC(2), FYC(3), and FYC(3) define a storage reserve. With an annual diversion target set at the computed safe yield, reservoir storage does not drop below the storage reserve plus inactive capacity during the simulation. The storage reserve is computed as the cumulative total diversions (FYC(2)=1), diversions plus evaporation (FYC(2)=2), or decrease in storage contents (FYC(2)=3) during the preceding FYC(3) months. Alternatively, with FYC(2) option 4, the total end-of-month storage consisting of the inactive storage plus additional storage reserve is not allowed to drop below FYIN(6) specified in field 13.

With negative entries for FYC(1) and FYC(2), absolute values of the entries are used to compute quantities tabulated as the last three columns of the YRO table, but these variables do not affect the iterative simulations. Positive FYC(1) and FYC(2) entries control the iterative simulations.

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 4ZZF 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.

RG Record – Parameters and Criteria Defining a Selected Group of Water Rights

Field	columns	variable	format	value	description
1	1-2	CD	A2	RG	Record identifier
2	3-8	RGI(I,1)	I6	1,+	Water right information is listed in message file.
				−9	Removed from the simulation, listed in MSS file.
				−99	Removed from the simulation, not listed in MSS file.
					Parameters Assigned to Selected Water Rights
3	9-16	RGID(I,1)	A8	AN	Second group identifier on *WR* or *IF* record.
4	17-24	RGI(I,10)	I8	+	Priority number in *WR* or *IF* record field 5.
5	25-28	RGI(I,2)	I4	+	DUAL(wr) in *PX* field 2 or DUALD in *JO* field 11.
6	29-32	RGI(I,3)	I4	+	XCP(px) in *PX* record field 4.
7	35-40	RGCP(I,1)	2x,A6	AN	XCPID in *PX* record field 5.
					Criteria for Selecting Water Rights
8	41-44	RGI(I,4)	I4	Blank,0,1	Only *WR* record rights are included. No *IF* rights.
				2	Both *IF* and *WR* record rights are included.
				3	Only *IF* record rights are included. No *WR* rights.
9	45-48	RGI(I,5)	I4	+	Lower limit on water right type in *WR* record field 6.
				−	Upper limit on water right type in *WR* record field 6.
10	49-56	RGA(I,1)	F8.0	+	Lower limit on target AMT in *WR* record field 3.
				−	Upper limit on target AMT in *WR* record field 3.
11	57-64	RGA(I,2)	F8.0	+	Lower limit on reservoir storage capacity.
				−	Upper limit on reservoir storage capacity.
12	65-72	RGI(I,6)	I8	+	Lower limit on priority in *WR* record field 5.
				−	Upper limit on priority in *WR* record field 5.
13	73-80	RGID(I,2)	A8	AN	Group identifier of water rights to include.
14	81-88	RGID(I,3)	A8	AN	Group identifier of water rights to exclude.
15	89-96	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 WR can not be above.
4	13-16	RGI(I,9)	I4	+	Number of upstream limits that WR must be below.
5	17-24	RGCP(I,3)	2x,A6	AN	Control point identifier for limit.
6-12	25-88	RGCP(I,4-11)	2x,A6	AN	Control point identifiers 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 7−15 and the *RG2* record are optional. With the exception of the field 8 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 water rights in the selected group are excluded from consideration in the simulation if so specified *RG* record field 2. These selected water rights are skipped over in the water rights loop in the simulation computations.

- The *WR* record field 14 or *IF* record field 13 second group identifier assigned to each of the rights by *RG* record field 4 is used in several *TABLES* routines that deal with groups of water rights defined by the two group identifiers on the *WR* and *IF* records.

- Values for the priority on the *WR* and *IF* records and 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 facilitates assigning values for these parameters to a large number of rights without revising *WR* or *IF* records or 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. 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 or IF record field 13. A non-zero (non-blank) *RG* field 4 results in the priorities being replaced on the *WR* and *IF* records. Entering values in *RG* fields 5, 6, and 7 results in replacing values from the *PX* records or providing values if water rights have no *PX* record.

<u>**Explanation of RG Record Fields**</u>

<u>***Field 2***</u>: A −9 or −99 entered in *RG* record field 2 results in the each of the selected water rights being omitted (excluded) from the simulation. These rights are skipped over in the water right computations. Any positive integer or −9 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* or *IF* records are placed in the DAT file.

- water right identifier (*WR* record field 12 or *IF* record field 11)
- first group identifier (*WR* record field 13 or *IF* record field 12)
- second group identifier (*WR* field 14 or *IF* field 11 replaced by *RG* field 3)
- control point (*WR* or *IF* record field 2)
- annual target amount (*WR* or *IF* record field 3)
- reservoir storage capacity (*WS* record field 3) for water right types 1, 5, and 7
- priority number (*WR* or *IF* record field 5 replaced by RG record field 4)
- 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 5, 6, and 7 if activated

Field 3:   Two optional water right group identifiers WRIDS(wr,1) and WRIDS(wr,2) are assigned on *WR* or *IF* records 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* field 14 or *IF* field 13.

Field 4:   *WR* or *IF* record field 5 priorities are replaced if *RG* field 4 is not blank or 0. An *RG* field 4 entry of 99999999 is the most junior possible and −9999999 is the most senior. For multiple rights with the same priority number, the right entered first in the DAT file is senior.

Parameter Fields 5, 6, 7: 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 DDUAL 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 8-15:   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 8 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 8: The group may be limited to either *WR* record or *IF* record rights or include both.

Field 9: 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 10: 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 11: 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 12: 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 13 and 14: 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 15: 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 upper limits in the delineation of sub-basins or river reaches. However, the upper limits are defined differently with fields 3 versus 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, 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.

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

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

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

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

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

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

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

A 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 *WR* and *IF* records.
3	9-16	USEP(I)	I8	+	Priority number which overrides *WR/IF* 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.

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

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

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

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

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

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

Chapter 3 SIM Input Records

Explanation of CP Record Fields

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.

Fields 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 in field 7. 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. Any other control point can serve as the source CPIN(cp).

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 11 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 10 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 10 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 12 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	Monthly target is 1/12 of annual AMT in field 3
				AN	Use type identifier to connect to *UC* and *UP* records
				LDAYS, NDAYS	Distribution based on number of days in each month
				XMONTH	Monthly rather than annual target in field 3
5	25-32	WRNUM(wr,7)	I8	–,0,+	Priority number
					Water Right Type
6	36	WRNUM (wr,5)	I4	blank,0,1	Type 1 water right (refills reservoir storage)
				2	Type 2 water right (no refilling storage)
				3	Type 3 water right (no stream flow depletions)
				4	Type 4 water right (inflow to river system)
				5, –1	Type 5 water right (hydroelectric power)
				6, –3	Type 6 water right (hydroelectric power)
				7	Type 7 water right (target sets storage capacity)
				8	Target is computed for use with *FS*, *TO*, *HC* records.
					Return Flow Specifications
7	40	RFMETH (wr)	I4	blank,0	Default *RFD* entered in *JO* record field 11
				1	Constant factor, flows returned same month
				2	Constant factor, flows returned next month
				3	Monthly factors, flows returned same month
				4	Monthly factors, flows returned next month
8	41-48	RFAC	F8.0	+	Constant return flow factor
		RFIDWR	2x,A6	AN	Identifier on RF record for monthly factors
9	51-56	RCP	2x,A6	blank	Flow returned to next downstream control point
				AN	Identifier of control point to return flow
					Optional Flow Switch FS or Cumulative Volume CV
10	57-60	FSCV(wr)	I4	+,–	Identifier in *FS* or *CV* record field 2
					Optional Drought Index (DI Record)
11	61-64	DINDEX (wr)	I4	+,–	Drought index identifier in *DI* record field 2
					Sign specifies steps 3 (+) versus 6 (–) on pages 87-88
					First Set of Identifiers
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
					Alternate Set of Identifiers (JD Record Field 13)
15	97-112	WRID(wr)	A16	AN	Alternate water right identifier
16	113-120	WRIDS(,1)	A8	AN	Alternate second water right identifier (first group)
17	121-128	WRIDS(,2)	A8	AN	Alternate third water right identifier (second group)

Explanation of WR and IF Record Fields

A water right is defined in the WRAP modeling system as a *WR* or *IF* record and supporting *SO*, *TO*, *LO*, *ML*, *CV*, *FS*, *TS*, *BU*, *WS*, *HP*, *OR*, *PX*, *AX*, *ES*, and *HC* records that provide additional information describing the water right. A set of supporting records follows behind the *WR* or *IF* records that it supports. A *WR* record models water supply diversions, hydroelectric power generation, and reservoir storage. An *IF* record water right models instream flow requirements.

Field 2: A *WR* record 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. An *IF* record water right sets a minimum instream flow target 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 negative entry in *WR* or *IF* record field 3 switches to the *HC/ES* record routine. USE in field 4 is not used with the methodology controlled by *HC* and *ES* records (negative number in field 3).

Field 4: The water use identifier connects *WR* and *IF* records to *UC* and *UP* records. Any identifier of 6 characters or less may be used, except LDAYS, NDAYS and XMONTH activate special options. If *WR* or *IF* record field 4 is blank, the 12 monthly water use factors otherwise found on *UC* records default to 1/12. XMONTH or xmonth in field 4 indicates that the target in field 3 is already a monthly amount. *USE* is not used with *ES* records.

If the term LDAYS or 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 (28, 29, 30, 31) in each month starting with January. LDAYS and NDAYS function the same except LDAYS assigns 29 days to February in leap years and otherwise 28 days. NDAYS assumes February has 28 days in all years.

The parameter GOUC in *GO* record field 2 activates a completely different additional optional use of the *WR* record field 4 water use identifiers. With the GOUC option activated, the water use identifiers are automatically assigned to the second water right identifier (WRIDS(,2) in *WR* record field 14). The water use identifier is then treated within *SIM* just as any other group identifier allowing water right simulation results output to be grouped by water use identifier.

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.

Explanation of WR Record Fields

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.

Type 8 rights compute targets for use by *FS*, *CV*, *TO, LO*, and *HC* record features of other water rights but do not otherwise affect the simulation computations.

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 for modeling return flows are outlined in Chapter 4 of the *Reference Manual*.

Fields 10: The *FS/CV* record FSCV(wr) cross-referenced in *WR* field 10 is not needed for *FS* or *CV* records that follow this *WR* record but can be used to connect to *FV* or *CV* records entered with other water rights.

Field 11: *DI* records include a drought index identifier DIID. A drought index is assigned to the *WR* record water right by the *DINDEX(wr)* in *WR* record field 11.

Fields 12-17: Water right identifiers are described in the last section of Chapter 5 of the *Reference Manual*. The 16-character water right identifier is unique to each water right. Any number of rights may have the same 8-character group identifier. The purpose of the optional group identifiers is to associate multiple rights together as a group for applying *SIM* output selection options and/or *TABLES* operations. 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. 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 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.
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 13 specifies whether the first or second set of three identifiers on the *WR* records is adopted in a particular model run.

Explanation of IF Record Fields

WR and *IF* record fields 1, 2, 3, 4, and 5 explained on the preceding page 70 are the same for both *IF* and *WR* record water rights. *IF* record fields 6 through 14 are described as follows.

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. A non-zero *IFM(IF,1)* means that upstream reservoir releases are excluded from the regulated flow in the determination of whether the flow exceeds the minimum instream flow target.

Field 7: The field 7 option switch *IFM(IF,2)* is pertinent only if more than one *IF* record with associated *WS*, *FS*, *TO*, *TS*, *SO*, *ES*, and *HC* 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 *IFM(IF,2)* 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 *IFM(IF,3)* 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.

IFM(IF,3) 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 *IFM(IF,2)* is zero (blank field 6). *IFM(IF,3)* options 1 and 3 should be used if these problems are not a concern and perhaps even if these problems are a concern.

IFM(IF,3) 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 *IFM(IF,3)* option.

With *IFM(IF,3)* options 2 and 4, instream flow requirements are not reflected in unappropriated flows for months without a second pass.

Field 9: As explained on page 99 *SIM* automatically sequentially numbers *FS* and *CV* records, and their integer identifiers may optionally be entered in *FS* and *CV* field 2. The integer identifiers in *IF* record field 9 references these *FS* and *CV* record identifiers, allowing *FS* or *CV* records entered with a particular water right to also be used by other water rights. If *FS* and/or *CV* records follow this *IF* record, there is no need for the FSCV(wr) cross-reference in *IF* field 9.

Field 10: *DI* records include a drought index identifier DIID. A drought index is assigned to the *IF* record water right by the *DINDEX(wr)* in *IF* record field 10.

Fields 11-13: The 16-character water right identifier is unique to each water right. Any number of rights may have the same 8-character group identifier. The optional group identifiers for both *IF* and *WR* records are used to associate multiple rights together as a group for applying *SIM* output selection options. Program *TABLES* also includes options for working with *WR* record groups, but these *TABLES* options are not applicable to *IF* record groups.

Field 14: The instream flow target is repeated for all control points for the reach from *CP* (*IF* field 2) downstream to *CP2* (field 14). OUT or out entered in *IF* field 14 sets *CP2* at the outlet.

IF Record – Instream Flow Right

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
				−9, −	Targets are set by *ES*, *HC*, and *PF* records.
				−99.0	*ES* record targets are tabulated in MSS file.
4	19-24	USE	2x,A6	blank	Monthly target is 1/12 of annual AMT in field 3.
				AN	Use type identifier to connect to *UC* and *UP* records
				LDAYS, NDAYS	Distribution based on number of days in each month
				XMONTH	Monthly rather than annual target in field 3
5	25-32	WRNUM (wr,7)	I8	−,0,+	Priority number
					Inclusion or Exclusion of Reservoir Releases
6	34	IFM (if,1)	I2	blank,0	Instream flow limit is based on total regulated flow.
				1,non-zero	Reservoir releases for downstream use are excluded.
					Options for Applying Instream Flow Target
7	36	IFM (if,2)	I2	Blank,0,1	Junior *IF* target at cp replaces preceding senior target.
				2	Largest *IF* record target at control point is adopted.
				3	Smallest *IF* record target at control point is adopted.
					Reservoir Release and Repeat Simulation Options
8	39-40	IFM (if,3)	I4	blank,0,1	Constraints on water availability during first pass
				2	Constraints on water availability during second pass
				−2	Constraints during both first and second passes
				3	Constraints during first pass, reservoir storage used
				4	Constraints during second pass, reservoir storage
				−4	Constraints during both first and second passes
					Optional Flow Switch FS or Cumulative Volume CV
9	41-44	FSCV(wr)	I4	+,−	Identifier in *FS* or *CV* record field 2
					Optional Drought Index (DI Record)
10	47-48	DINDEX (wr)	I4	+,−	Drought index identifier in *DI* record field 2.
					Sign sets location in the target setting sequence
					defined on pages 87-88. Step 3 (+) or step 6 (−).
					Water Right Identifier and Two Group Identifiers
11	49-64	WRID(wr)	A16	AN	Optional water right identifier.
12	65-72	WRIDS(wr,1)	A8	AN	Optional first water right group identifier.
13	73-80	WRIDS(wr,2)	A8	AN	Optional second water right group identifier.
					Optional Stream Reach Specification
14	83-88	CP2	2x,A6	AN	Control point defining downstream end of reach.

WR and *IF* record water rights are defined on page 70. The fields of the *WR* and *IF* records are explained on pages 70-72. Fields 1, 2, 3, 4, and 5 are the same for both *IF* and *WR* record water rights. Entering −9 or any other negative number in *IF* record field 3 specifies that instream flow targets are set by the environmental flow standard (EFS) features described on the next page.

SB3 Environmental Flow Standards

A negative entry in *IF* record field 3 activates the use of *HC* and *ES* records to establish instream flow targets for an *IF* record water right. With a negative field 3, *IF* record fields 3 and 4 are not used, but the other *IF* record fields are still valid. *HC* records define hydrologic conditions for *ES* and/or *PF* records. *PF* and *PO* records (pages 155-161) can be employed only for a daily *SIMD* simulation. *HC*, *ES*, and *SIMD PF/PO* records are placed in any order following an *IF* record.

ES and *HC* records are designed to simulate the subsistence and base flow components of Senate Bill 3 (SB3) environmental flow standards (EFS) as described in *Reference Manual* Chapter 4. High flow components can also be included with *ES/HC* records but are typically much more accurately modeled with daily *PF/PO* records. High pulse components of SB3 environmental flow standards are simulated with *PF*, *PO*, and *HC* records as described in Chapter 4 of this *Users Manual* and Chapter 6 of the *Daily Manual*. An example of modeling SB3 environmental flow standards with *ES*, *HC*, *PF*, and *PO* records is presented in Chapter 8 of the *Daily Manual*.

ES and *HC* records are applicable for either a monthly *SIM* or daily *SIMD* simulation. In a daily *SIMD* simulation, high pulse flow components of an environmental flow standard can be added with *PF* and *PO* records. The *PF* and *PO* records are applicable only to a daily simulation.

SB3 environmental flow standards include subsidence, base, and high pulse flow components that vary seasonally. *ES* record flow limits vary over the 12 months of the year. Although the *ES/HS* records allow up to nine hydrologic conditions, actual environmental flow standards have included only three (dry, average, and wet) or four or none. The subsistence, base, and high flow components are each modeled with separate *ES* records for each applicable hydrologic condition. Thus, an *IF* record water right consists of an *IF* record, *HC* record, and several *ES* records.

Each *ES* record defines an alternative set of minimum instream flow limits ESQ(wr,es,m) for each of the 12 months of the year. Each of the *ES* records may be applicable for a specific hydrologic condition defined by the *HC* record. Instream flow targets for the *IF* record right are established based on the multiple sets of alternative ESQ(wr,es,m), representing combinations of flow regime components and hydrologic conditions, defined by the *HC* and multiple *ES* records.

Subsistence flow limits are applicable if the simulated regulated or ESV (*HC* record field 3) flow is less than the base flow limits. Base flow limits are applicable if the ESV flow equals or exceeds base flow limits but are less than the high flow limits. High flow limits, if specified, are employed if the ESV flow equals or exceeds the high flow limits. The higher of targets computed based on *ES* records versus *PF* records are adopted in each day of a daily simulation.

The same *HC* and *ES* records are used for both monthly *SIM* and daily *SIMD* simulations. The multiple alternative sequences of 12 monthly minimum mean flow rate limits in cfs entered on *ES* records are the same in either a monthly or daily simulation. Monthly volume limits are uniformly subdivided into daily volume limits in a daily simulation. The selection within the *SIM* or *SIMD* simulation between subsistence, base, high, and high pulse flow limits depends upon regulated flows (or other specified ESV flows) computed for each month of a monthly or each day of a daily simulation. A daily simulation is more accurate for all flow components due to better representing within-month daily stream flow fluctuations. High flow pulse components are particularly much more accurately modeled by *PF/PO* records and a daily *SIMD* simulation.

ES Record – Environmental Flow Standards

field	columns	variable	format	value	description
1	1-2	CD	A2	ES	Record identifier.
					Flow Regime Components
2	4-7	ESF	1x,A4	SUBS	Subsistence flow.
		(wr,es)	1x,A4	SF50	Subsistence flow with 50% rule.
			1x,A4	BASE	Base flow.
			1x,A2,I2	HAnn	High flow. Maximum of nn periods per year.
			1x,A2,I2	HSnn	High flow. Maximum of nn periods per season.
			1x,A4	PFES	*PF* record pulse flows only. No other *ES* records.
					Hydrologic Condition
3	8	ESHC	I1	+	Hydrologic condition defined by *HC* record.
		(wr,es)		blank, 0	Applicable for all or no hydrologic conditions.
					Minimum Instream Flow Limits
4	9-16	ESQ(wr,es,1)	F8.0	+	Mean monthly flow rate limit in cfs for January.
5	17-24	ESQ(wr,es,2)	F8.0	+	Mean monthly flow rate limit in cfs for February.
6	25-32	ESQ(wr,es,3)	F8.0	+	Mean monthly flow rate limit in cfs for March.
7	33-40	ESQ(wr,es,4)	F8.0	+	Mean monthly flow rate limit in cfs for April.
8	41-48	ESQ(wr,es,5)	F8.0	+	Mean monthly flow rate limit in cfs for May.
9	49-56	ESQ(wr,es,6)	F8.0	+	Mean monthly flow rate limit in cfs for June.
10	57-64	ESQ(wr,es,7)	F8.0	+	Mean monthly flow rate limit in cfs for July.
11	65-72	ESQ(wr,es,8)	F8.0	+	Mean monthly flow rate limit in cfs for August.
12	73-80	ESQ(wr,es,9)	F8.0	+	Mean monthly flow rate limit in cfs for September.
13	81-88	ESQ(wr,es,10)	F8.0	+	Mean monthly flow rate limit in cfs for October.
14	89-96	ESQ(wr,es,11)	F8.0	+	Mean monthly flow rate limit in cfs for November.
15	97-104	ESQ(wr,es,12)	F8.0	+	Mean monthly flow rate limit in cfs for December
					Alternative Unit Option and Multiplier Factor
16	105-108	ESAF	I4	−9	ESQ are entered in preceding fields 4-15 in acre-feet.
		(ws,es)		blank, 0	Option is not used. ESQ are entered in units of cfs.
17	109-116	ESQX	F8.0	+	ESQ multiplier or conversion factor. Default = 1.0

ES, *HC*, and/or *PF* records follow in any order directly behind an *IF* or *WR* record. *PF* records function only in a *SIMD* daily simulation. A *HC* record defines hydrologic conditions referenced by *ES* and/or *PF* records. An optional *HC* record is included with a set of *ES* records to serve one or both of the following two functions. (1) Regulated flow is the default ESV compared with *ES* record limits to define subsistence, base, and high flow regimes. Any other ESV option requires an entry in *HC* record field 3, and thus a *HC* record. (2) The hydrologic condition for an *ES* record is specified by ESHC in *ES* record field 3 and defined by the *HC* record.

The final product of the simulation routine controlled by the *ES* and *HC* record input parameters is a computed instream flow target for an *IF* record water right or diversion target for a *WR* record water right. The *ES* and *HC* records are designed specifically for defining environmental instream flow targets for an *IF* record water right, but can coincidentally also be employed with *WR* record rights. A target is computed for an *IF* or *WR* record water right for the current month in a monthly *SIM* simulation or current day in a daily *SIMD* simulation. Hydrologic conditions are defined the same on a monthly basis for a daily *SIMD* as well as monthly *SIM* simulation.

Explanation of ES Record Fields

Field 2:   Each *ES* record defines an alternative sequence of 12 monthly minimum flow limits, which are listed in fields 4 through 15. Field 2 classifies the flow limits as applying to either subsistence (ESF = SUBS or SF50), base (ESF = BASE), or high (ESF = HAnn or HSnn) flows. Multiple *ES* records allow minimum flow limits to vary between flow regime components (ESF in *ES* record field 2) and between different hydrologic conditions (ESHC in field 3). Selection between subsistence, base, and high flow ESQ(wr,es,m) occurs each month in a *SIM* monthly or each day in a *SIMD* daily simulation based on a comparison with regulated flow or other variable specified by ESV in *HC* record field 3. The default ESV is regulated flow.

High flow (HA or HS) limits, if specified, apply if the ESV flow equals or exceeds the fields 4-15 ESQ and the annual (HA) or seasonal (HS) exceedance count limit nn has not been exceeded. Employment of HA or HS flow limits are limited to nn flow exceedances per year or season. For example, a HA 3 limit (nn=3) is not applied after the flow has already exceeded the ESQ limit during 3 months or 3 days of the current year in the *SIM* monthly or SIMD daily simulation. A HS 2 limit is not applied if more than two periods (nn=2) have already experienced flows exceeding the ESQ earlier in the current season. Seasons are defined by the *HC* record. Blanks or zeros for nn in *ES* record field 2 default to 12 months or 366 days, which means no count limits.

The default ESV is regulated flow computed in the priority sequence at the priority of the water right. The 50% rule option applies only to subsistence flow with ESF=SF50. With ESF=SUBS, if the *SIM* computed regulated flow (or other ESV) is less than the base flow limit, the instream flow target is set equal to the subsistence flow limit. An entry of SF50 in *ES* record field 2 activates the 50% rule, defined as follows. If the ESV is less than the subsistence flow limit, the target is set equal to the subsistence flow limit. If the ESV quantity equals or exceeds the subsistence flow limit but is less than the base flow limit, the target is equal to the subsistence flow limit plus 50 percent of the difference between the ESV flow and subsistence flow limit.

Field 3:   All hydrologic conditions referenced by *ES* or *PF* records are defined on the *HC* record. The hydrologic condition integer identifier ESHC(wr,es) ranges from 0 to 9. If field 3 is blank, the flow limits [ESQ(wr,es,m), m=1,12] are not a function of hydrologic condition and a *HC* record is not required. Hydrologic conditions ESHC(wr,es) 1, 2, 3, 4, 5, 6, 7, 8 and 9 connect to the matching HCL(es, j=1,10) limits in *HC* record fields 18 through 27.

Fields 4-15:   Minimum flow limits ESQ(wr,es,m) are specified in fields 4-15 by default as mean monthly flow rates in cubic feet per second (cfs) for each of the 12 months of the year. These seasonally (monthly) varying minimum instream flow limits are for a specified flow regime component (*ES* field 2) and hydrologic condition (*ES* field 3). *SIM* automatically converts the ESQ mean flow rates entered in fields 4-15 in cfs to monthly flow volumes in acre-feet employed in the simulation, considering the number of days [28 or 29 (leap year), 30, or 31] in each month. *SIMD* converts flow rates in cfs in fields 4-15 to daily flow volumes in acre-feet.

Field 16:   ESAF in field 16 allows the ESQ quantities in fields 4-15 to be entered as monthly volumes in acre-feet rather than mean flow rates in cfs. A −9 in *ES* record field 16 deactivates the *SIM* routine that converts the input ESQ quantities from cfs to acre-feet. Parameter NCFS in *JT* record field 14 serves the same purpose for *SIMD* daily variables as well as the monthly ESQ.

Field 17:   The 12 ESQ read from *ES* record fields 4-15 are multiplied by ESQX from field 17, which has a default of 1.0. ESQX can be used as a unit conversion factor or for other purposes.

HC Record – Hydrologic Conditions Referenced by *ES* and *PF* Records

field	columns	variable	format	value	description
1	1-2	CD	A2	HC	Record identifier
2	3-8	CPHC	A6	AN	Control point identifier. Default is *IF* record field 2.
				HCCP	Multiple identifiers are listed on a *HCCP* record.
				Variable Used to Select Regime Component	
3	12	ESV	I4	blank,0,1	Regulated flow at priority of the water right (default).
		(wr)		−1	Regulated flow without upstream reservoir releases.
				2	Naturalized flow.
				3	Field 4 HCV without summation for NHCM months.
				4	ESV is identically the same as HCV in field 4.
				Variable Used to Define Hydrologic Conditions	
4	13-16	HCV	2x,A2	RF	Regulated flow during the preceding NM months.
		(wr)		RR	Regulated flow without upstream reservoir releases.
				NF	Naturalized flow during the preceding NM months.
				ST	Preceding reservoir storage at NCP control points.
				HI	Hydrologic index series on *HI* input records.
				WR	Monthly target for the water right in field 28.
5	17-20	NHCM(wr)	I4	+	Number of preceding months for summation.
				Months to Update Hydrologic Condition	
6	21	HCM(1)	A1	J	January
7	22	HCM(2)	A1	F	February
8	23	HCM(3)	A1	M	March With all 12 fields left blank, the default
9	24	HCM(4)	A1	A	April is to update each and every month.
10	25	HCM(5)	A1	M	May Otherwise, blank fields indicate months
11	26	HCM(6)	A1	J	June in which the hydrologic condition is not
12	27	HCM(7)	A1	J	July updated. The one-character labels J, F,
13	28	HCM(8)	A1	A	August M, A, M, J, J, A, S, O, N, and D indicate
14	29	HCM(9)	A1	S	September months in which the hydrologic index
15	30	HCM(10)	A1	O	October is updated at the beginning of the month.
16	31	HCM(11)	A1	N	November
17	32	HCM(12)	A1	D	December
				Limits Defining Hydrologic Conditions	
18	33-40	HCL(wr,1)	F8.0	+, −9	Lower limit for hydrologic condition (HC) 1.
19	41-48	HCL(wr,2)	F8.0	+, −9	Upper limit for HC 1. Lower limit for HC 2.
20	49-56	HCL(wr,3)	F8.0	+, −9	Upper limit for HC 2. Lower limit for HC 3.
21	57-64	HCL(wr,4)	F8.0	+, −9	Upper limit for HC 3. Lower limit for HC 4.
22	65-72	HCL(wr,5)	F8.0	+, −9	Upper limit for HC 4. Lower limit for HC 5.
23	73-80	HCL(wr,6)	F8.0	+, −9	Upper limit for HC 5. Lower limit for HC 6.
24	81-88	HCL(wr,7)	F8.0	+, −9	Upper limit for HC 6. Lower limit for HC 7.
25	89-96	HCL(wr,8)	F8.0	+, −9	Upper limit for HC 7. Lower limit for HC 8.
26	97-104	HCL(wr,9)	F8.0	+, −9	Upper limit for HC 8. Lower limit for HC 9.
27	105-112	HCL(wr,10)	F8.0	+, −9	Upper limit for hydrologic condition (HC) 9.
				Water Right Identifier for HCV WR Option	
28	113-128	HCWR(wr)	A16	AN	Water right identifier only if HCV is WR in field 4.

HCCP Record − Control Point Identifiers (Applicable Only for More than One Control Point)

field	columns	variable	format	value	description
1	1-2	CD	A4	HCCP	Record identifier.
2	3-8	NHCCP	I4	+	Number of control points. Maximum of 15.
3-17	9-128	HCCP(J) J=1,NHCCP	2x,A6	AN	Control point identifiers.

A list of NHCCP control point identifiers provided on the *HCCP* record shown above replaces the single control point identifier in *HC* record field 2 if two or more control points are employed for summing the HCV(es) variable selected in *HC* record field 4. The *HCCP* record extension of the *HC* record is added only if the term HCCP is entered in *HC* record field 2. During each month of the simulation, the HCV quantity at each of the NHCCP control points are summed. The auxiliary *HCCP* record, if used, must follow directly behind the *HC* record in the DAT file.

The computations controlled by the *HC* record input parameters contribute two distinctly different items of information to the *ES/HC* record procedure for setting a water right target amount. (1) The environmental flow variable EFV selected in *HC* record field 3 is used in the selection between the subsistence (ESC=SUBS), base (ESC=BASE), and high (ESC=HIGH) flow *ESF* record ESQ limits for adoption for the current time period of the simulation. (2) The input parameters entered in *HC* record fields 4 through 28 are used in the specification of hydrologic condition used in the selection between *ESF* record ESQ limits for adoption for the current time period of the simulation.

Explanation of HC Record Fields

<u>*Field 2*</u>: HCV options RF, RR, NF, ST, and HI are based on quantities for one control point or the summation of quantities at multiple control points. Two or more control points are specified by inserting an extra record (*HCCP record*) with a list of NHCCP control points. The default number of control points is one. The default control point is the control point CP identified in *IF/WR* record field 2. A different control point can be specified in *HC* record field 2. An extra *HC* record is required for summing quantities at more than one control point (NHCCP ≥ 2).

<u>*Field 3*</u>: The stream flow variable used to select between the sets of *ES* record ESQ(wr,es,m) instream flow limits is specified as ESV in *HC* record field 3. Subsistence limits are applicable if the ESV amount computed in the simulation is less than the base flow limits. Base flow limits are applicable if the ESV value equals or exceeds base flow limits but are less than the high flow limits. High flow limits, if specified, are employed if the ESV value equals or exceeds the high flow limits. Regulated flow is the default ESV (ESV=0,1 or blank *HC* field 3 or no *HC* record.)

ESV options 1 and −1 refer to the regulated flow in the current time period at the priority (*IF/WR* record field 5) in the water right priority sequence of the water right at the control point of the water right (*IF/WR* field 2). Option 2 is naturalized flow in the current month at the control point of the water right. ESV option 4 applies the HCV (*HC* field 4) monthly quantity without modification as the ESV quantity used to select between the *ES* record ESQ(wr,es,m). ESV option 3 uses the HCV quantity for just the preceding month without the NHCM-month (*HC* field 5) cumulative summation for the ESV quantity.

Field 4: Hydrologic conditions are defined based on one of the following HCV variables. The two-character HCV identifier is entered in *HC* record field 4.

> RF – Cumulative regulated flow volume in acre-feet during a specified number NHCM of preceding months at one or more control points.

> RR – Cumulative regulated flow volume without upstream reservoir releases during a specified number NHCM of preceding months at one or more control points.

> NF – Cumulative naturalized flow volume in acre-feet during a specified number NHCM of preceding months at one or more control points.

> ST – Beginning-of-month reservoir volume in acre-feet at one or more control points.

> HI – Hydrologic index from *HI* records for current month at a specified control point or summation of hydrologic index at multiple specified control points.

> WR –The target computed for the water right specified in *HC* record field 28. The referenced water right would normally be a type 8 *WR* record water right.

Field 5: HCV options RF, RR, and NF require specification of the number of preceding months over which the variable is summed. For example, with HCV=RF and NHCM=12, the hydrologic condition is defined by total regulated flow volume in acre-feet during the preceding 12 months.

Fields 6-17: Updating the hydrologic condition means determining the range within which the value of the HCV variable falls in order to specify which hydrologic condition is in effect. For example, the hydrologic condition may change between dry (HC-1), normal (HC-2), and wet (HC-3) at the beginning of specified months during the simulation. The default is to update the hydrologic condition status each month. The twelve one-character wide fields 5 through 16 allow the update interval to be greater than one month. J, F, M, A, M, J, J, A, S, O, N, or D is entered for each month in which the hydrologic condition is to be updated at the beginning of that month.

Fields 18-27: The hydrologic condition is based on the HCV variable falling within the ranges defined by the HCL limits in *HC* record fields 18-27. The nine possible hydrologic conditions are defined by the ten limits HCL(J=1,10). The hydrologic condition identifier ESHC(es) in *ES* record field 4 is an integer identifier between 1 and 9. A set of multiple *ES* records may refer to any number of from zero to nine hydrologic conditions. All of fields 18-27 are blank except for those needed. A −9 assigns an arbitrarily large (90,000,000,000) quantity as the upper limit of the last hydrologic condition. The HCL must be entered in order of increasing magnitude.

A typical environmental flow standard may specify *ES* record flow limits for three hydrologic conditions, dry (HC-1), normal (HC-2), and wet (HC-3), which use four HCL limits. However, hydrologic conditions may be defined in greater detail using up to nine different hydrologic conditions defined in *HC* fields 18-27. Different subsets of hydrologic conditions may optionally be assigned to subsistence, base flows, and high flows.

Field 28: *HC* record field 28 is applicable only if HCV=WR in *HC* record field 4. Although this feature also works with other water right types, the HCV=WR option is designed primarily for a type 8 *WR* record water right. *SIM* target-building features can be combined to define hydrologic conditions for *ES* record environmental flow standards. With the *WR* record water right assigned a priority senior to the *IF* record right, the *WR* record target for the current month is adopted in defining the *HC* record hydrologic condition. With the *WR* record right assigned a priority junior to the *IF* record right, the *WR* record target for the preceding month is adopted.

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 and *TE/TQ* records are provided. 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 tail-water 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 tail-water 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.

Reference Manual Chapter 4
Water Management in the Simulation Model

Detailed explanations of water management simulation options outlined in this chapter of the *Users Manual* are explained in detail in Chapter 4 of the *Reference Manual*. Hydroelectric power operations controlled with the *HP* record are explained on pages 96-101 of the *Reference Manual*. Reservoir system operations controlled with the *WS* and *OR* records are described on pages 139-155 of the *Reference Manual*. Likewise, the concepts and methodologies activated by the other *SIM* input records are explained in various sections of the *Reference Manual*.

WS Record – Reservoir Storage Associated with a Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	WS	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3	9-16	WRSYS(sr,3)	F8.0	+	Total storage capacity at top of the conservation pool.
					Storage-Area Relationship
4	17-24	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
5	25-32	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
6	33-40	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below.

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

If fields 4, 5 & 6 are all blank, a table on *SV* and *SA* records is required to define the storage-area relation.

field	columns	variable	format	value	description
					Optional Storage Specifications
7	41-48	INACT	F8.0	+	Storage capacity at top of the inactive pool.
8	49-56	BEGIN	F8.0	blank,0	Reservoir is full to capacity (field 3) at the beginning.
				+	Storage volume at the beginning of the simulation.
				−1	Storage volume is zero at the beginning of simulation.
					Evaporation Allocation Reservoirs
9	57-64	IEAR	I8	blank,0	Option not used.
				+	*EA* record identifier (1, 2, 3, ...). 1 for first *EA* record.
10	71-72	SA	I8	blank,0	A separate storage-area relationship is provided.
				−1	Use *SV/SA* records for first reservoir on *EA* record.
					Downstream Versus Lakeside Diversions
11	79-80	LAKESD	I8	blank,0	Water supply diversions are accessible to hydropower.
		= WRNUM(wr,11)		−1	Lakeside diversions do not generate hydropower.
		or SN3(swr,sr)			

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, and 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. With multiple *WS* records for the same reservoir, BEGIN on the first *WS* record read is adopted. A −1 denotes empty reservoir.

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.

OR Record – Operating Rules for Secondary Reservoirs

field	columns	variable	format	value	description
1	1-2	CD	A2	OR	Record identifier
2	3-8	CP	A6	AN	Control point identifier of reservoir location.
				blank,0	Control point for reservoir is assigned by prior right.
3	9-16	Zone Delineation	F8.0	+	Storage capacity at top of zone 2 (bottom of zone 1).
				blank,0	Default = inactive storage from *WS* record field 7
4	17-24	Multiplier Factor (M)	F8.0	+	Zone 1 multiplier factor (M). Default = 1.0
				−1.0	Multiplier factor set at zero.
5	25-32	Multiplier Factor (M)	F8.0	+	Zone 2 multiplier factor (M). Default = 1.0
				−1.0	Multiplier factor set at zero.
6	36	Rank Index Equation	I4	blank,0, 1	Storage volume rank index equation (Eq. 3.1).
				2	Drawdown depth rank index equation (Eq. 3.2).
7	39-40	Conveyance Option	I4	−1	Pump/pipeline conveyance and releases to river flow.
				blank,0	Releases only as gravity flow in river channels.
8	41-48	Upper Sub-Pool	F8.0	blank,0	Upper sub-pool option is not employed.
				+	Storage capacity at bottom of upper sub-pool.
9	49-56	Rank Index	F8.0	+	Rank index for lower sub-pool. Default = 1.0
10	57-64	Lower Sub-Pool	F8.0	blank,0	Lower sub-pool option is not employed.
				+	Storage capacity at top of lower sub-pool.
11	65-72	Rank Index	F8.0	+	Rank index for lower sub-pool. Default = 1.0
12	72-80	Release Limit	F8.0	+	Monthly release limit. Default is option not used.
13	80-84	CV or FS	I4	+	Identifier of *CV* or *FS* record for release limit.
14	85-88	Record	I4	blank,−1	Blank means *FS/CV* volume. −1 activates *FS* switch.

$$\text{rank index} = M \left[\frac{\text{content volume}}{\text{capacity volume}} \right] \tag{3.1}$$

$$\text{rank index} = (-1.0) \times M \times (\text{drawdown depth}) \tag{3.2}$$
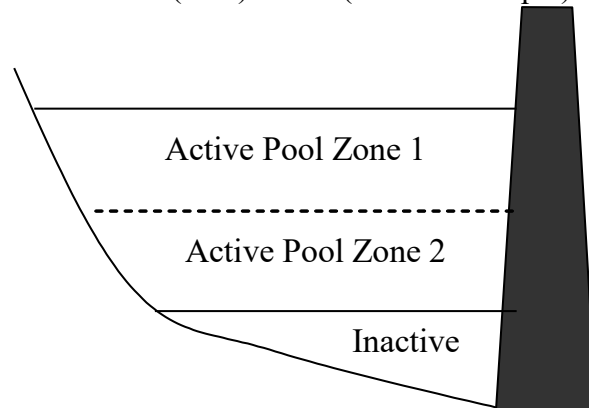
Figure 3.1. Zones for *OR* Record Fields 3 through 6 and Equations 3.1 and 3.2

Reservoir system operating rules are explained in Chapter 4 of the *Reference Manual*. Operating rule *OR* records are required only if non-default *OR* record parameters are needed to define particular operating rules. Defaults are adopted if there is no *OR* record or if *OR* record fields are blank. 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 7 may also be used with a single reservoir to model pump and pipeline or other conveyance facilities. *OR* record fields 10, 11, and 12 may be used with single reservoirs or components of multiple-reservoir systems to set release capacities with or without application of a flow switch *FS* record or *CV* record.

Diversion, instream flow, and hydropower targets may be supplied by releases from multiple reservoirs. 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 *WR* 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).

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 factor (M) is 1.0 in the rank index equations.

Reservoir system operations, as modeled by *OR* records, consist of the following components employed individually or in combination. Multiple-reservoir operating rules are based on releasing from the reservoir that has the largest value for the rank index, which is computed in the first component described below subject to being replaced in the second component.

1. Multiple-reservoir release decisions are based on balancing storage levels by releasing from the reservoir with the largest rank index computed with either Eq. 3.1 or Eq. 3.2 using parameters entered in *OR* record fields 3, 4, 5, and 6. Equation 3.1 is based on storage contents as a fraction of storage capacity. Alternatively, Equation 3.2 is based on reservoir drawdown in feet below the top of conservation pool. Releases are made only from zone 1 of each reservoir until zone 1 is empty in all reservoirs. When zone 1 is empty in all reservoirs, releases are made from zone 2. For example, with defaults activated by blank fields 4, 5, and 6, a rank index between 0.0 and 1.0 is computed with Eq. 3.1 for each of the reservoirs with beginning-of-month storage contents in zone 1 in a particular month of the *SIM* simulation. The release for the month is made from the reservoir with the largest rank index.

2. The rank indices computed with Eq. 3.1 or 3.2 may optionally be replaced in any of the reservoirs by user-specified rank indices (fields 9 and 11) whenever the simulated beginning-of-month storage volume is within the upper sub-pool, defined as above the storage volume entered in field 8, or the lower sub-pool defined as below the storage volume in field 10. For example, again with defaults activated by blank fields 4, 5, and 6, with a rank index of any number larger than 1.0 entered in field 9 for one of the reservoirs, that reservoir will release whenever its beginning-of-period storage contents exceeds the volume entered in *OR* field 8.

3. *OR* record field 7 activates the pump and pipeline conveyance option. Otherwise, diversion sites must be located at or downstream of the dams, with conveyance only by gravity flow.

4. *OR* record fields 12, 13, 14 allows maximum limits to be placed on reservoir releases.

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.

__Fields 3, 4, 5, 6__: Each reservoir of a multiple-reservoir system may optionally be divided into the two zones shown in Figure 3.1 in conjunction with defining release rules. Zone in *OR* field 3 is the reservoir storage capacity volume in acre-feet at the top of zone 2 (bottom of zone 1). Releases are not made from zone 2 of any reservoir until zone 1 has been emptied in all reservoirs. The release is limited to the amount that empties the zone, switching to the reservoir with the next highest rank index. The release is also constrained to not exceed the release limit entered in *OR* record field 12 or determined with a *CV* or *FS* record (*OR* fields 13 and 14).

The release each month is made from the reservoir with the greatest rank index computed with Eq. 3.1 or Eq. 3.2. Field 6 default option 1 is to release from the reservoir with the largest rank index computed based on storage content expressed as a fraction of storage capacity (Eq. 3.1). Option 2 (Eq. 3.2) consists of releasing from the reservoir with the lowest rank index computed based on drawdown in feet below the top of conservation elevation. Option 2 requires *PV* and *PE* record storage volume versus water surface elevation tables. The same *PV/PE* record tables are used for both *HP* record hydropower and *OR* record Equation 3.2 computations.

__Field 7__: Diversion, instream flow, or hydropower targets at locations other than the control point of the reservoir may be supplied from releases or withdrawals from the reservoir. By default (blank field 7), 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 in *OR* field 7 removes this location constraint, thus simulating pump and pipeline or canal conveyance to any location.

__Fields 8, 9, 10, and 11__: Optional user-specified rank indices entered in *OR* record fields 9 and 10 supersede or replace the Eq. 3.1 or Eq. 3.2 rank index values during months of the simulation in which the storage contents falls within the upper or lower sub-pools defined in fields 8 and 10. The upper sub-pool is the portion of the conservation pool above the storage volume in field 8. The lower sub-pool is the portion of the conservation pool below the storage volume in field 10.

__Field 12__: 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 12.

__Fields 13, 14__: The integer identifier of a *CV* or *FS* record may be entered in *OR* field 13 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 12 blank, a *FS* record likewise develops the release limit. Thus replaced, any entry in *OR* field 12 is not used.

With a −1 in *OR* record field 14, 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* record field 12. The release capacity entered in *OR* field 12 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 11) 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.

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 at 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. *SIM* combines the annual amount *AMT* entered in *WR* or *IF* record field 3 with a monthly multiplier determined from *UC* record distribution coefficients to obtain a target for the month. *UC* records are not required if the target is constant over the year. With a −9 entered in *IF* record field 3, the target is computed based on *HC*, *ES*, and *PF/PO* records.

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. A positive *WR/IF* record *DINDEX* specifies step 3. 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.

With a set of multiple *TO* records provided for a particular water right, the target building continues 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.

   - 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.

<u>*TO Record Lower and Upper Limits on Targets*</u>

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 on pages 87-88. With the first two options listed below applied in step 4, 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.

<u>*CV and FS Record Adjustments Based on Cumulative Flow Volume*</u>

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.

<u>*CV, FS, TO, LO, HC, and OR Record Use of Targets for Other Purposes*</u>

Computation of diversion, hydropower, or instream flow targets is controlled by a *WR* or *IF* record and auxiliary *TO*, *TS*, *SO*, *DI*, *BU*, *CV*, and *FS* records. The computed target quantity can also be used by a *FS* or *CV* record (*CVV* or *FSV* option 10), *TO* or *LO* record (*TOTARGET* option 13), or *HC* record (*HCV* option *WR*) in defining hydrologic conditions for *ES* and *PF* records. A *CV* or *FS* record flow switch can be referenced by *OR* record parameter FSOR in developing reservoir operating rules. The *CV* or *FS* record connected to the *OR* record can access a *WR* or *IF* record target.

HC, FS, TO, and *LO* records can use the target created by any water right. However, water right type 8 (*WR* record field 6) is designed for creating a quantity, using target computations, for the sole purpose of use by these records. The type 8 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 hydrologic condition, 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
					Option for Limiting Water Availability
2	3-8	WSHED (wr)	F6.0	+	Drainage area ratio or other naturalized flow multiplier.
				blank	Watershed flow limit option not used.
					Stream Flow Depletion Limits
3	9-16	MONDEP (wr)	F8.0	+	Monthly maximum limit on stream flow depletions.
				blank,0	Either there is no monthly limit on stream flow depletions or limits are entered on a *ML* record.
4	17-24	ANNDEP (wr)	F8.0	+	Annual or seasonal limit on stream flow depletions.
				blank,0	No annual/seasonal limit on stream flow depletions.
					Alternate Control Point for Stream flow Depletions
5	27-32	ACPID	2x,A6	AN	Identifier of alternative control point for stream flow.
				blank,0	Control point specified in field 2 of *WR/IF* record.
					Backup Water Right
6	35-40	BACKUP	2x,A6	BACKUP	Shortages for another specified right are added to the target at the end of target building process.
				BFIRST	Shortages for another specified right are added to the target at the beginning of target building process.
				RETURN	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.
				blank	Feature is not used, or *BU* record version is used.
					Reservoir Withdrawal Limits
7	41-48	MRW(wr)	F8.0	+	Monthly limit on withdrawals from reservoir storage.
8	49-56	ARW(wr)	F8.0	+	Annual/seasonal limit on withdrawals from storage.

SO Record – Supplemental Water Right Options (Continued)

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

Explanation of SO Record Fields

__Field 2__: A drainage area or other parameter ratio *WSHED* entered in field 2 activates the watershed flow option in which the 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

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 page 87. 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
					Target Based on Flow at Control Point in Field 7
2	7-8	TOTARGET (n)	I6	1, –1	Naturalized flow in same (1) or prior (-1) month.
				2, –2	Regulated flow in same (2) or prior (-2) month.
				22, –22	Regulated flow excluding reservoir releases.
				3, –3	Unappropriated flow in same or prior month.
					Target Based on Reservoir Specified in Field 8
				4, –4	Storage in same (4) or prior (-4) month.
				5, –5	Drawdown in same (5) or prior (-5) month.
					Target Based on Water Right Specified in Field 9
				6, –6	Streamflow depletion for same or prior month.
				7	Target based on seasonal/annual depletion to date.
				–7	Cumulative flow depletion excludes current month.
				8, –8	Withdrawal from storage in same or prior month.
				9	Seasonal withdrawal from storage to date.
				–9	Cumulative withdrawal excludes current month.
				11, –11	Diversion in same (11) or prior (-11) month.
				12	Target based on cumulative diversion to date.
				–12	Cumulative diversion excludes current month.
				13, –13	Instream flow or diversion target.
				14, –14	Instream flow shortage (target less flow if positive).
					Other Options
				10	Fields 5&6 limits applied as step 7 on page 88.
				15	Target is equal to the factor in the following field 3.
				16, –16	Index on *HI* records in HIS file.
					Multiplier Factor
3	9-16	FACT(n)	F8.0	+ or –	Factor multiplied by field 2 amount (default=1.0)
					Apply Limit or Combine with Intermediate Target
4	17-24	TOCOMB (n)	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	*AMT* from *WR/IF* field 3 and *UC/DI* records applied if target falls within limits of *TO* fields 5 and 6
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.
					Control Point, Reservoir, or Water Right Identifier
7	43-48	TOFLOW	2x,A6	blank	Control point from *WR* record field 2 used for target.
				AN	Control point of stream flow used to set target.
8	51-56	TORES(n)	2x,A6	AN	Identifier of reservoir used to set target (*TO* field 2).
9	57-72	TOWR(n)	A16	AN	Identifier of water right used to set target (*TO* field 2)

Any number of *TO* records may be included in the set of supporting records that follow a *WR* or *IF* record. The second and subsequent *TO* records in a group of *TO* records continue to build the diversion or instream flow target. No other types of records, other than comment ** records, can be inserted within the set of *TO* records for a particular water right.

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 87-88. *TO* records also can be used by *FS* records to create a flow switch.

The *LO* record is identical to the *TO* record but creates a stream flow depletion limit instead of a target. The same variable definitions and rules apply to both *LO* and *TO* records.

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, 5, 6, 8, 11, 13, 14, or 16 for *TOTARGET* flags use of stream flow or storage volumes or other quantities 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, −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 (target=1.0*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 (*TOCOMB* = SET). Alternatively, the target resulting from a *TO* record may be combined with a preceding cumulative intermediate target specified by the preceding *TO* record.

- The values may be added, the second subtracted from the first, or the first multiplied or divided by the second (*TOCOMB* = ADD, SUB, MUL, DIV). Negative results possible with subtraction are set equal to zero.

- Optionally, either the minimum or maximum adopted (*TOCOMB* = MAX, MIN).

- Optionally, (*TOCOM* = LIM), the *AMT* from the *WR* or *IF* record field 3 adjusted by use coefficient *UC* and drought index *DI* records is adopted if the *TOTARGET*-specified target falls between the limits entered in *TO* record fields 5 and 6, and otherwise the preceding *TO* record target (or zero if no prior *TO* record) is adopted.

Fields 5 and 6: The target limits may be applied in three different alternative ways described on page 89 either within step 4 (two alternatives) or as step 7 outlined on pages 87-88.

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, 16, and –16, 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.

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 87-88, *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 102.

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)	F6.0	+	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 entered as variable *MONDEP* in field 3 of the *SO* record. Limits may be computed as a function of various factors with *LO* records.

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 *FV* 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. 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.

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

CV and *FS* records are described on the following pages 100-105. *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 98.

Explanation of 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,1) = 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 are defined in Chapter 5 of the *Reference Manual*. *CVV/FSV* option 12 refers to the *HI* record hydrologic index described on page 131.

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
					Variable for Cumulative Volume
3	8	CVV	I3	blank,0,1	Regulated flow at control point (field 4).
		= FSI(FS,1)		−1	Regulated flow excluding reservoir releases (field 4).
				2	Naturalized flow at control point (field 4).
				3	Unappropriated or available flow at control point.
				4	Stream flow depletion at control point (field 4).
				5	Diversion at control point (field 4).
				6	Inflow to control point excluding upstream releases.
				7	Stream flow depletion for water right (field 16).
				8	Total diversion for water right (field 16).
				9	Diversion from reservoir storage for right (field 16).
				10	Target for water right (field 16).
				11	Instream flow shortage for *IF* record right (field 16).
				12	Hydrologic index provided on *HI* records (field 4).
4	9-16	CVCP	2x,A6	AN	Control point identifier of CVV variable location.
					Multiplication and Addition Factors
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
					Lower and Upper CVV Bounds
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	X is not dependent on bounds at this stage.
				2	X is set at bounds if bounds are exceeded.
				3	X is set at zero if bounds are exceeded.
				4	X is set at zero if V_{T-1}/V_{T-2} ratio exceeds bounds.
					Combining with Preceding Target
10	53-56	FSI(FS,3)	I4	blank,0,1	Start with zero. Preceding target is not considered.
				2	*CV* record X is added to the preceding target.
				3	Smallest of the two quantities is adopted.
				4	Largest of the two quantities is adopted.
				5	X is adopted if X exceeds bounds of fields 7 and 8.
				6	0.0 if X exceeds bounds. Otherwise, preceding target.
					Parameters Defining Summation Period
11	57-60	FSI(FS,5)	I4	+	Number of time steps not counting the current period.
12	61-64	FSI(FS,6)	I4	+	Beginning month (1, 2, ... , 12) for annual cycle.
				blank,0	Default is continuous without an annual cycle.
13	65-68	FSI(FS,7)	I4	+	Ending month for annual cycle summation period.
				blank,0	Default is eleven months after the beginning month.

CV Record – Target or Limit Developed Based on Cumulative Volume (continued)

field	columns	variable	format	value	description
14	69-72	FSI(FS,8)	I4	blank,0,1	Second pass or latest regulated flow in current period.
				2	Latest regulated flow in current period in summation.
				3	Current period is not included in flow summation.
				Other Input Variables	
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 99. 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* or *WR* record. These fields are described on page 99.

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 4 uses the ratio $R=V_{T-1}/V_{T-2}$ where V_{T-1} and V_{T-2} are the cumulative volumes of the CVV in the preceding time period and its preceding time period (two periods before current period). 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.

Sequencing of *WR* and *IF* Records and Associated
SO, TO, LO, ML, ES, HC, 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 a -1 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.

- *ES* and *HC* records are used only with *IF* records. The set of all *ES* records for an *IF* record instream flow right follow directly behind the *IF* record. The corresponding set of *HC* records are placed after the set of *ES* records.

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 *FS* and *CV* record sequential count identifier
					Cumulative Flow Variable Defining Switch
3	8	FSV	I3	blank,0,1	Regulated flow at control point (field 4).
		= FSI(FS,1)		−1	Regulated flow excluding reservoir releases (field 4)
				2	Naturalized flow at control point (field 4).
				3	Unappropriated or available flow at control point.
				4	Stream flow depletion at control point (field 4).
				5	Diversion at control point (field 4).
				6	Inflow to control point excluding upstream releases.
				7	Stream flow depletion for water right (field 17).
				8	Total diversion for water right (field 17).
				9	Diversion from reservoir storage for right (field 17).
				10	Target for water right (field 17).
				11	Instream flow shortage for *IF* record right (field 17).
				12	Hydrologic index provided on *HI* records (field 4).
4	9-16	FSCP	2x,A6	AN	Control point identifier of switch variable location.
				Blank	Control point from *IF/WR* record is the default.
					Target Multiplier Factors
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
					Lower and Upper Volume Bounds for FSI(FS,2) Options 1 and 2 or Multiplier Factors for FSI(FS,2) Option 3
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
					Options for Applying the Flow Volume Bounds
9	49-52	FSI(FS,2)	I4	blank,0	The flow bounds are not applied to target or release.
				1	Cumulative total volume applied to setting target.
				2	Count of number of periods applied to setting target.
				3	Increasing versus decreasing FSV Volume
					Lower and Upper Count Bounds
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
					Parameters Defining Flow Summation Period
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	Current period is included in FSV summation.
				3	Current period is not included in FSV summation.
					Other Input Variables
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	+	Month for setting FSV volume and count to zero.
				blank, 0	Feature is not activated.

Explanation of FS Record Fields

<u>Field 2</u>: Field 2 is described on page 99. Both *FS* and *CV* records are included together in the same sequential numbering with no differentiation between *CV* versus *FS* records.

<u>Fields 3, 4, and 17</u>: The flow switch is based on the variable *FSV* selected in field 3 at the control point in field 4, or for the water right in field 17. These fields are explained on page 99.

<u>Fields 5 and 6</u>: 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.

<u>Fields 7 and 8</u>: 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.

<u>Fields 9, 10, 11</u>: 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:

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

<u>Fields 12, 13, 14, 15</u>: 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 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 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)*.

<u>Field 12</u>: *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 pass the beginning of the simulation.

<u>Fields 13 and 14</u>: 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.

<u>Field 15</u>: 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 *IFM(IF,3)* 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.

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

<u>Field 18</u>: 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	Back-up is applied as step 2 described on page 87.
				9	Back-up is applied as step 10 described on page 88.
3	9-16	BUX(n)	F8.0	+	Factor by which the shortage is multiplied.
				blank,0	Default = 1.0
4	17-32	BUWRID	A16	AN	Identifier of water right being backed up.
				blank	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 87-88. The shortages may be added to the target as either the default step 2 or as step 10.

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.

PX Record – Priority Sequence Circumvention Options

field	columns	variable	Format	value	description
1	1-2	CD	A2	PX	Record identifier
					Dual Simulation Options
2	8	DUAL (wr)	I6	blank, 0, or −9	Water right is activated during all simulations. Flow depletion constraint feature is not applied. A −9 sets DUAL=0, over-riding default in *JO* record field 12.
				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.
					Stream Flow Availability Multiplier Factor
3	9-16	XAX	F8.0	blank,0	Not activating option is equivalent to XAX of 1.0.
				F8.0	Factor by which flow availability is multiplied.
				−1	Monthly factors are entered on following *AX* record.
					Downstream Control Point Flow Availability Limit
4	24	XCP(px)	I8	blank,0	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.
					Transient-Priority Water Right Options
6	40	XP(px)	I8	blank,0	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	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 2nd component of water right duo.
9	63-64	XPOUT(px)	I8	blank,0,1	Water right output is treated same as regular rights.
				−1	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 2nd component right.
12	89-96	WRID3(px)	A8	AN	Water right group identifier for 2nd component right.

AX Record – Monthly Stream flow Availability Multiplier Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	AX	Record identifier
					Stream Flow Availability Multiplier Factors
2	3-8	XA(px,1)	F6.0	+	Multiplier factor for month 1
3-13	9-96	XA(px,M)	F8.0	+	Multiplier factor for months 2 through 12
		M = 2, 12			
					Minimum and Maximum Limits
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 12, which is applied if *PX* record field 2 is blank or zero. 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 16).

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.

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. *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.

<u>*Field 6*</u>: 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.

<u>*Field 7*</u>: 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.

<u>*Field 8*</u>: *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.

<u>*Field 9*</u>: 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.

<u>*Field 10, 11, 12*</u>: 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 *SA* record

SA Record – Surface Areas for Reservoir Storage versus Area Table

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

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

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

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 *TE* record

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

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

DI Record – Drought Index Reservoirs

field	columns	variable	format	value	description
1	1-2	CD	A2	DI	Record identifier
2	7-8	DIID	2x,I4	+	Drought index integer identifier between 1 and 9999
				blank,0	Default is *DI* record counter in sequential order read.
3	11-12	EMPTY	I4	blank,0	Reservoir emptying option is not used.
				−1	Reservoir(s) is emptied at beginning of every month.
				1,2,3, ... 12	The month in which emptying occurs each year.
4	15-16	NR	I4	+	Number of reservoirs (Not to exceed 12)
				−1	All reservoirs.
5-16	17-112	DIRES(I)	12(2x,A6)	AN	Reservoir identifiers (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 *IP* record DIPER

IP Record – Drought Index Percentages

field	columns	variable	format	value	description
1	1-2	CD	A2	IP	Record identifier
2	7-8		6x		Field 2 is not used.
3-12	9-104	DIPER(I)	TL(F8.0)	+	Percentages corresponding to *IS* 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 drought index is applied in either target building steps 3 or 6 outlined on pages 87-88. The *WR* record field 11 or *IF* record field 10 *DINDEX(wr)* connects to the drought index identifier DIID(di) in *DI* record field 2. User-assigned DIID(di) can be any integers between 1 and 9999 and are not required to be in any sequential order. *SIM* counts the *DI* records as read and assigns the count to DIID if *DI* record field 2 is blank. For example, by default, the first *DI* record read is assigned DIID=1 and the second *DI* record DIID=2.

A storage versus target adjustment is defined by the *IS/IP* records with no more than TL (*JD* record field 12, default=12) pairs of storage and 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 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 DIFACT 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,+,–	
14	53-64	DIIN(I)	F8.0	+	DIFACT is set at DIIN(I) at beginning of long-term or multiple CRM simulations. Default = 1.0

The *IM* record is optional but, if used, follows the *IP* record. The *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 switching-variable EMPTY is *DI* record field 3 is essentially obsolete having been replaced by newer *FS* and *CV* record features as explained in the Chapter 4 of the *Reference Manual*.

EA Record – Net Evaporation-Precipitation Allocation

field	columns	variable	format	value	description
1	1-2	CD	A2	EA	Record identifier
2	7-8	NEA	I6	+	*EA* record integer identifier which may be blank since *SIM* automatically numbers. NEA = 1, 2 , 3, ...
					Allocation Method
3	16	NEAF (NEA)	I8	blank,0,1	Incremental based on water right priorities.
				2, 22	Based on beginning-of-month storage content.
				3, 33	Based on factors from the following *EF* record.
				4	Incremental combined with factors from *EF* record.
					Reservoirs
4-23	17-176	EARES (NEA,I)	20 (2x,A6)	AN	Reservoir identifiers for from 2 to 20 reservoirs. I = 1, 20

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	Any individual reservoir; beginning storage.
				2	Sum of storage in all reservoirs; beginning storage.
				3	Any individual reservoir; EAF factors; for NEAF=4.
				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 *EA* record used with *EA* 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 *EA* 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.

FD Record – Flow Distribution *FD* Record for Flow Distribution Options 3-8 and EWA

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 control point.
3	11-16	DSG	A6	AN	Source gaged control point (cp).
4	17-24	NG	I8	+ −1	Number of gaged cps above ungaged cp (blank = 0). Ungaged cp is downstream of source cp.
5-no limit	25-no limit	UGID(I)	2x,A6	AN	Identifiers of gaged cps upstream of source cp. No limit on the maximum number of upstream cps.

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 control point.
3	11-16	−	8X	blank	Field 3 is not used in the option 10 computations.
5	17-24	NG	I8	+	Number of source control points in the equation.
4-no limit	25-no limit	UGID(I) I = 1, NG	2x,A6	AN	Identifiers of source control points in the equation. Coefficients are assigned on the following *FC* record.

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

field	columns	Variable	format	value	description
1	1-2	CD	A2	FC	Record identifier.
2	3-8	COEF(1)	F6.0	+,−	Multiplier factor.
3	9-16	COEF(2)	F8.0	+,−	Exponent.
4	17-24	COEF(3)	F8.0	+,−	Addition factor.
5-no limit	25-no limit	COEF(I) I=4,NG+3	F8.0	+,−	Flow distribution option 10 multiplier coefficients for the NG gages listed on the preceding *FD* record.

WP Record – Watershed Parameters for Flow Distribution Options 4, 5, 6, 7, and 8 and EWA

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 in a DIS File

Methods for distributing naturalized flows from gaged (primary, known flow) to ungaged (secondary, unknown flow) control points and the evaporation-precipitation adjustment methodology are described in Chapter 3 of the *Reference Manual*. Flow distribution methods are illustrated by Example 4 in Appendix C of the *Reference Manual*. 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(cp) 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* record field 6 require a DIS file. The evaporation-precipitation adjustment activated in *JD* record field 11 or *CP* record field 9 [EWA(cp)] may also require information from *FD* and *WP* records. A *FC* record must follow directly behind its *FD* record. Otherwise, the *FD/FC* and *WP* records may be in any order. A DIS file ends with an end-of-data *ED* record.

A *FD* record is required for each ungaged control point [ID in *FD* record field 2] for which flows are synthesized from flows at other control points [DSG(I) and UGID(I)]. *FD* records are also required if pertinent options are specified [*JD* field 11 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 UGID(I) listed on the *FD* record 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. *FC* record fields 2, 3, and 4 provide the three coefficients *COEF(1)*, *COEF(2)*, and *COEF(3)* for the following option 3 equation.

$$Q_{ungaged} \ = \ COEF(1) \, Q_{DSG}{}^{COEF(2)} \ + \ COEF(3)$$

The *FC* record provides *COEF(I)* for any number *NG* of control points for the option 10 equation where Q(I) are the naturalized flows at the control points *UGID(I)* listed on the *FD* record.

$$Q_{ungaged} = COEF(1) \, [COEF(4)Q(1)+COEF(5)Q(2)+...+COEF(NG+3)Q(NG)]^{COEF(2)} + COEF(3)$$

A watershed parameter *WP* record is provided for each gaged (primary) and ungaged (secondary) 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 in field 2. However, the parameter INWS in *CP* field 12 allows the three parameters to be assigned to the incremental watershed defined by the *FD* record rather than to the total watershed.

Time Series Input Data Recorded on *IN*, *EV*, *FA*, *RU*, *HI*, *TS*, and *DF* records

All of the different types of *SIM* and *SIMD* time series input data are listed in the following table. The simulation input variables are sequences of quantities for each month of the hydrologic period-of-analysis. The last column of the table references the pages of this chapter of the descriptions of the data records. Daily flows on *DF* records are used only in daily simulations as discussed in the *Daily Manual*. The data listed below can all be stored as DSS records in a single *SIM/SIMD* hydrology input DSS file with the filename extension rootHYD.DSS. Alternatively, the time series data can be stored in the other files listed below. The record identifiers are placed in the first two columns of the text file records or as pathname part C in DSS records.

Time Series Data	*JO* Record Switch	Alternative Input Files	Record Identifier	Manual Pages
monthly naturalized flow volumes	INEV	DSS, DAT, FLO	IN	123
monthly evaporation-precipitation depths	INEV	DSS, DAT, EVA	EV	123
monthly naturalized flow adjustments	DSSFA, FAD	DSS, FAD	FA	48, 127
regulated-unappropriated flow adjustments	DSSRU, RUF	DSS, RUF	RU	48, 129
monthly hydrologic index	DSSHI	DSS, HIS	HI	48, 131
water right targets or flow depletion limits	DSSTS	DSS, DAT, TSF	TS	132
SIMD daily flow pattern hydrographs	JU record DFFILE	DSS, DCF	DF	146, 170

The time series input data are all assigned to control points with the exception of the *TS* record time series which are assigned to *IF* or *WR* record water rights. *HI* record hydrologic indices are identified by control point and referenced by *TO*, *LO*, *CV*, and/or *FS* records for water rights.

Any or all *SIM* or *SIMD* time series input data can be stored in a single DSS file with the filename rootHYD.DSS along with any other unread time series data that may be in the file. *SIM* does not read more than one DSS file; all DSS records must be in the same file. control points are listed on DAT file *FA*, *RU*, and *HI* records described on page 48. Target series identifiers on *TS* records following their *IF* or *WS* record reference the data sequences to be read from the DSS file. These identifiers comprise DSS pathname part B. Alternatively, the data can be stored in the other files listed above. All or none of the *IN* and *EV* records and/or all or none of the *RU* records and/or all or none of the *HI* records can be stored in the DSS file. Different *TS* records associated with different water rights can be stored in the DSS, DAT, and TSF files.

IN and *EV* records are read from the DSS file if and only if INEV option 6 is selected in *JO* record field 2. *FA*, *RU*, *HI*, and *TS* record quantities are read from the DSS file if and only if specified by DSSFA, DSSRU, DSSHI, and DSSTS, respectively, in *JO* record fields 4, 5, 6, 7. Otherwise, the time series data, if read, are read from the files listed above. *IN* record naturalized flow are required for at least one control point. All of the other time series data are optional.

FA record input data are required in either a FAD or DSS file if specified by FAD or DSSFA in *JO* record fields 3 and 4. *TS* record time series are required as specified by inclusion of *TS* records in sets of records accompanying *WR* or *IF* records that define water rights. *HI* record hydrologic indices are required if referenced by one or more *HC*, *TO*, *LO*, *CV*, and/or *FS* records associated with water rights. *FA*, *RU*, and *HI* identifier records described on page 48 are grouped together near the beginning of the DAT file. Target series identifiers are provided on *TS* records inserted in individual water rights record sets.

IN and EV Records in FLO and EVA File 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 *IN* record repeated for multiple years
				blank,0	*IN* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not zero or blank)
5	17-24	INFLOW(cp,1)	F8.0	+	Naturalized 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,1)	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 *EV* repeated for multiple years
				blank,0	*EV* record is for one year only; it is not repeated
4	13-16	PYR	I4	+	Year (last year to repeat if field 3 is not zero or blank)
5	17-24	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 1
6	25-32	EVAPR(cp,2)	F8.0	+	Net evaporation-precipitation for Month 2
7	33-40	EVAPR(cp,3)	F8.0	+	Net evaporation-precipitation for Month 3
8	41-48	EVAPR(cp,1)	F8.0	+	Net evaporation-precipitation for Month 4
9	49-56	EVAPR(cp,5)	F8.0	+	Net evaporation-precipitation for Month 5
10	57-64	EVAPR(cp,6)	F8.0	+	Net evaporation-precipitation for Month 6
11	65-72	EVAPR(cp,7)	F8.0	+	Net evaporation-precipitation for Month 7
12	73-80	EVAPR(cp,8)	F8.0	+	Net evaporation-precipitation for Month 8
13	81-88	EVAPR(cp,9)	F8.0	+	Net evaporation-precipitation for Month 9
14	89-96	EVAPR(10)	F8.0	+	Net evaporation-precipitation for Month 10
15	97-104	EVAPR(11)	F8.0	+	Net evaporation-precipitation for Month 11
16	105-112	EVAPR(12)	F8.0	+	Net evaporation-precipitation for Month 12

IN and EV Records in HYD File Format

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

First IN Record for Each Year – Inflows

field	columns	variable	format	value	description
1	1-2	CD	A2	IN	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-16	PYR	I8	+	Year
4	17-24	Q(1)	F8.0	+	Naturalized 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 -1 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 124. 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 as DSS records in a single DSS file with the filename rootHYD.DSS.

FA Record – Adjustments to Naturalized Flows

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

The *FA* record flow adjustments are positive or negative monthly volumes which are added to the naturalized stream flows. Unlike the constant inflow *CI* record, a different *FA* record is provided for each year. *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. *FA* and/or *CI* records may be entered for any number of control points.

The default is no *FA* records. *FA* records are read from a DSS file if specified by DSSFA in *JO* record field 4, and the flow adjustment computations are the same as for FAD options 2 and 3. The following discussion is not relevant if the flow adjustments are read from the DSS input file.

FA records are read from a FAD file if DSSFA is zero and FAD in *JO* record field 3 is greater than zero. The FAD file contains only *FA* records and optional ** and *ED* records. 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.

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. These organizational differences are not relevant for flow adjustments are stored in a DSS file.

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 ICKECK 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 Adjustments to Naturalized or Unappropriated Flows

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 *RU* record repeated for multiple years.
				blank,0	RU 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

The need to incorporate regulated flows in condensed datasets described in the *Hydrology Manual* provided the original motivation for adding the optional regulated-unappropriated *RU* record feature to *SIM*. However, this generic modeling feature may be used for various other types of applications as well. The flow volumes stored on *RU* records 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 17 and 18 of the *JO* record and explained on the next page.

RU record flow adjustments are read if activated by *RUFIN* or *RUF* on the *JO* record. The *RU* record flow adjustments are stored in the DSS file if specified by DSSRU in *JO* record field 5 and otherwise read from a RUF file. Identifiers are listed on *RU* records, described on page 48, in the DAT file for the control points for which flow adjustments are read from the DSS file. DSS file records are discussed in Chapter 6. With the RUF file alternative, the control point identifiers are read along with the flow adjustments from the *RU* records in the RUF file, and the *RU* record format is the same as the standard default *IN* and *EV* records.

RU records are included in the DSS or 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 in a RUF file 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. The entire period-of-analysis must be covered on DSS records, but any number of months may have zeros.

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.

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 (ΔF = 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.

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 were originally 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: $R = U + \Delta F +$ 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.

HI Record – Hydrologic Index Referenced by *HC*, *TO*, *LO*, *CV*, and *FS* Records

field	columns	variable	format	value	description
1	1-2	CD	A2	HI	Record identifier
2	3-8	ID	A6	AN	Control point identifier
3	9-12	NYR	I4	+	First year for an *HI* record repeated for multiple years
				blank,0	*HI* 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 *HC*, *TO*, *LO*, *CV*, and *FS* records which include entries with control point identifiers that 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 and alternatively as DSS records in the DSS hydrology input file.

The default is no *HI* records. *HI* records are read from the DSS input file if specified by DSSHI in *JO* record field 6. Otherwise, *HI* records are read from a HIS file if referenced by one or more *HC*, *TO*, *LO*, *CV*, and/or *FS* records.

The *HI* option in hydrologic condition *HC* record 3 employs a *HI* record index series. An *HI* record index series can also be referenced by *TOTARGET* option 16 in *TO* record field 2 or similarly used with an *LO* record. 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.

TS Record – Single *TS* Record with *IF* or *WR* Record in DAT File Referencing DSS or TSF File

field	columns	variable	format	value	description
1	1-3	CD	A2	TS	Identifier of single *TS* record in DAT file.
2	4-8	TSL	3x,A3	blank, AN	TSL options are defined on the next page.
3	9-12	TSFA	1x,A3	blank, DSS	*TS* records are in the DSS file.
				TSF	*TS* records are in the TSF file.
4	13-32	TSID	A6	blank	Default is the water right control point identifier.
			A20	AN	Identifier to connect to *TS* records in DSS file.
			A6	AN	Identifier to connect to *TS* records in TSF file.

TS Record – Target Series in DAT File

field	columns	variable	format	value	description
1	1-3	CD	A2,1x	TS	Identifier required for first year, optional thereafter.
2	4-8	TSL	A3	blank, AN	TSL is read only with first *TS* record. See next page.
					Years Covered
3	9-12	TSYR1	I4	–	Beginning year (optional)
4	13-16	TSYR2	I4	+	Ending year (required)
					Amounts of Targets or Limits
5-16	17-112	QTS (yr,wr,mt)	12F8.0	+	Amounts for each of the 12 months of the year

TS Record – Target Series in TSF File

field	columns	variable	format	value	description
1	1-2	CD	A2	TS	Identifier required for first year, optional thereafter.
2	3-8	TSID	A6	AN	Identifier for *TS* records in TSF file for first year.
					Years Covered
3	9-12	TSYR1	I4	–	Beginning year (optional)
4	13-16	TSYR2	I4	+	Ending year (required)
					Amounts of Targets or Limits
5-16	17-112	QTS (yr,wr,mt)	12F8.0	+	Amounts for each of the 12 months of the year

The three forms of *TS* records described above provide options for inputting the same target series quantities [QTS(yr,wr, mt)] in either the DSS (recommended default), DAT, or TSF file. QTS(yr,wr,mt) recorded on sets of *TS* records may be placed in the DAT file with the water right records or in a DSS or TSF file. *TS* records in a DSS or TSF file require a single referencing *TS* record following the *IF* or *WR* record in the DAT file to connect the water right to the set of *TS* records in the DSS or TSF file using the connecting identifier TSID. The DSS or TSF file is employed if DSS or TSF is specified by TSFA in *TS* record field 3. Otherwise, the time series quantities QTS(yr,wr,mt) are input as a sequence of *TS* records following the *IF* or *WR* record. Time series can be repeated and altered using the TSR record described on the next page.

TSR Record – Repeat or Modification of a Preceding Target Series in the DAT or TSF File

field	columns	variable	format	value	description
1	1-3	CD,TSC	A2,A1	TSR	Record identifier
2	6-8	TSL	A5	blank	TSL options for applying the QTS are defined below.
3	9-16	K	I8	blank,0 +	Repeat the last time series read. Number of the time series to be repeated.
4	17-24	TSA	F8.0	blank,0 +	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.

$$QTS(yr, \text{TSCOUNT}, mt) = TSA\,[QTS(yr,K,mt)] + TSB$$

Options for employing the target series QTS(yr,wr,mt) quantities in setting water right targets or streamflow depletion limits in the *SIM* simulation are specified by the parameter TSL in *TS* or *TSR* record field 2 as follows. The 3-character entry is placed anyplace in the 5-column field 2.

TSL (field 2)	Use of QTS(yr,wr,mt) Quantities in *SIM* Simulation
blank	*TS* record amounts are the only targets used. Target = QTS(yr,wr,mt)
MAX, max	Maximum of QTS(yr,wr,mt) and preceding target is adopted.
MIN, min	Minimum of QTS(yr,wr,mt) and preceding target is adopted.
ADD, add	*TS* record amount QTS(yr,wr,mt) is added to preceding target.
SUB, sub	*TS* record amount QTS(yr,wr,mt) is subtracted from preceding target. (A negative result will be set equal to zero.)
MUL, mul	*TS* record amount QTS(yr,wr,mt) is multiplied by preceding target.
SDL, sdl	*TS* record amount is upper limit on allowable stream flow depletions.

Monthly targets QTS entered on *TS* records are for either instream flow, diversion, hydroelectric energy, or storage 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 using the parameter TSL defined in the table above. The mechanism incorporated in *SIM* for combining *TS* record targets with other alternative targets are outlined as step 5 on page 88.

With SDL (stream flow depletion limit) entered for the parameter TSL in *TS* record field 2, the QTS(yr,wr,mt) quantities 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 allow time series of quantities setting or affecting water right targets or streamflow depletion limits to be developed external to the *SIM* simulation and provided as simulation input. *TS* records may be employed for a variety of different purposes. One application described in the

Daily Manual consists of computing daily environmental flow targets in a daily *SIMD* simulation which are summed to monthly quantities incorporated on *TS* records in a *SIM* input dataset.

A single *TS* record (TSFA options for DSS or TSF files), single TRS record (referencing QTS in DAT or TSF files), or set of multiple *TS* records is inserted in the DAT file any place within the group of auxiliary records that follow an instream flow *IF* record or water right *WR* record. With the DSS and TSF file TSFA options, TSID connects DAT file *TS* records with sets of *TS* records in the TSF or DSS file that contain the QTS(yr,wr,mt) quantities. Otherwise, the *TS* records with the QTS(yr,wr,mt) are inserted directly in the DAT file within the *IF* or *WR* record group. A maximum of only one target series can be assigned to each *IF* or *WR* record water right.

Each set of *TS* records provides monthly targets or limits for each month of each year of the hydrologic period-of-analysis. The entire period-of-analysis must be covered on DSS records, but any number of months may have zeros. With the TSF or DAT file options, the entire period-of-analysis must be covered, but the *TS* records may be repeated for multiple years. 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 as TSYR1 and TSYR2 in fields 3 and 4. TSYR2 controls the program. Field 4 is not used by the program except in error checks 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. *TS* records covering all years are grouped together in chronological order for a specific water right.

TSID in DAT file *TS* record field 4 is an identifier with up to 20 characters assigned to *TS* records in the DSS file or up to six characters assigned to *TS* records in a TSF file. TSID is entered as any 20 or six or fewer columns of the 20-column field 4 (columns 13-34) of the single referencing *TS* record in the DAT file. The default (blank *TS* record field 4) TSID is the control point identifier CP assigned in *IF* or *WR* record field 2. Thus, the default assigns the *TS* record target series the same identifier as the control point identifier assigned to the water right.

A *TSR* record may be included in a DAT file group of auxiliary records that follow an *IF* record or *WR* record to repeat with or without alterations another target series already assigned to a preceding right. *TSR* records are used only with DAT and TSF files, not with a DSS file.

A target series QTS(yr,wr,mt) associated with a particular *WR* or *IF* record may be repeated or computed from the target series QTS(yr,K,mt) previously entered as *TS* records for another *WR* or *IF* record based on the following equation with the factors TSA and TSB from *TSR* record fields 4 and 5.

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

QTS(yr,K,mt) are previously entered on the Kth set of *TS* records or developed with a previous *TSR* record. Target series are automatically numbered consecutively (K = 1, 2, 3, ...) by *SIM* in the order that the *IF* and *WR* record water rights with *TS* records are 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 referenced by the *IF* and *WR* records in the DAT file. The default (blank field 3, K=0) is to repeat the last series referenced by a preceding water right as read from the DAT file.

CHAPTER 4
SIMD DAILY SIMULATION MODEL

The daily simulation model *SIMD* is an expanded version of the monthly *SIM* that incorporates the additional modeling capabilities described in the *Daily Manual*. *SIMD* includes all *SIM* simulation capabilities plus additional features associated with adopting a daily rather than monthly computational time step. The files described in Chapter 2 and input records described in the preceding Chapter 3 are applicable with either *SIM* or *SIMD*. Additional *SIMD* files and input records that are not relevant to *SIM* are covered in the present Chapter 4.

SIM will read an input dataset that contains the records described in Chapter 4 and perform a monthly simulation. *SIM* simply skips over the records described in Chapter 4 without reading the input data entered on the records. *SIMD* and *SIM* generate the same simulation results with an input dataset containing none of the records described in Chapter 4. *SIMD* can perform only a daily simulation (not monthly) if any of the record types described in Chapter 4 are included in the *SIMD* input dataset. *SIMD* was originally designed for any integer number of sub-monthly time steps but is fully operational and actually applied with only a daily sub-monthly time step. Sub-monthly time steps other than daily are not addressed in this manual.

SIMD Input and Output Files

Input and output files for all of the WRAP programs are listed in Tables 1.2 and 1.3 of Chapter 1. The types of input files listed in Table 2.1 of Chapter 2 are applicable to both *SIMD* and *SIM*. The following additional optional files are used only by *SIMD*.

DIF input file –   Only file for *RT*, *DC*, and *SC* records.
                   Optional file alternative for *DW*, *DO*, *PF*, *PO*, and *DF* records.
SMM output file – Daily (sub-monthly) messages and supplemental tables.
SUB output file – Time series of daily (sub-monthly) simulation results.
AFF output file – Annual peak flows and storage volumes for flood frequency analyses.

The DIF file is the only additional input file that is read by *SIMD* but not read by *SIM*. The optional DIF file contains optional input records, and a daily *SIMD* simulation is possible without a DIF file. The DIF file is the only file that can contain *RT*, *DC*, and *SC* records. *DW*, *DO*, *PF*, and *PO* records defining daily features of water rights can be stored in either the DAT or DIF file. The *DW*, *DO*, *PF*, and *PO* records can be combined with *SC* records if stored in the DIF file. The daily flow *DF* records can be stored in either the DSS hydrology input file or the DIF file. The DSS file is the recommended standard file for *DF* records.

Upon execution, *SIMD* automatically searches for a DIF file. If no DIF file is found, defaults are adopted for the parameters otherwise read from input records found in the DIF file. *SIMD* writes a warning message in the MSS message file if no DIF file is found.

The message file with filename extension SMM is automatically created with each execution of *SIMD*. The *SIMD* SMM file supplements the *SIM/SIMD* message MSS file. *JT* record fields 10-13 input parameters activate creation of optional tables in the SMM file.

SIMD

An output file with filename extension SUB is automatically created with each execution of *SIMD* to record the daily (sub-monthly) simulation results. The daily interval simulation results are aggregated by month within *SIMD* to create an output file with the filename extension OUT. The OUT file developed by *SIMD* has the same format as an OUT created by *SIM*. The SUB and OUT files also have the same format. The SUB file contains time series of daily simulation results. The OUT file contains time series of monthly simulation results from a monthly simulation or monthly summations of daily simulation results from a daily simulation.

Control points, water rights, and reservoirs are selected for daily simulation results output to the SUB file on the *JT* and *C2*, *W2*, and *R2* records independently of the selections on the *JD*, *CO*, *WO*, and *RO* records for the OUT file. Monthly versus daily output can be recorded for different sets of control points, water rights, and/or reservoirs. Another output management option for the SUB file is selection of a sub-range from the simulation period-of-analysis. These features provide flexibility for limiting the potentially massive size of the SUB file.

The annual flood frequency analysis file with the filename extension AFF contains annual series of maximum daily naturalized flow, regulated flow, and reservoir storage. *TABLES* performs flood frequency analyses with the annual series of daily peaks contained in the AFF file.

Types and Sequencing of *SIMD* Input Records

All of the input records described in the preceding Chapter 3 are applicable for either a monthly *SIM* or monthly *SIMD* simulation or a daily *SIMD* simulation. The additional input records described in Chapter 4 are valid only for a daily *SIMD* simulation.

The *JT* record is the only record required to convert a monthly *SIM* dataset to a *SIMD* daily dataset. A daily simulation must have a *JT* record in the DAT file. The other optional records described in this chapter are employed only with a daily simulation and are either inserted in the DAT and DSS files that are used for both monthly and daily simulations or in the DIF file used only for daily simulations. The hydrology DSS (data storage system) input file optionally contains daily and/or monthly data. The records listed in Table 4.1 are described in Chapter 4.

JT, JU, DF, C2, C3, W2, G2, and R2 Records in the DAT File

As explained in Chapter 3, for a monthly simulation, a *SIM* or *SIMD* input DAT file begins with the optional title (*T1*, *T2, T3*) records, if used, followed by *JD*, *JO*, *CR*, *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records in any sequential order. This group of records is placed between the title records and use coefficient *UC* and control point *CP* records. The *JD* record is required. All of the other records in this group are optional. For a daily simulation, the daily *JT*, *JU*, *DF*, *C2*, *C3*, *W2*, *G2*, and *R2* records can be inserted any place in the group of monthly/daily *JD*, *JO*, *CR*, *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records. The sequencing of the daily *JT*, *JU*, *DF*, *C2*, *C3*, *W2*, *G2*, and *R2* records must abide by the following rules, but otherwise can be intermixed with the monthly-only records in any sequential order.

Like all the other records listed in the preceding paragraph, the *JT* record is placed any place in the DAT file between the title records and *UC* and *CP* records. The optional *JU* record

must follow the *JT* record which is required for a daily simulation. The *JT* and *JU* records can be separated by comment ** records but by no other type of record.

Table 4.1
SIMD Input Records

<u>DAT File Input Records</u>

JT and JU records control time step, output, and forecasting options.
W2, *G2*, *C2*, *C3*, and *R2* records control selection of daily simulation results output.
FR, *FF*, *FV*, and *FQ* records implement flood control reservoir operations.
PF and PO records specify water right targets based on high flow pulses.
DF records list control point identifiers for daily flow *DF* records in the DSS file.

<u>Records Stored Optionally in Either the DAT and/or DIF Files</u>

DW and *DO* records specify target and forecast options for individual water rights.

<u>DIF File Input Records</u>

SC records provide selection criteria for assigning *DW* and *DO* record parameters.
RT, *DC* records provide flow routing and disaggregation specifications and data.

<u>Records Stored in Either the DSS File or DIF File</u>

DF records consist of sequences of daily stream flows.

    W2, *C2*, *C3*, *R2,* and *G2* records can be inserted any place within the group of records listed in the preceding two paragraphs, with the exception that they cannot be inserted between the *JT* and *JU* records. All *C2* records are grouped together as a set. All *C3* records are grouped together. All *R2* records are grouped. *W2* are grouped together. Likewise, *G2* records are grouped together. Each of these four sets of records may precede or follow the other sets in any order.

Flood Control FF, FR, FV, FQ Records in the DAT File

    FR and *FF* records are treated as types of water rights analogously to water right *WR* and instream flow *IF* records and placed in the DAT file with the *WR* and *IF* records and auxiliary records. The same rules for organizing the DAT file are applicable to *FR*, *FF*, *WR*, and *IF* records.

    The set of all *FV* and *FQ* records is placed before the set of all *SV* and *SA* records and follows the set of all *WR*, *IF*, *FR*, and *FF* records. A *FQ* record must follow each *FV* record.

Pulse Flow PF and PO Records in the DAT File

    PF and *PO* records are used in combination with *HC* and *ES* records to simulate environmental flow standards. The *PF* and *PO* records are included in the group of *HC*, *ES*, *SO*, *TO*, *TS*, *FS*, *CV*, *WS*, *DW*, and *DO* records that follow a water right *WR* or instream flow *IF* record in the same manner as *DW* and *DO* records. The *PF/PO* record data are automatically assigned to

the *IF* record water right that the*y* follow in the same manner as the information provided by all of the other auxiliary records in the group of records following the *IF* record. Any number of *PF* records or pairs of *PF/PO* records can follow a particular *IF* record. Each pulse flow options *PO* record must follow directly behind the pulse flow *PF* record that it supplements, separated by no other records except comment ** records.

The *SIM/SIMD ES* and *HC* records (Chapter 3) and daily *SIMD PF* and *PO* records (Chapter 4) are designed for modeling environmental instream flow standards as described in Chapter 4 of the *Reference Manual* and Chapters 6 and 8 of the *Daily Manual*. The *HC* record defines hydrologic conditions for the *ES* and *PF* records. These input records are designed for use with instream flow *IF* record rights but can also generically be applied with *WR* record rights.

Water Right DW and DO Records in the DAT or DIF Files

DW and *DO* records may be placed in either the DAT file or DIF file or both files or neither file. A *DO* record, if used, follows the corresponding *DW* record that it supplements.

In the DAT file, the *DW* and *DO* records are included in the group of *ES*, *HC*, *SO*, *TO*, *TS*, *FS*, *CV*, *WS*, *HP*, and *PX* records that follow a water right *WR* or instream flow *IF* record. The *DW* and *DO* records may be placed anyplace within the records that follow a *WR* or *IF* record. A *DO* record, if used, follows its *DW* record separated by no other records except comment ** records.

Selection criteria *SC* records may be included in the DIF file but are not allowed in the DAT file. A *SC* record directly follows the *DW* or *DO* record in the DIF file to which it applies. All *DW*, *DO*, and *SC* records are grouped together as a set in the DIF file. The set of all *DW*, *DO*, and *SC* records can be placed before, after, or between the sets of all *RT* records and all *DC* records.

Routing RT and Disaggregation DC Records in the DIF File

All *RT* records are grouped together as a set in the DIF file. Likewise, all *DC* records are grouped together. All *DF* records are grouped together. The set of all *RT* records set of all *DC* records can be placed in any order before the *DF* records. All *DF* records are grouped together as the last set in the DIF file. Both the DIF file and DAT file end with an end-of-data ED record.

Daily Flow DF Records in the DAT and DSS or DIF Files

DF records of daily stream flows are read by *SIMD* from the DSS hydrology input file for the default DFFILE option 1. *DF* records are read from the DIF file if DFFILE option 3 is selected in *JU* record field 3. Storing *DF* record daily flows in the DSS file is recommended. If *DF* records of stream flow are stored in the DSS file, *DF* identifier records are placed in the DAT file anyplace after the *T1*, *T2*, and *T3* records and before the *UC* records.

Time series data on *IN*, *EV*, *FA*, *RU*, *HI*, *TS*, and *DF* records are discussed on page 122 of Chapter 3. Daily flows on *DF* records are stored in the DSS hydrology input file along with the other monthly time series data. *DF* records are the only daily data in the hydrology input DSS file.

JT Record – Daily Simulation Control

field	columns	variable	format	value	description
1	1-2	CD	A2	JT	Record identifier
					Control Points and Water Rights Output in SUB file
2	3-8	OUTCP2	I6	blank,0	Control point output is specified only by *C2* records.
				1	All control points except artificial control points.
				2	Control points with *IN* records plus *C2* records.
				3	Output for only artificial control points.
				4	All control points including artificial control points.
				5	Control points with daily flow *DF* records.
				≥ 6	First *CPOUT2* control points plus *C2* records.
3	9-12	OUTWR2	I4	blank,0	Water rights output specified by *W2* and *G2* records.
				1	All *WR/IF* rights except hydropower and artificial.
				2	All *WR* and *IF* record rights with no exceptions.
				3	Only non-hydropower *WR* record water rights.
				4	Only instream flow (*IF* record) rights are output.
				5	Only hydropower *WR* record water rights.
				6	Only artificial water rights are output.
				7	Only *FF* and *FR* record flood control rights.
				≥ 8	First *OUTWR2* rights plus rights on *W2/G2* records.
					Time Block for Output Recorded in the SUB File
4	13-16	BEGYR	I4	+	Beginning year for output data in SUB file.
				blank,0	*BEGYR* is set equal to *YRST*.
5	17-20	BEGMON	I4	+	Beginning month (1, 2, 3, ... , 12) of *BEGYR*.
				blank,0,1	*BEGMON* is set equal to 1.
6	21-24	ENDYR	I4	+	Last year for output data in SUB file.
				blank,0	*ENDYR* is set equal to *YRST+NYRS-1*
7	25-28	ENDMON	I4	+	Last month (1, 2, 3, ... , 12) of *ENDYR*.
				blank,0,12	*ENDMON* is set equal to 12.
					AFF File of Annual Series for Flood Frequency Analyses
8	29-32	AFF	I4	blank,0,1	AFF file is not created.
				2	AFF file is created and includes all control points.
				3	AFF file is created for control points on C3 record.
					Table of Control Points for Flow Disaggregation in SMM File
9	33-36	DCSMM	I4	blank,0,1	Flow disaggregation parameter table is not created.
				2	All control points included in disaggregation table.
				3	Only the control points included in the OUT file.
				4	Only the control points included in the SUB file.
				5	Only the control points included in the AFF file.
				6	Only control points with *DF* records.
				7	Only control points with either *DF* or *DC* records.

JT Record – Daily Simulation Control (continued)

field	columns	variable	format	value	description
					Tables of Routing Factor Arrays in SMM File
10	37-40	RFASMM	I4	blank,0,1	Routing factor arrays are not recorded in SMM file.
					Options 2-5 limited to control points with *RT* records.
				2	All control points with *RT* records are included.
				3	Only those in OUT file are in SMM file RFA table.
				4	Only those in SUB file are in SMM file RFA table.
				5	Only those in AFF file are in SMM file RFA table.
					Water Right Summary Table in SMM File
11	41-44	APRDSMM	I4	blank,0,1	Availability table is not included in SMM file.
				2	All water rights are included in the availability table.
				3	Only the water rights included in the OUT file.
				4	Only the water rights included in the SUB file.
					Routing Adjustments Table in SMM File
12	45-48	RTGSMM	I4	blank,0,1	Routing adjustments table is not created.
				2	All control points are included in the table.
				3	Only the control points in the OUT file included.
				4	Only the control points in SUB file included in table.
				5	Only the control points in AFF file included in table.
					Daily Output File with Filename Extension SUB
13	49-52	SUBFILE	I4	blank, 0	The SUB output file is not created.
				1	The SUB output file is created.
14	53-56	SUBLIMIT	I4	blank,0,1	Default limit on SUB file size.
				9	Override SUB file size limit
					Volume/Day Instead of Flow Rate in CFS
15	57-60	NCFS	I4	blank, 0	The optional NCFS feature is not employed.
				−9	The not-cfs NCFS option is activated.

The *JT* record is required to use a daily time step in a *SIMD* simulation. A blank *JT* record activates defaults for all *JT* record parameters. The daily *JT* and *JU* records can be inserted in the DAT file any place in the set of monthly/daily *CR*, *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, *GO*, and *RG* records that follow after the *JD* and *JO* records. The optional *JU* record follows the *JT* record. If no *JU* record is provided, the daily simulation will proceed with default values for the *JU* record variables.

Explanation of *JT* Record Fields

Output Control: *JD* record fields 4 and 5 and *CO*, *RO*, *WO*, and *GO* records control which control points, water rights, and reservoirs are included in the monthly simulation results DSS and OUT output files. Likewise, *JT* record fields 2 and 3 and *C2*, *R2*, *W2*, and *G2* records are used to select which control points, water rights, and reservoirs are included in the daily simulation results DSS and SUB output files. Reservoir output is specified only by use of *RO* and *R2* records.

Field 2: Selection of control points for inclusion in the simulation results DSS and SUB files is controlled by CPOUT2 in *JT* record field 2 along with *C2* records. With CPOUT2 option 1, daily

results are recorded in the output files for all control points except those designated as artificial on *CO* records. Option 4 outputs all control points including artificial. If field 5 is blank or zero and there is no *CO* record, no control points are output. Option 2 specifies output for control points for which *INMETHOD* in *CP* record field 7 is 0, 1, or 2. Control points listed on *C2* records are included in the daily output along with those specified by the *JT* record. Either positive (1, 2, 3, 4, 5) or negative (−1, −2, −3, −4, −5) entries for OUTCP2 provide identically the same results.

Field 3: OUTWR2 allows selection for inclusion of simulation results in the DSS and SUB output file for either no rights, all *WR* and *IF* record rights except hydropower and artificial (option 1), all *WR* and *IF* record rights (option 2), all *WR* record rights excluding hydropower (option 3), all instream flow rights (option 4), all hydropower rights (option 5), all artificial rights (option 6), or all flood control rights (option7). OUTWR2 also allows the first any number of water rights greater seven in the DAT file to be selected. Water rights identified by *W2* and *G2* records are included in the output files along with those that may be specified by the *JT* record field 4 options.

Fields 4, 5, 6, 7: The data recorded in the SUB file covers the period extending from the beginning year and month through the ending year and month defined in *JT* record fields 4, 5, 6, and 7. Monthly simulation results in the OUT file always covers the entire simulation period.

Field 8: Annual series of maximum daily naturalized and regulated flows and reservoir storage may be written to an AFF file to be read by *TABLES* to perform flood frequency analyses. The default is to not create an AFF file. A 2 in field 8 creates an AFF file containing all control points. Option 3 consists of only control points listed on *C3* records being included in the AFF file.

Optional Tables SMM File: Fields 9, 10, 11, and 12 control reports written to the daily message SMM file for information purposes only with no effect on the simulation computations. The example in Chapter 7 of the *Daily Manual* illustrates these optional SMM file tables.

Field 9: DCSMM creates two tables in the SMM file that list the naturalized flow disaggregation method and parameters of all or selected control points as assigned by *JU* record field 2 and the *DC* records. Information regarding daily flows read from the DSS or DSC file is also provided. Disaggregation methods and parameters are assigned automatically to multiple control points. Information input on *DF* and *DC* records for selected control points may be assigned to all of the all control points in the dataset. The DCSMM table allows the user to verify the disaggregation method and parameters assigned automatically to the control points.

Field 10: RFASMM creates tables of the routing factor arrays (RFAs) described in Chapter 3 of the *Daily Manual*. The routing factor arrays are generated only for control points with non-zero routing parameters in *RT* record fields 4 and 5 or *RT* record fields 7 and 8. However, the routing factor array is used for every control point for routing changes to flow downstream to the outlet, and for conducting reverse routing if forecasting is applied. Day 0 is the current time step. Days 1 or greater are indicative of the routing that occurs in future time steps.

Field 11: *JT* record field 11 controls the creation of a water rights summary table in the SMM file report listing various water right information including the flow availability forecast period limit for each water right. With forecasting activated by *JU* record parameter FCST option 2, each water right is assigned a forecast period limit of *JU* record APRD or *DW* record APERIOD(wr). The limit set with *DW* record APERIOD(wr) can be assigned automatically to a large number of water rights using *DW/SC* record pairs in the DIF file. The APRDSMM table allows the user to verify the flow availability forecast period limits assigned to the water rights.

Field 12: RTGSMM activates creation of a report in the SMM file that lists monthly totals of the routing adjustments. Routing adjustments are performed automatically during any simulation that uses routing parameter *RT* records to control the downstream propagation of water right changes to stream flow. The routing parameters on an *RT* record are applied in all time steps and under all flow conditions when a change to flow is propagated downstream. A portion of the depletion may arrive in a different time step than the flow event being depleted by the upstream water right. The *RT* record routing parameters are calibrated to routing conditions representative of flow events throughout the period of analysis. However, if flow events in the simulation are patterned with real-world gaged flow data, the flow events will vary in travel velocity according to a variety of factors including discharge rate. When flow depletions arrive at a downstream control point with no stream flow remaining, the routing computations automatically allow flow in the next time step to be decreased by the amount necessary to complete the depletion routing from the previous time step. Thus, the volume budget is maintained over the course of the hydrologic period-of-analysis.

Field 13: The daily simulation results with filename extension SUB is created only if a 1 is entered for SUBFILE in *JT* record field 13. The default is to not create a SUB file. Daily results and monthly summations of daily results can be recorded in a DSS file as specified on the *OF* record.

Field 14: SUBLIMIT allows the user to override the file size limit on the SUB file. The SUB and OUT files are identical in format and the number of variables reported, but the SUB file contains output variables for each daily time step. Thus, the SUB file for a daily simulation will be about 30 times larger than the monthly OUT simulation results output file for the same number of control points, water rights, and reservoirs. Massive quantities of output may significantly slow down a simulation as well as consume a large amount of computer hard disk space. Caution should be exercised in overriding the SUB file size limit.

The SUB file size limit is 5 million output records when producing output data in text file format. The text file format is the default option for *JD* record variable OUTFILE. Each output record in the text file is 136 ASCII characters in length. Each ASCII character is 1 byte of data. Therefore, 5 million output records will create a SUB file size equal to 680 megabytes (MB).

The SUB file size limit is 10 million output records when producing SUB output data in the binary file format. Binary SUB file output is selected with JD record OUTFILE option 2. Each output record in the binary file is 20 entries long. Each entry is 4 bytes of data. Therefore, 10 million output records will create a SUB file size equal to 800 MB.

The total number of output records to be generated during the simulation is computed as the first six lines of the SUB file plus the number of sub-monthly time steps during the simulation time block multiplied by the sum of the control point, water right, and reservoir output records specified for output by the *JT*, *C2*, *W2*, *G2*, or *R2* records. The number of sub-monthly time steps and the number of control point, water right, and reservoir output records are listed as the final four variables on the fifth line of the SUB file. The number of sub-monthly time steps in the simulation time block is controlled by *JT* record fields 4 through 7.

Field 15: NCFS is relevant only to the following input variables that are otherwise in units of cubic feet per second (cfs): ESQ on *ES* records; pulse trigger on *PF* record; flood flow limit on *FF* record; maximum release limit on *FR*; and reservoir outflows on *FQ* records. With the default NCFS=0, these variables are entered in cfs. With NCFS=−9 in *JT* record field 15, these variables are entered in acre-feet/day or other appropriate volume/day units such as cubic meters per day.

JU Record – Daily Simulation Options

field	columns	variable	format	value	description
1	1-2	CD	A2	JU	Record identifier
					Default Flow Disaggregation Option
2	8	DFMETH	I6	1	Uniform distribution method.
				2	Linear interpolation method.
				3	Variability adjustment method.
				blank, 0, 4	Flow pattern option with automatic repetition.
				8	No disaggregation. *IN* record flows in volume/day units.
				9	No disaggregation. Daily flows are input on *DF* records.
					Input File for DF Record Daily Flows
3	12	DFFILE	I4	blank, 0, 1	Daily flows are read from hydrology DSS file.
				2	Daily flows are read from *DF* records in DIF file.
				3	Daily flows are read from DIF file and recorded in a DSS file without performing simulation.
					Next-Day Placement of Routed Flow Changes
4	16	WRMETH	I4	blank, 0, 1	Final flow changes at beginning of sequence.
				2	Final flow changes are placed in priority sequence.
5	20	WRFCST	I4	blank, 0, 1	Forecast flow changes at beginning of sequence.
				2	Forecast flow changes are placed in priority sequence.
					Stream Flow Forecasting Parameters
6	24	FCST	I4	blank, 0, 1	No forecasting.
				2	Stream flow forecasting is activated.
7	28	FPRD	I4	blank, 0	Simulation forecast period F_P is automatically set.
				+	Length of simulation forecast period F_P = FPRD
8	32	APRD	I4	blank, 0	Availability forecast period limit is automatically set.
				+	Maximum limit on availability forecast period.
					Default Options for WR Record Target Distribution
9	33-36	DND	I4	blank, 0	The default is the uniform distribution.
				+	Number of days for selected-days option.
10	37-40	DSHORT	I4	blank, 0	Shortages are not supplied in subsequent days.
				+	Shortages are supplied in subsequent days.
11	41-44	DHMETHOD	I4	blank, 0	No disaggregation of *HI* record hydrologic indices.
				9	Uniform disaggregation of *HI* record monthly data.
					Multiplier Factor for Daily Flows
12	45-52	DFMULT	F8.0	blank, 0	Default = 1.0
				+	Multiplier for daily flows from DSS or DIF file.
					Factor Used with Flow Disaggregation Option 3
13	53-60	VRL	F8.0	blank, 0	Default = 0.10 for VRL in Equation 2.1.
				+	Multiplier VRL in Equation 2.1 used with option 3.

Explanation of *JU* Record Fields

Field 2: Monthly flows are disaggregated to daily in *SIMD* using the alternative methods listed in *Daily Manual* Table 2.2. The global default *DFMETH* set in *JU* record field 2 may be over-ridden for individual control points by *DFMETHOD(cp)* in *DC* record field 4. The *JU* record *DFMETH* option is used for all control points that have no other option activated by *DC* record *DFMETHOD(cp)*. The default for the default setting *DFMETH* is flow disaggregation option 4.

Field 3: All flow disaggregation options except methods 1, 2, and 8 use *DF* record daily flows. By default (DFFILE = 0 or 1), daily flows are read from a DSS file. With DFFILE option 2, daily flows are read from *DF* records in the DIF file. DFFILE option 3 consists of creating a DSS file with daily flows previously compiled in a DIF file. With DFFILE=3, daily flows are read from a DIF file and, after possible optional adjustments, written to a DSS file.

Field 4: Streamflow depletions for diversions and refilling reservoir storage for *WR* record water rights affect flows at downstream control points in future days. With the default *WRMETH* option 1, routed stream flow adjustments for streamflow depletions in preceding days are placed at the beginning of the water right priority sequence each day. Thus, actions of water rights in preceding days may affect streamflow availability in the current day for any water rights including senior rights. With *WRMETH* option 2, the routed flow changes from preceding days are inserted in the water right loop at the priority of the water right making the depletion. *WRMETH* option 2 is designed to protect senior rights in the current day from streamflow depletions by junior water rights in preceding days.

WRMETH is used for placing the final changes to flow that do not originate within the forecast simulation. The forecast simulation is initiated by *FCST* in *JU* record field 6. Final changes to flow that do not originate within the forecast simulation will continue to be placed either before or within the priority sequence according to *WRMETH* in future days until the changes to flow reach the basin outlet. If a forecast simulation is activated by *JU* record parameter *FCST*, those changes to flow that originate outside of the forecast simulation will continue to be placed either before or within the priority sequence according to *WRMETH* during the forecast simulation.

WRMETH is applicable to the changes to flow resulting from streamflow depletions and releases that are made for flood control purposes from *FR* record rights. Releases from *FR* record rights are treated as return flows.

WRMETH is not applicable to the placement of changes to flow resulting from *WR* record return flows. Return flows by *WR* record water rights are placed either at the beginning of the next-day simulation sequence (*RFMETH* options 1 and 3) or inserted in the water rights priority sequence (*RFMETH* options 2 and 4) based on the parameter *RFMETH* entered in *WR* record field 7.

Field 5: Streamflow depletions by *WR* record rights and depletions and return flows from *FR* record rights that originate within the forecast simulation are placed before or after the priority sequence according to *WRFCST*. The options for *WRFCST* are analogous to *WRMETH*, except that *WRFCST* is only applicable to changes to flow that originate within the forecast simulation. Changes to flow that were made outside of the forecast simulation continue to be placed either before or within the priority sequence according based on *WRMETH*. Therefore, during the forecast simulation, if different options are chosen for *WRMETH* and *WRFCST*, two different placements for changes to flow may occur. If *WRMETH* option 1 and *WRFCST* option 2 are selected, changes to flow for all *WR* and *FR* record rights that originated outside of the forecast

simulation in preceding days will continue to be placed before the priority sequence. Changes to flow being made within the forecast simulation will be placed within the priority sequence for the remainder of the forecast simulation. A selection of *WRMETH* option 2 and *WRFCST* option 1 will have the opposite placement configuration from that described above.

WRFCST is not applicable for simulations that do not utilize forecasting.

WRFCST is not applicable to the placement of changes to flow resulting from *WR* record return flows. Return flows are placed either at the beginning of the next-day simulation sequence (*RFMETH* options 1 and 3) or inserted in the water rights priority sequence (*RFMETH* options 2 and 4) based on the parameter *RFMETH* in *WR* record field 7.

Field 6: *FCST* activates flow forecasting. The reverse routing forecasting methodology described in the Daily Manual is applied for all water rights if and only if *FCST* option 2 is selected.

Field 7: The default global simulation forecast period in days is set automatically by *SIMD* as twice the longest routing period in the routing factor array unless over-ridden by *FPRD*. *JU* record fields 7 and 8 are ignored if forecasting is not enabled by *FCST* in field 6.

Field 8: *APRD* in *JU* record field 8 is a global maximum limit on the flow availability forecast period, which may be replaced for individual rights by *APERIOD(wr)* in *DW* record field 2. The simulation forecast period F_P is set automatically by *SIMD* subject to being replaced by the user with *FPRD* entered in *JU* record field 7. *APRD* in *JU* record field 8 and *APERIOD(wr)* in *DW* record field 2 can shorten the forecast period adopted in the water availability computations to less than F_P but cannot exceed F_P. *APRD* and *APERIOD(wr)* are maximum limits.

Fields 9 and 10: Monthly diversion, instream flow, and hydropower targets are set as specified by *WR*, *IF*, and *UC* records. The monthly target for a *WR* record is then distributed to daily intervals based on global default options specified in *JU* record fields 9 and 10 which may be over-ridden for individual water rights by *DW* record fields 4 and 5. The overall default is a uniform distribution of the target over the entire month. Alternatively, a target may be distributed over the first *ND* days of the month, with or without allowing shortages to be supplied later in the month. A *DW* record is required for each *IF* record to set the *ND* variable.

The optional parameter *SHORT* in field 10 is applicable only in combination with a positive value of *ND* in field 9. A positive *ND* activates an option in which the monthly target is uniformly distributed over the first *ND* days of the month. The daily target volume is the monthly target volume divided by *ND*. If the *SHORT* option is not activated with the *ND* option, targets are met only during the first *ND* days of the month, with shortages declared if the targets cannot be met each day. The *SHORT* option allows diversion and hydropower shortages during the first *ND* days to be supplied in subsequent days of the same month that follow after the first *ND* days.

Field 12: Daily flow quantities may be multiplied by a factor entered in *JU* field 11. In disaggregating monthly flows to daily, the units of the daily flows in the input file are irrelevant. However, if the daily flows from the input file are used directly without activating monthly disaggregation options, *DFMULT* in *JU* field 11 may be a unit conversion factor used to convert the units of the *DF* record flows to be consistent with the other simulation quantities.

Field 13: Equation 2.1 in the *Daily Manual* defines an upper limit *VRL* on the variability ratio *VR* used with flow disaggregation option 3. The limit is set as the inputted daily flows from multiplied by *VRL*. The default VRL of 0.10 may be replaced by entering a value in *JU* record field 12.

DF Identifier Records – Control Point Identifiers for Daily Flow *DF* Records in DSS Input File

field	columns	variable	format	value	description
1	1-2	CD	A2	DF	Record identifier
2	3-8		6x		Field is not read.
3-17	9-128	ID(1,15)	15A8	AN	Control point identifiers of the DSS file *DF* records.

DF records listing control point identifiers for DSS file daily flows must be included in the DAT file if the default DFFILE option 1 is activated in *JU* record field 3. *DF* identifier records are not used with DFFILE options 2 and 3.

Control point identifiers on the *DF* records of daily flows to be read from the DSS hydrology input file are listed on *DF* records in the DAT file. The *DF* records described here provide a list of all of the control points for which daily flows are to be read from the DSS file. These records are placed in the DAT file anyplace after the *JD*, *JO*, *JT*, and *JU* records but before the *UC* records.

Any number of control points up to a maximum of 15 can be listed on each *DF* record. Any number of *DF* identifier records may be used. As an example, assume *DF* record daily flow sequences are to be read from the DSS file for 27 control points. Two *DF* records can be included in the DAT file with 15 control points listed on the first and twelve on the second. Alternatively, five control points could be listed on each of five *DF* records in the DAT file or 13 and 14 control points could be listed on the first and second records. The identifiers consisting of up to six characters are entered any place in the 8-column fields.

The DF records are analogous to the *IN*, *EV*, *FA*, *RU*, *HI*, or *TS* records described in the *Users Manual*. The *SIM* and *SIMD* hydrology input file with the filename rootHYD.DSS may contain any number of *DF*, *IN*, *EV*, *FA*, *RU*, *HI*, or *TS* records of time series data. *DF*, *IN*, *EV*, *FA*, *RU*, *HI*, or *TS* records are included in the DAT file with lists of control point identifiers connecting to the records in the DSS file.

C2 Record – Control Point Output Records to be Included in SUB and DSS Files

field	columns	variable	format	value	description
1	1-2	CD	A2	C2	Record identifier
2	3-8		6x		Columns 3-8 are not read by the computer.
3-7	9-48	CPOUID2(J) J=1,12	12A8	AN	Identifiers of control points included in the SUB and DSS output files.

W2 Record – Water Right Output Records to be Included in SUB and DSS Files

field	columns	variable	Format	value	description
1	1-2	CD	A2	W2	Record identifier
2	3-8		6x		Columns 3 through 8 are not read by the computer.
3-7	9-88	WROUT2(J) J=1,12	12A16	AN	Identifiers of water rights included in the SUB and DSS output files.

G2 Record – Groups of Water Right Output Records to be Included in SUB and DSS Files

field	columns	variable	format	Value	description
1	1-2	CD	A2	G2	Record identifier
2	3-8		6x		Columns 3 through 8 are not read by the computer.
3-7	9-48	GROUP2(J) J=1,12	12A8	AN	Group identifiers for water rights included in SUB and DSS output files.

R2 Record – Reservoir/Hydropower Output Records to be Included in SUB and DSS Files

field	columns	variable	format	Value	description
1	1-2	CD	A2	R2	Record identifier
2	3-8	ALL	I6	−1	All reservoirs are included in the SUB output file.
3-7	9-48	REOUID2(J) J=1,12	12A8	AN	Reservoir identifiers for reservoir/hydropower projects included in SUB and DSS output files.

C3 Record – Control Point Output Records to be Included in AFF File

field	Columns	variable	Format	value	description
1	1-2	CD	A2	C3	Record identifier
2	3-8		6x	+	Columns 3 through 8 are not read.
3-7	9-48	CPOUID3(J) J=1,12	12A8	AN	Control point identifiers of control points included in the AFF File.

Any number of *C2*, *W2, G2*, and *R2* records are used along with *JT* record parameters CPOUT2 and OUTWR2 to select daily simulation results to include in the SUB and/or DSS output files. *C2, W2, G2,* and *R2* records specifying daily output data are analogous to the *WO, CO, GO,* and *RO* records that control monthly output data. The *C3* record controls which, if any, control points are included in an annual flood frequency AFF output file created with *JT* record parameter AFF.

The optional *C2, C3, W2, R2,* and *G2* records are placed in the DAT file any place in the group of daily and monthly/daily records located after the optional title (*T1, T2, T3*) records and before the use coefficient *UC* and control point *CP* records. All *C2* records are grouped together. All *C3* records are grouped together. All *R2* records are grouped as a set. Likewise, all *W2* are grouped together, and all *G2* records are grouped together. Any of the sets of records can precede or follow the others. Each of these records provides sets of identifiers used to select data to include in the simulation results output files.

Any number of control points, reservoirs, water rights, and water right groups may be listed on any number of *C2, C3, RO, WO,* and *GO* records with any number up to 12 of identifiers on each record. For example, any number of control point identifiers may be provided on any number of *CO* records, with any number up to 12 of identifiers on each record. For example, 53 control point identifiers could be listed on 11 *CO* records with five identifiers on each of ten records and three on the 11th record. Alternatively, the 53 control point identifiers could be listed on five *CO* records with 12 identifiers on any four of the *CO* records and five identifiers on the other *CO* record.

Control point and reservoir identifiers, which have up to six characters, can occupy any of the columns of the eight-column fields of the *CO* and *RO* records. Likewise, water right identifiers can occupy any of the columns of the eight-column fields of the *WO* and *GO* records.

Selection parameter DSS(3) in *OF* record field 3 the simulation results DSS file to include only monthly results (DSS(3) option 1), both monthly and daily results (option 2), or only daily results (option 3). For option 2, daily and monthly results are provided for the same control points, water rights, and reservoirs as controlled by the *JT, C2, W2, G2, R2,* and *C3* records, without using the corresponding monthly output selection records.

DW Record – Daily Data for a Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	DW	Record identifier
					Forecasting Limit in Availability Simulation
2	3-8	APERIOD(wr)	I6	blank,0	No limit on forecast period.
				+	Forecast period limit in daily time steps.
				−1	Default set by *JU* record field 8 is adopted.
				−9	Do not replace a previously set value of APERIOD
					WR/IF Record Daily Target
3	9-12	XDAY(wr)	I4	blank,0	Daily target XDAY feature is not activated.
				1	*WR*, *IF*, or *FF* record field 3 without *UC* record.
				2	Daily set using *WR/IF/FF* record and *UC* record.
				−9	Do not replace a previously set value of XDAY.
					Variation in Daily Targets During Month
4	13-16	ND(wr)	I4	blank,0	ND feature is not activated.
				+	Number of daily time steps.
				−1	Default set by *JU* record field 10 is adopted.
				−9	Do not replace a previously set value of ND.
5	17-20	SHORT(wr)	I4	blank,0	Shortages are not supplied in subsequent days.
				+	Shortages are supplied in subsequent days.
				−1	Default is set by *JT* record field 11.
				−9	Do not replace a previously set value of SHORT.
6	21-24	NDSBU(wr)	I4	blank,0	NDSBU feature is not activated.
				+	Number of daily time steps.
				−9	Do not replace a previously set value of NDSBU.
					Water Right Type for SC Record Consideration
7	25-28	SCTYPE	I4	blank,0,1	*WR* record type rights.
				2	*IF* record type rights.
				3	*FF* record type rights.
					Water Right Identifier
8	29-44	DWID	A16	AN	*WR* or *IF* record water right identifier.

Water rights may have *DW* and *DO* records placed in either the DAT file or DIF file or both or neither. The optional *DW* and *DO* records are included in the set of records that follow a water right *WR* or instream flow *IF* record in the DAT file and provide supporting information for a water right. The *DW* and *DO* records may be placed anyplace in the DAT file within the group of *SO*, *TO*, *TS*, *FS*, *WS*, *HP*, and *OR* records that follow a *WR* or *IF* record. *DW* and *DO* records can also be placed in the DIF file, where they can be paired with *SC* records. Selection criteria *SC* records following a *DW* or *DO* record in the DIF file define the characteristics of rights to which the *DW* or *DO* record applies.

DW or *DO* records in the DIF file over-write any parameters set by *DW* or *DO* records in the DAT file, except when the value of −9 is used for *DW* record fields 2 through 6 and *DO* record fields 2

through 7. Fields 7 and 8 of the *DW* record and fields 8 and 9 of the *DO* record are only read when the *DW* or *DO* records are read from the DIF file. The entry option −9 in fields 2 through 6 is applicable only for *DW* records placed in the DIF file. Similarly, the entry option −9 in fields 2 through 7 is applicable only for *DO* record placed in the DIF file.

Explanation of *DW* Record Fields

Field 2:   An optional maximum limit on the forecast period (F_P) used in determining water availability in days is entered in *DW* record field 2. A positive value in field 2 will limit the forecast period of the associated water rights to not exceed the value in field 2. Forecasting periods will be calculated based on longest travel time to the outlet and may be less than the value of field 2.

A default global forecast period in *JU* record field 9 applies to all water rights that have no *DW* record. The *JU* record default F_P is also adopted if a −1 is entered in *DW* field 2. For a *DW* record in the DIF file, a −9 prevents the *DW* record from replacing a F_P that has been set by another *DW* record in the DAT or DIF file or the *JU* record.

If the forecast period is set to zero and the simulation uses forecasting, the water right will not consider water availability information generated during the forecast simulation.

Field 3:   *XDAY*=1 sets the daily target equal to the amount in field 3 of the *WR*, *IF*, or *FF* record without applying *UC* record coefficients. *XDAY* of 2 sets daily targets equal to the value in *WR/IF/FF* record field 3 distributed using the 12 monthly *UC* record coefficients.   The implementation of the *XDAY* option is described in Chapter 2 of the *Daily Manual* under steps 1 and 14 of the target building process. *XDAY* can be used in combination with the *ND* and *SHORT* options as discussed below.

Fields 4 and 5:   With field 4 blank, the monthly diversion, hydropower, or instream flow target specified on the *WR* or *IF* record and *UC* records is uniformly distributed over each day of the month. The uniform distribution option is the default. The optional parameter *SHORT* in field 5 is applicable only in combination with a positive value of *ND* in field 4. The *ND* option with or without the *SHORT* option can be applied to diversion, hydropower, or instream flow targets. Global defaults for *ND* and *SHORT* are set by *JU* record fields 10 and 11 subject to being superseded for individual *WR* record water rights by *DW* record fields 4 and 5. The *ND* option is designed for applicability to multiple as well as individual water rights.

A positive *ND* activates an option in which the monthly target is uniformly distributed over the first *ND* days of the month. The daily target volume is the monthly target volume divided by *ND*. If the *SHORT* option is not activated with the *ND* option, targets are met only during the first *ND* days of the month, with shortages declared if the targets cannot be met each day. The *SHORT* option allows diversion and hydropower shortages during the first *ND* days to be supplied in subsequent days of the same month that follow after the first *ND* days.

A positive value of *XDAY* is used in conjunction with *ND* to establish a daily target. *XDAY* allows the target in field 3 of a *WR* or *IF* record to be used directly as the daily target without distribution from annual to monthly targets. The implementation of the *XDAY* option is described in Chapter

2 of the *Daily Manual* under steps 1 and 14 of the target building process. The *XDAY* daily target is established in the first *ND* days of the month if the *ND* option is activated. The *SHORT* option is applied the same as with the case for a positive value of *ND* and a zero value of *XDAY*. Remaining days at the end of the month are available for the *SHORT* option.

Field 6: Field 6 is only used for Type 2 *WR* record water rights and only when the *ND* and *SHORT* options have a positive value. *NDSBU* controls the number of days that reservoir storage will be used to meet shortages resulting from stream flow depletions that are less than the daily target. When *ND* and *SHORT* are activated with a positive value in fields 4 and 5, an attempt at recovering shortages in previous days is made in subsequent days. However, water rights with access to reservoir storage will not develop shortages if there is adequate storage supply. In order for a Type 2 *WR* record water right to develop shortages and for stream flow depletions to be used to a greater extent to meet those shortages, the access to reservoir storage as a back-up source of supply must be withheld. *NDSBU* should always be set equal to or greater than ND in *DW* record field 4 to ensure that the entire monthly target can access reservoir storage in the situations where no stream flow depletions are possible.

When *NDSBU* is blank or 0, reservoir storage is available to meet any shortage in any day of the month for a Type 2 *WR* record water right with an associated reservoir. Shortages will only develop if reservoir storage is insufficient to back up any shortage in meeting the daily target. If *NDSBU* is positive, and *ND* and *SHORT* are positive, then the Type 2 right will not seek reservoir storage to meet daily shortages until the final *NDSBU* days of the month. Whereas the *ND* option counts days from the beginning of the month, *NDSBU* counts the number of days until the end of the month.

Fields 7 and 8: *DW* record fields 7 or 8 are used if and only if the *DW* record is placed in the DIF file. Fields 7 and 8 are not read for *DW* records in the DAT file. Likewise, *SC* records are placed only in a DIF file. A *SC* record follows the *DW* record to which it refers.

Field 7: For *DW* records placed in the DIF file, *DW* record field 7 activates the *SC* record feature and specifies the type of water right to select from the set of all water rights in the DAT file. The water rights selected based on *DW* record field 7 and accompanying *SC* records are assigned the parameters on the *DW* record unless a −1 or −9 is entered in fields 2 through 6 for particular parameters.

Field 8: If a *DW* record is placed in the DIF file and there are no *SC* records following the *DW* record, then the water right identifier DWID entered in *DW* record field 8 is required to indicate to which water right the *DW* record parameters are to be assigned. Field 8 is not read for *DW* records in the DAT file.

DO Record – Daily Target and Supplemental Options

field	columns	variable	format	value	description
1	1-2	CD	A2	DO	Record identifier
					Target Building Options
2	3-8	DBU(wr)	I6	blank,0,1	DBU feature is not activated.
				15	Back-up is applied as step 15 (*Daily Manual* Chap 2).
				21	Back-up is applied as step 21 (*Daily Manual* Chap 2).
				−9	Do not replace a previously set value of DBU.
3	9-12	DTO(wr)	I4	blank,0,1	DTO feature is not activated.
				16, 17	*TO* record *TOTARGET* option applied as step 16 or 17.
				−9	Do not replace a previously set value of DTO.
4	13-16	DDI(wr)	I4	blank,0,1	DDI feature is not activated.
				18	*DI*/*IS*/*IP* record drought index is applied as step 18.
				−9	Do not replace a previously set value of DDI.
5	17-20	DFS(wr)	I4	blank,0,1	DFS feature is not activated.
				19	FS/CV record applied as steps 19 and 20.
				−9	Do not replace a previously set value of DFS.
					Supplemental Options
6	21-24	DTSH(wr)	I4	blank,0,23	Target and shortage written to the OUT and SUB output files are based on the last target built in steps described in Chapter 2 of the *Daily Manual*.
				1 - 12	Same as *SO* record option *ISHT*
				13	After applying *ND* to monthly target (step 13)
				14	After applying *XDAY* (step 14)
				15	After applying back-up (step 15)
				16	After applying *TOTARGET* (step 16)
				17	After applying *TOTARGET*=10 (step 17)
				18	After applying drought index (step 18)
				19	After applying options on *CV* or *FS* record (step 19)
				20	After applying options on *CV* or *FS* record (step 20)
				21	After applying back-up (step 21)
				22	After applying daily shortage recovery (step 22)
				−9	Do not replace a previously set value of DTSH
7	25-32	DAYDEP (wr)	F8.0	blank,0.0	No daily limit on stream flow depletions.
				+	Daily limit on stream flow depletions.
				−9.0	Do not replace a previously set value of DAYDEP
					Water Right Type for SC Record Consideration
8	33-36	SCTYPE	I4	blank,0,1	*WR* record type rights
				2	*IF* record type rights
				3	*FF* record type rights
					Water Right Identifier
9	37-52	DOID	A16	AN	*WR* or *IF* record water right identifier

An optional *DO* record follows its *DW* record. A *DO* record can also be used with a *WR* or *IF* record without a *DW* record. *DW* records and their associated *DO* records may be placed in either the DAT file or DIF file. *DW* and *DO* records are included in the set of records that follow a water right *WR* or instream flow *IF* record in the DAT file and provide supporting information for a water right.

Explanation of DO Record Fields

Fields 2 through 5: Options in *DO* record fields 2 through 5 control the computational sequence in the 22-step target building process described in Chapter 2 of the *Daily Manual*.

Field 2: Activation of option *DBU* will override any placement within the target building process of the back-up option that was previously set by the *BU* record. Placing back-up within the daily target building process will result in back-up targets being created which are equal to the current daily shortage of the water right identified by the *BU* or *SO* records.

Field 3: Activation of option *DTO* will move consideration of *TO* record *TOTARGET* options to steps 16 and 17 within the target building process. Negative values of *TOTARGET* will use the previous day's value of their respective target setting variable. If the *JU/DW* record option *ND* is activated, *TOTARGET* options in steps 16 and 17 will applied on the first *ND* days of the month.

Field 4: Activation of the *DDI* option will move consideration of the *DI/IS/IP* drought index to step 18 within the target building process. Any step placement setting identified by *DINDEX* on the *WR* or *IF* record will be overridden by the placement specified by the *DDI* option.

Field 5: Activation of the *DFS* option will move consideration of the *FS* and *CV* record options from step 8 or 9 to step 19 or 20 of the target building process described in Chapter 2 of the *Daily Manual*.

Field 6: The *DTSH* option is equivalent to the *ISHT* option on the *SO* record. Activation of the *DTSH* option will override any selection made on the *ISHT* option.

Field 7: The *DAYDEP* option is equivalent to the *MONDEP* and *ANNDEP* options on the *SO* record. *DAYDEP* can be used with *MONDEP*, *ANNDEP* or with *ML* records to limit the volume of stream flow depletions at the daily, monthly, seasonal or annual scale.

Fields 8 and 9: *DO* record fields 8 or 9 are used if and only if the *DO* record is placed in the DIF file. Fields 8 and 9 are not read for *DO* records in the DAT file. Likewise, *SC* records are placed only in a DIF file. A *SC* record follows the *DO* record to which it refers.

Field 8: For *DO* records placed in the DIF file, field 8 activates the *SC* record feature and specifies the type of water right to select from the set of all water rights in the DAT file. The water rights selected based on *DO* record field 8 and accompanying *SC* records are assigned the parameters on the *DO* record unless a −1 or −9 is entered in fields 2−7 for particular parameters.

Field 9: If a *DO* record is placed in the DIF file and there are no *SC* records following the *DO* record, then the water right identifier entered in field 9 is required to indicate to which water right the *DO* record parameters are to be assigned.

SC Record – Water Right Selection Criteria for Assignment of *DW* Record Parameters

field	columns	variable	format	value	Description
1	1-2	CD	A2	SC	Record identifier
					Selection Criteria
2	3-8	MASK	I6	blank,0,1	Water rights located at or above CPID in field 3.
				−1	Water rights not located at or upstream of CPID.
				2	Water rights located at or below CPID in field 3.
				−2	Water rights not located at or downstream of CPID
				3	Water rights with field 4 *UC* record identifier.
				−3	Rights with *UC* record ID not matching field 4.
				4	Water rights with annual demands greater than or equal to field 5 and less than or equal to field 6.
				−4	Water rights with annual demands less than or equal to field 5 or greater than or equal to field 6.
				5	Water rights with priority number greater than or equal to field 7 and less than or equal to field 8.
				−5	Water rights with priority number less than or equal to field 7 or greater than or equal to field 8.
				6	Type 1 *WR* record rights with: field 9 $\leq$ conservation storage capacity $\leq$ field 10
				−6	Type 1 *WR* record with conservation storage $\leq$ field 9 or $\geq$ field 10
3	11-16	LOCID	2x,A6	AN	CP record field 2 identifier
4	19-24	UCID	2x,A6	AN	UC record field 2 identifier
5	25-32	DM1	F8.0	+	Annual target demand, default = 0.0
6	33-40	DM2	F8.0	+	Annual target demand, default = 99999999.0
7	41-48	PR1	I8	+	Priority number, default = 0
8	49-56	PR2	I8	+	Priority number, default = 99999999
9	57-64	ST1	F8.0	+	Conservation storage capacity, default = 0.0
10	65-72	ST2	F8.0	+	Conservation storage capacity, default = 99999999.0
					Optional Message SMM File Information
11	76	SCM	I4	blank,0,1	Option to list identifiers is not activated.
				2	List of identifiers of water rights meeting criteria.

SC records are inserted after *DW* and *DO* records in the DIF file. *DW* record field 7 and DO record field 8 activate the *SC* record option and defines the type of water right to which the *SC* record criteria is applied. For a water right to be assigned the *DW* or *DO* record parameters, the water right must satisfy all of the *SC* record criteria. An unlimited number of *SC* records can be placed after each *DW* or *DO* record. The parameter values on the *DW* or *DO* record apply to all water rights that meet all of the criteria defined by the associated *SC* record. The water right identifiers of those rights meeting the criteria may be included in SMM file for information.

PF Record – High Pulse Flow Components of Environmental Flow Standards

field	columns	variable	format	value	description
1	1-2	CD	A2	PF	Record identifier
					Flow Variable for Defining Pulse Events
2	6	Flow Variable PFV	I4	blank, 0, 1	Regulated flow.
				−1	Regulated flow excluding reservoir releases.
				2	Naturalized flow.
					Hydrologic Condition for this PF Record
3	8	Hydrologic Condition	I2	+	Hydrologic condition defined by *HC* record.
				blank, 0	Applicable for all hydrologic conditions.
					Pulse Flow Event Initiation Criterion
4	9-16	Trigger	F8.0	+	Daily flow trigger in cubic feet per second (cfs).
					Pulse Flow Event Termination Criteria
5	17-24	Volume	F8.0	blank, 0.0	Criterion not used.
				+	Total flow volume of pulse event in acre-feet.
6	25-28	Duration	I4	blank, 0	Criterion not used.
				+	Duration of event in days, including initiation day.
					Pulse Flow Event Frequency Criterion
7	29-32	Frequency	I4	blank, 0	No limit on the number of events per tracking period.
				+	Number of pulse events per tracking period.
					Parameters Defining Tracking Period
8	41-36	Tracking Period	I4	blank, 0	Seasonal tracking is activated in field 9.
				+	Number of time steps not counting the current period.
9	37-40	Season Start	I4	blank, 0	Default is continuous cycle tracking.
				+	Beginning month (1, 2, 3, … , 12) for seasonal cycle.
10	41-44	Season End	I4	blank, 0	Default is 11 months after the beginning month.
				+	Ending month for seasonal cycle tracking.
11	45-48	Season Count	I4	blank,0, 1	Only one season is considered for meeting frequency.
				+	More than one season is considered.
12	52	Flow Option	I4	blank, 0, 1	Latest regulated flow used for pulse initiation. The end-of-period regulated flow used for event volume.
				2	Latest flow for pulse initiation and event volume.
					Target Setting Options
13	56	Target Limit	I4	blank,0,1	Targets are based only on the PFV selected in field 2.
				2	Targets are constrained to not exceed the PF field 4 trigger. Targets are less than or equal to the trigger.
14	60	Target Selection	I4	1	*PF* record targets replace the preceding target.
				blank, 0, 2	Largest of the *PF* versus preceding target is adopted.
				3	Smallest of the *PF* versus preceding target is adopted.
				4	*PF* record targets are added to the preceding target.
				5	*PF* record targets are not considered by *WR/IF* target.

PF Record – High Pulse Flow Components of Environmental Flow Standards (continued)

field	columns	variable	format	value	description
					Pulse Flow Table in Message SMM File
15	64	Table in SMM File	I4	blank, 0	Optional SMM file table is not created.
				1	Table of PF computations within water rights loop.
				2	Summary of counts of events initiated and terminated.
				3	Tables for both options 1 and 2 are included.
				4, 5	PF summary at the end of the water rights sequence.
				6	Tables of counts pulse event initiated and terminated.
					CP, PF, and WR Identifiers
16	65-72	PFCP	2x,A6	blank	Control point from *IF* record field 2 is default.
				AN	Control point identifier for pulse flow site.
17	73-88	PFID	A16	blank, AN	Optional auxiliary PF record identifier.
18	89-104	PFWR	A16	blank, AN	Water right identifier. Default from *IF* record.

HC, *ES*, *PF*, and *PO* records are designed for simulating SB3 environmental flow standards. *ES* and *HC* records are described in Chapter 3 (pages 74-78) of this manual. Computations controlled by *PF* and *PO* records are described in Chapter 6 of the *Daily Manual*. An example illustrating use of *HC*, *ES*, *PF*, and *PO* records in modeling SB3 environmental flow standards is presented in Chapter 8 of the *Daily Manual*. These records are designed for computing instream flow targets for *IF* record rights but can also be used to compute *WR* record targets. By default (blank *PF* record field 14), the final computed target for the day at the control point for the *IF* record water right is the maximum of (1) the target computed by the set of *PF* records and (2) the target computed based on the accompanying set of *ES* records and/or other target-setting records. However, other options for combining targets can be activated in *PF* record field 14.

Any number of *PF* records and accompanying *PO* records may be placed after an *IF* record along with an optional set of *ES* records and an optional *HC* record (and optionally other target-setting records). No more than one optional *PO* record follows the *PF* record. If a *PO* record is not provided, the default values for the *PO* record parameters are adopted.

A set of *PF* records for a control point represents combinations of seasons of the year and hydrologic conditions. For example, 12 *PF* records may represent four seasons and three hydrologic conditions (dry, average, wet). Each of the *PF* records represent one season and one hydrologic condition. The hydrologic conditions (*PF* record field 3) are defined by a *HC* record. Seasons (tracking periods) are defined in *PF* record fields 8-12.

Explanation of PF Record Fields

Field 2: Pulse flow events are defined based on the variable *PFV* selected in *PF* record field 2 at the control point specified in field 16. The default PFV and control point are the regulated flow at the control point in *IF* record field 2. Any of the *FS* record FSV options listed on page 103 can also be employed with the *PF* record. However, the three options listed above for *PF* record field 2 are relevant for the environmental flow standards that motivate the *PF* record pulse flow modeling capabilities.

Field 3: All hydrologic conditions referenced by *ES* or *PF* records are defined on the *HC* record (page 76). Hydrologic conditions 1, 2, 3, 4, 5, 6, 7, 8 or 9 connect to the ten HCL limits in *HC* record fields 17 through 26. Field 3 of both *PF* and *ES* records reference hydrologic conditions in the same way. An integer 1 through 9 is entered in field 3 to connect to a hydrologic condition. Pulse flows for each individual *PF* record are computed only when the specified hydrologic condition is in effect. Different *PF* records are input for the different possible hydrologic conditions. A *HC* record is required if and only if field 3 of a *PF* or *ES* record is not blank.

Field 4: A pulse flow event may be initiated when the daily value of the flow variable *PFV* selected in field 2 exceeds the trigger value in field 4. A pulse event is considered to be initiated and eligible to meet the field 7 frequency criterion on the day in which the value of *PFV* exceeds the trigger value in field 4 and no preceding pulse event is being tracked. The initiation of a new pulse event is also subject to any options selected by entries in *PO* record fields 2, 3, 4, 5, 14, and 15.

Fields 5 and 6: Upon initiation, the pulse event is tracked until one of the termination criteria is met. Fields 5 and 6 set the volume and duration criteria. If not yet terminated by other criteria, a pulse event terminates after the number of days in the event equals the duration criterion. A pulse event terminates when a total cumulative volume specified by field 6 of regulated flow (default) or other *PFV* selected in field 2 has passed through the control point. The total cumulative volume of the pulse event is measured as the summation of the daily *PFV*. Optional termination criteria are set with *PO* record fields 6, 7, 8, 9, 16 and 17.

One or both criteria may be activated by entering positive integers in fields 5 and/or 6, but at least one must be selected. If the total event volume criterion (field 5) is not used, the event duration criterion (field 6) must be a positive number of days. Conversely, if the event duration criterion (field 6) is not used, the total event volume criterion (field 5) must be a non-zero amount.

Field 7: Each pulse event that is initiated during the tracking period will set daily pulse targets. When the number of pulse events exceeds the frequency value of field 7, no further daily pulse targets will be set for the tracking period. However, pulse events will still be initiated, tracked, and terminated during the simulation when the number of target setting pulse events exceeds the frequency. These pulse events are referred to as excess pulse events. Excess pulse events do not set daily pulse targets. The excess pulse events from the previous tracking period may be counted towards meeting the frequency value only with the use of *PO* record field 11. Excess events per month can be output to the message SMM file with a non-zero entry in *PF* record field 15.

Fields 8, 9, and 10: Pulse events may be initiated and counted towards the field 7 frequency criterion on a continuous or seasonal basis. Continuous pulse event tracking is established with a number of time steps in field 8 and a blank or zero entered in field 9. Field 10 is ignored for continuous pulse event tracking. The field 8 window is the number of time steps prior to the current period in which the number of pulse flow events is considered for meeting the field 7 frequency. If the number of pulse flow events within the field 8 window is less than the field 7 frequency criterion, a new pulse event will set daily pulse targets. If the number of pulse events within the field 8 window is greater than or equal to the field 7 frequency, new pulse events are considered to be excess events and do not set daily pulse targets. Excess pulse events may be counted towards satisfying the field 7 frequency criterion according to *PO* record field 11.

Seasonal (or annual) pulse event tracking is engaged with field 9. The field 8 window is ignored for seasonal tracking. Seasonal tracking establishes a fixed number of months, up to a total of 12,

in which pulse events are counted towards the field 7 frequency. The recorded number of pulse events resets to zero when the field 9 start month is first encountered each year. Excess pulse events in the current seasonal period may be counted towards the field 7 frequency requirement in the next season according the field 12 option. The field 7 frequency requirement can be evaluated over multiple seasons according to the option selected in *PF* record field 12.

Field 11: By default, the recorded number of pulse events only from the current season, and optionally the excess pulse events from the previous season (field 12), are considered for meeting the field 7 frequency criterion. Field 12 optionally allows more than one season to be considered for meeting the frequency criterion. If more than one season are used, then excess pulse events are not registered in the current season until all qualifying pulse events from the current and previous number of seasons attains the field 7 frequency criterion.

Field 12: Field 12 is only applicable for tracking regulated flow (field 2 *PFV* = 1 or −1). The daily pulse target set by the *PF* record is based only on the regulated flow as observed at the priority of the *PF* record. If the default option is selected, the pulse event total volume is initially computed at the priority of the *PF* record but also updated at the end of the time step. If the regulated flow at the end of the time step is different than the regulated flow considered at the priority of the *PF* record, the total volume will be adjusted accordingly for the field 5 total volume termination criterion. Option 2 accumulates total pulse event volume according to the regulated flow at the priority of the right only. Total event volume is not adjusted at the end of the time step.

Field 13: Field 13 by default allows the daily pulse targets to exceed the field 2 daily flow variable PFV, which may exceed the trigger, subject to the cumulative daily pulse targets not exceeding the field 5 volume criterion. Option 2 limits the daily pulse targets to not exceed the value of the field 4 trigger criterion when the PFV amount is greater. With either option, the daily pulse target can be less than the field 4 trigger criterion when the PFV amount is less than trigger criterion.

Field 14: The target computed as specified by each *PF* record is combined with the target that has already been computed by *ES* records, preceding *PF* records, and/or other target setting records. With the default option 2, the computed target for the *IF* record water right each day is the maximum of (1) the target computed by the *PF* record and (2) the preceding target computed based on *ES* records and/or other target setting records. Other options can be specified in *PF* field 14.

Field 15: This option allows information from the *PF* record computations to be recorded in the daily message SMM file. Option 1 records intermediate daily results for initiated pulse flow events as each water right is simulated. Options 4 and 5 record results at the end of the water right loop for only days with initiated events or all days, respectively. Option 2 summarizes and option 6 provides complete tables of counts of pulse events initiated, excess events initiated if *PO* record field 11 equals 2, and events that are terminated before achieving the event volume criterion.

Field 16: PFCP is the control point identifier for the pulse flow requirements. With *PF* record field 16 left blank, the default is the control point in *IF* record field 2.

Field 17: The optional field 17 *PF* record identifier must be different than any other *IF*, *WR*, or *PF* record identifier. This labeling identifier is used in the SMM file table activated by field 15.

Field 18: This water right identifier is equivalent to FSWR(FS) in *FS* record field 17 (page 104) but is applicable only for *FSV* option 11 specified for *PFV* in *PF* record field 2. *PSV* or *FSV* options 7-10 cannot be used with *PF* records. The *WR* identifier may also be included in SMM file tables.

PO Record – Pulse Flow Supplemental Options

field	Columns	variable	format	value	description
1	1-2	CD	A2	PF	Record identifier
					Pulse Event Initiation Options
2	3-8	Previous Event	I6	blank,0,1	Pulse initiation allowed the day after the final daily target of the previous pulse event.
				2	Pulse initiation blocked until *PF* record field 6 duration number of days since the previous pulse start.
3	9-12	Delay	I4	blank,0	No additional days before pulse event initiation.
				+	Pulse initiation blocked until additional days since previous pulse termination.
4	13-16	Larger Events	I4	blank,0,1	Pulse initiation does not consider other pulse events at this control point.
				2	Pulse initiation blocked if another pulse at same control point is engaged with larger trigger criterion.
5	17-20	Previous Flow	I4	blank,0,1	Pulse initiation may occur regardless of the magnitude of the regulated flow in the previous day.
				2	Pulse initiation blocked unless regulated flow in the previous day is less than the *PF* record field 5 trigger.
					Pulse Event Termination Options
6	21-28	Lower Limit	F8.0	+	Lower flow threshold criterion.
				blank, 0.0	Lower threshold criterion is not used.
7	29-36	Upper Limit	F8.0	+	Upper flow threshold criterion.
				blank, 0.0	Upper threshold criterion is not used.
8	37-44	Change	F8.0	+	Fractional change in flow between 0.0 and 1.0.
9	45-48	Season Terminate	I4	blank,0,1	Initiated pulse events may continue beyond seasonal cycle until terminated by other criteria.
				2	Pulse events are terminated at end of seasonal cycle.
					Pulse Event Volume and Frequency Options
10	49-52	Volume Credit	I4	blank,0,1	Volume credit is not given for other pulse events at the same control point.
				2	Volume credit given for smaller pulses of same PFV.
				3	Volume credit given for smaller pulses of any PFV.
11	53-56	Excess Events	I4	blank,0,1	Frequency cannot be met by excess pulse events.
				2	Frequency can be met by excess pulse events.
12	57-60	Volume	I4	blank,0,1	Frequency criterion can be met by all pulse events.
				2	Frequency criterion cannot be met by events failing to meet the volume criterion.
					Other Initiation and Termination Options
13	69-84	PFWR2	A16	AN	*WR*, *IF*, or *PF* record identifier used for optional pulse event initiation feature.

PO Record – Pulse Flow Supplemental Options (continued)

field	Columns	variable	format	value	description
14	85-100	PFWR3	A16	AN	*WR*, *IF*, or *PF* record identifier used for optional pulse event initiation feature.
				Blank	Field 14 option not used.
15	101-116	PFWR4	A16	AN	*WR*, *IF*, or *PF* record identifier used for optional pulse event termination feature.
				Blank	Field 15 option not used.
16	117-132	PFWR5	A16	AN	*WR*, *IF*, or *PF* record identifier used for optional pulse event termination feature.
				Blank	Field 16 option not used.

An optional *PO* record but no more than one *PO* record may follow a *PF* record. If no *PO* record is provided for a *PF* records, all of the *PO* record defaults are employed as needed.

Explanation of PO Record Fields

Field 2: The default option is for pulse events to be eligible to initiate immediately after the last target set by the previous pulse event. Field 2 optionally allows a pulse event to initiate only after the *PF* record field 6 duration number of days has lapsed since the start of the previous pulse event.

If the *PF* record field 6 pulse event duration criterion is not used, then *PO* record field 2 must be set to the default option. *PO* record option 2 can only be used to control sequential pulse event initiations when the pulse events have a specified number of days of duration.

Fields 3, 4 and 13: The number of additional days before a pulse event can initiate is entered in field 3. The days of delay are counted after the option set by field 2. Delay days are also applied to larger pulses at the same control point as selected by *PO* record field 4, and any pulse selected by the use of a *PF* record identifier in *PO* record field 13. Delay days are not applied to when a pulse is selected in *PO* record field 14.

Field 4: Field 4 option 2 checks if a pulse event with a higher trigger magnitude is engaged. If larger pulse events at the same control point are engaged, new pulse events will be blocked from initiation until the larger event(s) have been terminated. *PF* records at the same control point and of the same priority number should be arranged in order of descending trigger magnitude to ensure larger pulses are evaluated prior to smaller pulses.

Field 5: Pulse event initiation can occur, by default, regardless of the value of regulated flow in the previous day. Option 2 blocks pulse event initiation unless the regulated flow in the previous time step is less than the trigger criterion set by *PF* record field 5.

Fields 6, 7, 8, 15 and 16: Additional termination criteria may optionally be set with fields 6, 7, 8, 15, and 16. If daily regulated flow is less than the lower threshold of field 6, the pulse event

terminates immediately. No daily pulse targets are established for the time step. If daily regulated flow during the pulse event is less than the regulated flow of the preceding time step and the daily regulated flow is below the field 7 upper threshold, the fractional decrease in flow is calculated. If the fractional decrease of regulated flow from the preceding to current time step is less than value of field 8, the pulse event will terminate immediately. Pulse events will terminate immediately if any target is set by the water right or *PF* record identified in field 15 in the current time step. Pulse events will terminate immediately if the water right or *PF* record identified in field 16 does not set a target or a target is set equal to zero.

Field 9: By default, a pulse event will continue to be tracked and to set daily pulse targets beyond the *PF* record field 11 end of season until one of the termination criteria are met. Option 2 terminates pulse events on the last day of the last month of the season.

Field 10: Pulse event volume is accumulated only while a pulse event is engaged. However, field 10 option 2 allows the event volume of a pulse a with smaller trigger magnitude in preceding days at the same control point to count towards the total event volume. A qualifying smaller pulse event is one that initiated prior to the current day and is still engaged during the current day when the larger pulse event is being initiated. Event volume of the smaller pulse as measured prior to the current day is used to initiate the event volume counter for the larger pulse.

Field 11: By default, excess pulse events do not count towards meeting the *PF* record field 8 frequency criterion. Field 11 option 2 allows the excess events to count towards meeting the frequency criterion even though no daily pulse targets are used to set final *PF* record targets during the excess events.

Field 12: By default, all pulse events that set daily targets or pulse events that are considered excess will be counted towards meeting the *PF* record field 8 frequency criterion. However, field 13 optionally allows only those events which have satisfied the *PF* record field 6 volume criterion to be counted towards meeting the frequency. The selection of the field 13 option does not affect the pulse event termination criteria. Field 12 option 2 can only be used when the *PF* record field 6 total event volume is set to a positive value. If the *PF* record field 6 total event volume criterion is set to zero, all pulse events are terminated according to criteria other than a total event volume.

Fields 13, 14, 15, and 16: Water right identifiers from *IF* record field 11 of other IF record water rights can be entered into *PO* record fields 13, 14, 15 or 16. The water right identifier or *PF* record identifier associated with this *PO* record cannot be entered in fields 13, 14, 15 and 16.

Fields 13 and 14: A new pulse event will not be initiated if a target is set by the water right or *PF* record selected by field 13. Field 14 is used to block initiation when the water right or *PF* record does not set a target or the target is set equal to zero.

Fields 15 and 16: A pulse event will be terminated if a target is set by the water right or *PF* record selected by field 15. Field 16 is used to terminate a pulse when the water right or *PF* record does not set a target or the target is set equal to zero.

FF Record – Flood Flow Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	FF	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	FFL	F8.0	+	Flood flow limit in cubic feet per second (cfs).
4	17-24	APERIOD(wr)	I8	blank,0 + −	Default forecast limit APRD set in JU record field 8. Maximum forecast period for this *FF* record in days. Forecasting not applied for flow capacity at this cp.
5	25-32	DINDEX(wr)	I8	blank,0 +	Default is to not apply flood (drought) index. Storage index to connect to *DI/IS/IP* records.
6	33-48	WRID(wr)	A16	AN	Water right identifier (optional)

Flood control reservoir operations are described in *Daily Manual* Chapter 5. Reservoir operations for *FR* record flood control are based on emptying flood control pools as expeditiously as possible without contributing to river flows exceeding flow limits specified on *FF* records. Any number of *FR* record reservoirs may operate for any number of *FF* records at downstream control points. *FR* and *FF* records are treated as types of water rights analogously to water right *WR* and instream flow *IF* records and placed in the DAT file with the *WR* and *IF* records. The same rules for organizing the DAT file are applicable to *FR*, *FF*, *WR*, and *IF* records.

Explanation of FF Record Fields

Field 2: The *FF* record flood flow limit is applied to regulated flows at this control point.

Field 3: The flood flow limit FFL represents an allowable or non-damaging flow level at this control point. Release and impoundment decisions for upstream reservoir flood pools with gated controls are based on maintaining regulated flows below this limit. The flow flood limit in *FF* record field 3 and the maximum reservoir release FCMAX in *FR* record field 7 are entered in units of cubic feet per second (cfs) unless the optional NCFS feature is activated in *JT* record field 14.

Field 4: A positive *APERIOD(wr)* in field 4 serves as an upper limit on the number of days in the forecasting periods used to determine the available channel capacity. A negative integer in field 5 indicates no forecasting, meaning only the current day regulated flow is used to compute the available channel capacity at this control point. The default for *APERIOD(wr)* is set in by APRD in JU record field 8.

Field 5: A flood control reservoir storage index on a *FR* record is the same as a drought index on a *WR* record and connects the flow limit to a *DI/IS/IP* record storage-percentage target table.

Field 6: The optional *FF* record water right identifier does not affect the simulation computations.

FR Record – Flood Control Reservoir Operations

field	columns	variable	format	value	description
1	1-2	CD	A2	FR	Record identifier
2	3-8	CP	A6	AN	Control point identifier for location of reservoir
3	9-16	FCSTORE	I8	+	Storage priority number
4	17-24	FCREL	I8	+	Release priority number
5	25-28	FFNUM	I4	+	Number of *FF* record limits, default is all *FF* records.
6	29-32	FCDEP	I4	blank,0,1	Downstream control point exclusion is not activated.
				2	Downstream control points are excluded in determining availability for making flood control depletions.
7	33-40	FCMAX	F8.0	+	Maximum limit on flood pool release rate in cfs.
				blank,0	Limit on flood pool releases is not activated.
					Storage Volumes
8	41-48	FCTOP	F8.0	+	Total storage capacity at top of flood control pool.
9	49-56	FCGATE	F8.0	+	Storage capacity activating *FV/FQ* record table.
10	57-64	FCBOTTOM	F8.0	+	Storage capacity at bottom of flood control pool.
					Multiple-Reservoir System Balancing Index
11	65-72	FCMUL	F8.0	+	Multiplier factor M, default = 1.0
12	73-80	FCADD	F8.0	+	Addition factor A, default = 0.0
					Water Right Identifiers
13	81-96	WRID(wr)	A16	AN	Water right identifier for storage right (optional)
14	97-112	WRID(wr)	A16	AN	Water right identifier for release right (optional)

The use of *FR* and *FF* records to model reservoir operations for flood control is described in *Daily Manual* Chapter 5. *FR* and *FF* records are treated as types of water rights analogously to water right *WR* and instream flow *IF* records and placed in the DAT file with the *WR* and *IF* records.

A single *WS* record must accompany each *FR* record to provide reservoir information. A single *WS* record may be provided for each *FR* record, or optionally a group of *FR* records may share a single *WS* record placed after the *FR* record group. *WS* record fields 3, 7, and 11 are relevant for conservation reservoirs but are ignored when a *WS* record follows a *FR* record. The default for *WS* record field 8 is to assume the flood control pool is empty at the beginning of the simulation.

FF records only result in establishing a daily target which serves as a regulated flow limit to be monitored by any number of upstream *FR* record flood control pools. Each *FR* record is only associated with a single *WS* record. Optional target building, supplemental, or priority circumvention records are not used with flood control *FR* records. Storage (drought) index *DI*, *IS*, and *IP* records may be used to vary *FF* record flow limits as a function of reservoir storage.

The primary source of output for analysis of flood control operations are the storages written to the DSS, OUT, and SUB output files for control points. The optional AFF file is also relevant for flood frequency and flood control analysis with *TABLES* Job 7 records. However, output for individual *FF* and *FR* records may be written to the DSS and/or SUB files. *FF* and *FR* record

output is not written to the OUT file. *JT* record field 4 option -6 writes output to the DSS or SUB file for all *FF* and *FR* records. *JT* record field 4 options 0 and 1 may be used in conjunction with a *W2* record to specify certain *FF* and *FR* records for output to the output files.

Explanation of FR Record Fields

Field 2: The reservoir is located at the control point with this identifier. *FR* record field 2 is equivalent to *WR* or *IF* record field 2.

Fields 3 and 4: Storage and release priorities control the order in which the water right simulation computations are sequenced. Low priority numbers are senior to larger numbers. The release priority must be junior to the storage priority.

Field 5: The default is for operation of the reservoir to be based on all *FF* record control points at and downstream of the reservoir. An integer in *FR* record field 6 limits the number of *FF* record control points considered. The control points nearest the reservoir are considered.

Field 6: The default is for the flood control pool to be filled with stream flow depletions using the standard computation of water availability which includes consideration of water at downstream control points. If the *FR* record field 7 option is activated (FCDEP=2), downstream control points are excluded from the water availability computation, and the flood control reservoir may deplete all stream flow at the control point of the reservoir.

Field 7: Release rates from the controlled flood control pool are constrained to not exceed this maximum limit. FCMAX in *FR* record field 7 is applied within *SIMD* in the same manner as the flow rate in *FF* record field 3 except FCMAX applies only to releases from the controlled flood control pool of this reservoir without considering forecasting. The flow flood limit FFL in *FF* record field 3 and the maximum reservoir release FCMAX in *FR* record field 7 are entered in units of cubic feet per second (cfs) unless the optional NCFS feature is activated in *JT* record field 14.

Field 8: The top of the flood control pool is the maximum cumulative storage volume to which inflows can be stored. If this level is exceeded, outflow equals inflow.

Field 9: A positive non-zero *FCGATE* entered in field 10 is required to activate routing with a storage-outflow table defined by *FV* and *FQ* records. The *FV/FQ* record storage-outflow relationship governs uncontrolled outflows if the storage rises above the level of *FCGATE*. Otherwise, *FR* and *FF* record release rules determine releases from controlled flood control storage. If *FCBOTTOM* is greater than zero and *FCGATE* is left blank, the entire flood control pool, defined as the capacity between *FCBOTTOM* and *FCTOP*, is assumed to be a controlled pool. If *FCBOTTOM* is zero and *FCGATE* is left blank, the entire pool is uncontrolled.

Field 10: Controlled flood control releases are not made if storage content falls below this level.

Fields 11 and 12: For purposes of flood control operations, multiple-reservoir systems are comprised of reservoirs that have the same priority number entered in fields 4 and/or 5 of their *FR* records. The rank index is used to sequence simulation of each reservoir of a multiple reservoir system.

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

The parameters M and A in *FR* record fields 12 and 13 are applied in multiple-reservoir release decisions for flood control pools in an analogous manner to applying the parameters M and A in *OR* record fields 5, 6, 7, and 8 in multiple-reservoir release decisions for conservation pools. However, whereas conservation pools may be subdivided into two zones, flood control pools are always treated as a single zone.

__Fields 13 and 14__: Flood control storage and release operations are assigned separate priority numbers in fields 3 and 4. As such, a single *FR* record is simulated as two separate water rights within *SIMD*. Fields 13 and 14 allow for assignment of independent identifiers for the storage and release rights associated with each *FR* record.

FV Record – Reservoir Storage Volume for Storage versus Outflow Table

field	columns	variable	format	value	description
1	1-2	CD	A2	FV	Record identifier
2	3-8	RES	A6	AN	Reservoir identifier
3	9-104	TARA(I) I=1,TL	12F8.0	+	Reservoir storage volumes corresponding to outflows in the corresponding fields of the *FQ* record.

FQ Record – Reservoir Outflow for Storage versus Outflow Table

field	columns	variable	format	value	description
1	1-2	CD	A2	FV	Record identifier
2	3-8	FCGATE	A6	blank FCGATE or fcgate	*FV/FQ* records used both above and below FCGATE. *FV/FQ* records are used only above FCGATE.
3	9-104	TARB(I) I=1,TL	12F8.0	+	Reservoir outflows in cubic feet per second (cfs) corresponding to reservoir storage volumes in acre-feet in the same fields of *FV* record.

Pairs of *FV* and *FQ* records are grouped together in the DAT file following the set of all *WR*, *IF*, *FR*, and *FF* records. A *FQ* record must follow each *FV* record. The set of all *FV* and *FQ* records is placed after the sets of all *FR* and *FF* records but before the set of all *SV* and *SA* records.

A pair of *FV* and *FQ* records must be supplied for reservoirs with uncontrolled surcharge storage established by a nonzero value for FCGATE in field 9 of a *FR* record that is less than FCTOP in field 8. Entering "FCGATE" or "fcgate" in *FQ* record field 2 limits application of the *FV/FQ* table to the uncontrolled pool above FCGATE. The uncontrolled pool of a flood control reservoir has only one set of operations logic as defined by one *FV/FQ* table. With *FQ* record field 4 blank, the *FV/FQ* table also models the outlet capacity for the controlled pool below FCGATE.

The *FQ* record flows are in cubic feet per second (cfs) unless the optional NCFS feature is activated in *JT* record field 14.

Sequential Order of Records in the DIF File

The types of *SIMD* input records contained in the DIF File are listed in the Table 4.1. *RT* and *DC* records are placed only in the DIF file. Although storing *DF* records in the DSS file is recommended, placing *DF* records in the DIF file is also an option. *DW* and *DO* records can be placed in either the DAT or DIF files. *SC* records may accompany *DW* and *DO* records in the DIF file, but not the DAT file. All *DW*, *DO*, and *SC* records are grouped together as a set in the DIF file. All *RT* records are grouped together as a set. All *DC* records are grouped together. The set of all *DW/DO/SC* records, set of all *RT* records, and set of all *DC* records can be placed in order before the *DF* records. The complete set of all *DF* records are grouped together as the last set of records in the DIF file. The DIF file ends with an *ED* record after the *DF* records.

RT Record – Routing Information for a Control Point

field	columns	variable	format	value	description
1	1-2	CD	A2	RT	Record identifier
2	3-8	RTID(cp)	A6	AN	Control point identifier corresponding to *CP* record.
					Routing Parameters for Normal Flows
3	9-12	RTPYE(cp,1)	I4	blank,0 1 2	Routing is not performed at this control point. Lag and attenuation method is applied. Muskingum method is applied.
4	13-20	RPARAMS	F8.0	+	Lag or Muskingum *K* for control point.
5	21-28	RPARAMS (cp,1&2)	F8.0	+	Attenuation or Muskingum *X* for control point.
					Routing Parameters for Flood Flows
6	29-32	RTPYE(cp,2)	I4	blank,0 1 2	Routing is not performed at this control point. Lag and attenuation method is applied. Muskingum method is applied.
7	33-40	RPARAMS (cp,3)	F8.0	blank,0 +	Parameter in field 4 is also applicable to flood flows. Lag or Muskingum *K* for the stream reach below CP.
8	41-48	RPARAMS (cp,4)	F8.0	blank,0 +	Parameter in field 5 is also applicable to flood flows. Attenuation or Muskingum *X* for the stream reach.
					Routing Factor Array (RFA) Limit
9	49-56	RFALIM (cp,1)	F8.0	blank,0 +	Limit on normal flow RFA coefficients. Parameter value entered between 0.0 and 1.0. Default 0.10.
10	57-64	RFALIM (cp,2)	F8.0	blank,0 +	Limit on flood flow RFA coefficients. Parameter value entered between 0.0 and 1.0. Default 0.20.

RT record fields 3, 4, and 5 are applicable to routing of all flow adjustments (flow changes) except those associated with *FR* record reservoir operations for flood control. *RT* record fields 6, 7, and 8 are applicable to routing flow adjustments associated with flood control operations defined by *FR* records. Lag-attenuation is the recommended standard routing method for both.

Explanation of RT Record Fields

Field 2: The data provided on the *RT* record is for the control point with the identifier in field 2. The routing computations are for the river reach below this control point.

Field 3: The default is no routing at this control point. The lag-attenuation routing method or the Muskingum routing method can be activated. The parameters for either method are entered in fields 4 and 5. Lag-attenuation is the recommended standard routing method.

Fields 4 and 5: Routing parameters are for the reach downstream of control point RTID. Only non-flood control related changes to flow are routed downstream with these parameters. Non-flood control related changes to flow are associated with streamflow depletions, reservoir releases, or return flows generated by *WR* record water rights. The lag time parameter for the lag-attenuation method or the parameter K for the Muskingum method is entered in field 4. The corresponding attenuation time or Muskingum X is entered in field 5.

Fields 6, 7, and 8: Routing specifications for *FR* record flood releases and streamflow depletions for filling of flood control pools are entered in fields 6, 7, and 8. Fields 6, 7, and 8 are the flood flow counterparts to the normal flow routing specifications of fields 3, 4, and 5.

The routing parameters from fields 4 and 5 can be also applied to routing of flood control changes to flow by selecting either the lag and attenuation or Muskingum routing method in field 6 but leaving fields 7 and 8 blank.

Fields 9 and 10: Routing parameters entered on *RT* records are used to create an array of numbers cumulatively less than or equal to 1.0 known as a routing factor array, RFA. The values within the RFA are used to distribute upstream flow changes to a control point in each day. The RFA is also used for reverse routing future values of downstream CPFLOW during the forecast simulation for determining present day water availability. The values within the RFA are expressed as a fraction of the total flow change at the control point. Computation of the RFA is discussed in Chapter 3 of the *Daily Manual*.

Creation of RFA values may result in extremely small quantities being distributed at the leading and trailing edges of the routed flow change. RFALIM is used to eliminate small quantities from the leading and trailing edges of the routing. The RFA values at a control point are accumulated. Days where the cumulative RFA value is less than RFALIM on the leading edge are changed to zero. Days where the cumulative RFA value is greater than 1.0 minus RFALIM on the trailing edge are set to zero. The RFA values that remain after zeroing any leading and trailing edge days are adjusted proportionally so that the remaining RFA values cumulatively equal 1.0.

Field 9 is applicable to adjusting the RFA for normal flow routing. Field 10 is applicable to adjusting the RFA for flood control routing.

RFALIM is only applicable to the stream reach below the control point identified as RTID in field 2. For realistic values in the RFA, parameters for RFALIM should not increase in downstream reaches. Increasing RFALIM in downstream reaches effectively represents decreasing attenuation as flow changes are propagated downstream.

DC Record – Disaggregation of Monthly Naturalized Flows to Daily

field	columns	variable	format	value	description
1	1-2	CD	A2	DC	Record identifier
2	3-8	DCID(cp)	A6	AN	Control point identifier that matches a *CP* record.
3	9-12	REPEAT	I4	0,blank,1	*DC* record is applicable only to this control point.
				2	Also applicable to upstream control points.
					Flow Disaggregation Method
4	15-16	DFMETHOD	I4	blank,0	Default is specified in *JU* record field 2.
		(cp)		1	Uniform distribution option.
				2	Linear interpolation option.
				3	Variability adjustment option.
				4	Flow pattern option.
				5	Drainage area ratio transfer option.
				6	Regression equation transfer option.
				8	No disaggregation. *IN* records in volume/day units.
				9	No disaggregation. Daily flows input on *DF* records.
					Source of Daily Flow Hydrograph
5	17-24	DFID(cp)	2x,A6	DSS	Daily flows read from DSS file for DCID in field 2.
				AN	Control point from which daily flows are obtained.
					Time Period Covered by DF Records in DIF File
6	25-32	BEGYR	I8	+	Beginning year of the pattern. Default = YRST
7	33-40	BEGMT	I8	+	Beginning month of the pattern. Default = 1
8	41-48	ENDYR	I8	+	Ending year of the pattern. Default=YRST+NYRS-1
9	49-56	ENDMT	I8	+	Ending month of the pattern. Default = 12
					Flow Lag Option
10	57-64	LAG	I8	+,−	Phase shift in units of time steps. Default = 0
					Coefficients for DFMETHOD Options 5 and 6
11	65-72	X	F8.0	+	Exponent for options 5 and 6. Default = 1.0
12	73-80	M	F8.0	+	Multiplication coefficient for option 6. Default = 1.0
13	81-88	A	F8.0	+	Addition coefficient for option 6. Default = 0.0

Explanation of DC Record Fields

Fields 2 and 3: The data provided on the *DC* record is for the control point with the identifier in field 2. With a 2 entered in field 3 for REPEAT, the data provided on this *DC* record is provided for all upstream control points until another control point with a *DC* record is reached. With the REPEAT option activated, each *DC* record read from the DIF file will overwrite the parameter assignment of previously read *DC* records where there is an overlap in upstream control points.

Field 4: With DFMETHOD(cp) options 8 and 9, there are no monthly flows to disaggregate. The inputted daily flows are the naturalized flows. Alternatively, monthly flows may be disaggregated to daily using the alternative optional methods outlined in Table 3.2 of the *Daily Manual* and selected in *DC* record field 4. If *DC* record field 3 is blank, the default DFMETH option defined in *JU* record field 2 is adopted. The default DFMETH, if not otherwise specified in *JU* record field 2, defaults to DFMETHOD(cp) option 4.

Field 5: Disaggregation methods 4, 5, 6, and 9 require daily flows provided as input on *DF* records stored in either the DSS or DIF file. DFID(cp) in *DC* record field 5 defines the control point identifier of the *DF* record daily flows. DFID(cp) in field 5 defaults to DCID(cp) in field 2.

DC records are not required for all of the control points that have *DF* records. DFID(cp) is the source of *DF* record daily flows. With the REPEAT option activated in *DC* record field 2, for other upstream control points with assigned disaggregation methods 4, 5, 6, or 9 but no *DC* record, the daily flow source control point DFID(cp) is automatically assigned as follows.

1. The control point DFID(cp) source of the daily flows is assigned as the first downstream control point where daily flows are provided in the input data, if such a site exists.
2. Otherwise, DFID(cp) is assigned an upstream control point where daily flows are provided in the input. If there are multiple upstream control points with inputted flows, the upstream location with the smallest number of intervening control points is selected.
3. Otherwise, only if necessary, DFID(cp) is assigned the control point where daily flows are input that shares a common downstream confluence with the control point being assigned to DFID(cp). If there are multiple confluent daily flow sites, the control points with the fewest number of intervening control points is selected.

Fields 6-9: Fields 6-9 are applicable only if daily flows are input on *DF* records in the DIF file rather than in a DSS file. Flows read from a DSS file must cover the entire hydrologic period-of-analysis. *DC* record fields 6-9 define the periods covered by flow sequences on *DF* records stored in the DIF file. Periods of missing daily flows are automatically filled in by repeating the available flows, with the exception that the *DF* records are always expected to cover the entire hydrologic period-of-record for DFMETHOD option 9.

Field 10: *LAG* in field 5 is used to shift the daily flow time series forward or backward in time. *LAG* greater than zero is used for transferring a pattern to a downstream destination from an upstream source. The time series at the upstream source is shifted forward in time, with the value at time step *T* at the source becomes the value at time step *T+LAG* at the destination. Likewise, *LAG* less than zero is used for transferring a downstream source pattern to an upstream destination by shifting the pattern earlier in time. The pattern is first checked for the need to repeat. Then during shifting, the values at the trailing end of the shift in the array are set equal to the last value of the trailing end. Values at the leading end of the shift in the array are lost.

Fields 11-13: As explained in *Daily Manual* Chapter 2, the flow adjustment methods of disaggregation options 5 and 6 activated in field 4 are based on transferring a pattern hydrograph from a source control point to a destination control point using one of the following equations (*Daily Manual* Eqs. 2.6 and 2.7) with parameter values provided in fields 11, 12, and 13.

$$P_{destination} = \left[P_{Source} \left(\frac{Area_{destination}}{Area_{source}} \right) \right]^X$$

$$P_{destination} = A + M \left(P_{source} \right)^X$$

DF Record – DIF File Version of Daily Flow Record

First *DF* Record for a Particular Month and Control Point

field	columns	variable	format	value	description
1	1-2	CD	A2	DF	Record identifier
2	3-10	DFID	2x,A6	AN	Control point identifier of the location for the flow pattern. *DFID* is entered on the first *DF* record only.
3	11-20	YEAR	2x,I8	+	Year for the *DFLOW* values.
4	21-30	MONTH	2x,I8	+	Month for the *DFLOW* values.
5	31-40	NUM	2x,I8	blank,0	By default, *NUM* is set to 4 to accommodate the default calendar day daily simulation.
				+	Number of *DFLOW* data records to follow. *NUM* is an integer between 1 and 4.

Second, Third, Fourth, and Fifth *DF* Records for a Particular Month and Control Point

field	columns	variable	format	value	description
1-8	1-80	DFLOW(J) J=1,8	8F10.0	+	Flow or flow pattern for daily time steps. Up to 8 flow values are entered on each record.

Daily flows are input in the hydrology DSS file by default but optionally can be input on *DF* records in the DIF file. *DF* records are placed in the DIF file after the complete set of *DC* records. The DIF file ends with an *ED* record after the complete set of *DF* records. Unlike other *SIM* and *SIMD* input records, the *DF* records are organized with field widths of 10 characters.

A set of up to five *DF* records is required to enter flows for one month at one control point. The parameter NUM in field 5 of the first *DF* record is the number of additional records required to contain the flows for each sub-monthly interval given that 8 flows can be entered on each record. With a daily time step, five *DF* records are required for each month at each control point. The first record provides the control point identifier and the year and month. The second, third, and fourth records contain flows for the first eight days, days 9 through 16, and days 17 through 24. The fifth record contains the flows for the remaining days of that month.

An example of a set of *DF* records with 31 daily flows for the month of December 1974 is as follows.

```
DF     CP-1        1974          12             4
       236.0      238.0      237.0      228.0      212.0      208.0      777.0      943.0
       421.0      286.0      958.0      734.0      459.0      316.0      265.0      244.0
       217.0      191.0      176.0      241.0      393.0      375.0      456.0      465.0
      1096.0     1618.0     1713.0     1647.0     1241.0      837.0      880.0
```

Daily Stream Flows in a DSS or DIF File

Daily flow sequences input on *DF* records can be either actual daily naturalized flow volumes or amounts used to define a pattern for monthly-to-daily flow disaggregation. With DFMETHOD(cp) options 8 and 9, daily flow volumes are adopted directly without naturalized flow disaggregation.

DF record flows serve as daily flow pattern hydrographs for the default option 4 disaggregation methodology activated by *JU* record DFMETH or *DC* record DFMETHOD(cp). Acre-feet/day, cubic feet per second (cfs) or any other units may be used since only the relative magnitude of the pattern flows affects the disaggregation computations. However, adopting actual computed daily naturalized flow volumes in acre-feet as the *DF* record daily flow volumes is convenient for visualizing the flows.

Option switch parameter DFFILE in *JU* record field 3 specifies whether *DF* records of daily flows are read from the DSS file or DIF file. The only option for inputting daily flows in early versions of *SIMD* was *DF* records in the DIF file. However, the newer DSS file option is more convenient and now is the default. All daily flow input must be stored in the either the DSS file or the DIF file; the flows cannot be split between the two files.

The DFMETHOD(cp) disaggregation methods function the same regardless of whether the daily flow pattern hydrographs are input in a DSS file or a DIF file. The *SIMD* automated algorithm for assigning daily flows input for a particular control point to any number of other control points is also the same regardless of whether the daily flow pattern hydrographs are input in a DSS file or a DIF file. Some of the other *DC* record parameters are also employed the same. The two alternative daily flow input strategies (DFFILE options 1 and 2 based on DSS versus DIF files) differ as follows.

- With daily flows read from a DSS file, the DAT file contains *DF* records listing control point identifiers for each and every control point for which daily flows are read from the DSS file as discussed on page 146. With daily flows read from the DIF file, listing all of the control points that have *DF* record daily flows is not required.

- Daily flows in the DIF file may optionally cover only the portion of the hydrologic period-of-analysis specified on *DC* records. Flows are automatically synthesized within *SIMD* for the sub-periods of missing flows by repetition of the DIF file flows. Daily flows in the DSS file must cover the entire hydrologic period-of-analysis. Time series data in the DSS file can be conveniently manipulated within *HEC-DSSVue*.

Old datasets with *DF* records in the DIF file can be easily updated to the new format of DSS records in the hydrology DSS file. DFFILE (*JU* record field 3) option 3 consists of converting a set of *DF* records read from a DIF file to a DSS file. Option 3 only converts the format of the daily flows; the simulation is not performed. However, the daily flows read from the DIF file *DF* records may be adjusted and extended within *SIMD* based on optional parameters entered on *DC* records. DFFILE option 3 consists of recording the final adjusted flows for the entire hydrologic period-of analysis in the hydrology DSS file.

DF Record Daily Stream Flows in the Hydrology Input DSS File

Application of the WRAP programs with DSS and *HEC-DSSVue* is described in Chapter 6 of this manual. *SIM and SIMD* read a single DSS hydrology input file, with filename rootHYD.DSS. Daily flow *DF* records are read by *SIMD* only, not *SIM*. SIM skips over records used only in a SIMD daily simulation. *IN*, *EV*, *FA*, *HI*, *RU*, and *TS* records are read and employed by both *SIM* and *SIMD*. All relevant time series input data are stored in the same DSS input file as outlined on page 122 of Chapter 3.

The default (blank field) DFFILE option 1 selected in *JU* record field 3 specifies that daily flows are read from *DF* records in the hydrology input DSS file. An identifier *DF* record described on page 146 is placed in the DAT anyplace after the *JD*, *JO*, *JT*, and *JU* records but before the *UC* records. The *DF* record in the DAT file lists control point identifiers of the *DF* records (DSS pathname part B) to be read in the DDS file.

The DSS file records have pathname parts /A/B/C/D/E/F/ defined in Table 6.6 of Chapter 6. The pathname parts of the *DF* records in the DSS input file are as follows.

A – Hydrology filename root without the appended HYD. This is the hydrology filename root entered at the initiation of the *SIM* or *SIMD* execution or optionally DSS filename root provided in *OF* record field 13.

B – Control point identifier that matches a control point identifier CPID(cp,1) found on a DAT file *CP* record.

C – Record identifier DF for daily flow.

D – Range of DSS record blocks that contain the data series.

E – 1DAY for daily data.

F – Part F is not used for the hydrology input file and is left empty.

CHAPTER 5
PROGRAM TABLES

The WRAP program *TABLES* reads *SIM*, *SIMD*, and *SALT* input and output files, performs various computations, and develops an assortment of tabulations, which are written to an output file. *TABLES* provides flexible post-simulation capabilities for computing reliability and frequency metrics 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 DSS records in a DSS file 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 manipulated, summarized, and displayed with *TABLES*.

This chapter covers the application of *TABLES* with *SIM* and *SIMD* input data and simulation results. All *SIM/SIMD*-related *TABLES* routines are covered here. 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 5.1 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 and DSS files. 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/SIMD* input and/or output files. Most applications involve *TABLES* reading simulation results from a *SIM* OUT, *SIMD* SUB file, or *SIM/SIMD* DSS file, but various *TABLES* options involve reading data from other *SIM* or *SIMD* 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 5.1
TABLES Input and Output File Types

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<u>*TABLES* Input Files</u>

TIN	required ***T****ABLES **in*put file with specifications regarding tables to be developed
DAT	*SIM/SIMD* input file
OUT	*SIM/SIMD* output file of monthly simulation results time series
SUB	*SIMD* output file of daily simulation results time series
HRR	*SIM/SIMD* output file of hydropower and reservoir releases
ZZZ	*SIM/SIMD* output file of flows in water rights priority sequence
DIS	*SIM/SIMD* flow distribution input file
CRM	*SIM/SIMD* conditional reliability modeling output file
SFF	storage-flow-frequency file created by *5CR1* record and read by *5CR2* record
AFF	*SIMD* annual flood frequency analysis file with annual peak daily flows and storage
SAL	*SALT* output file of salinity simulation results file described in *Salinity Manual*
DSS	Data storage system file created with any program

<u>*TABLES* Output Files</u>

TOU	*TABLES* main output file (optional filename extension with default TOU)
TMS	*TABLES* message file
DSS	Data storage system file created by *TABLES* (OUT added to root of DSS output file)

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Input Records and Associated Tables

The types of *TABLES* input records are listed in Table 5.2 with the four-character identifiers that are placed at the beginning of each record. Examples in the *Reference*, *Fundamentals*, and *Daily Manuals* 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 5.2
Input Records and Associated Tables
_____

<u>Miscellaneous Records</u>

TITL   – titles or headings   UNIT – units for table headings
COMM or **** or ** – comments   ENDF – end of input data file
PAGE – title page   DATA – dataset transformation
TEST – checks of *SIM* output file   IDEN – identifiers
FILE   – DSS file parameters   DSSM and DSSD DSS file data

<u>Type 1 Records − Tables Developed from *SIM* Input DAT File</u>

1REC – listing of specified input records
1RCT – counts of the 63 types of *SIM* input records and additional 17 *SIMD* input records
1SRT – listing of water rights sorted by priority, type of use, control point, or water right type
1SUM – water rights summary by control point, type of use, type of right, or group
1RES – listing of WS record input data describing reservoirs
1CPT – listing of control point information in upstream-to-downstream order

<u>Type 2 Records − Tables Developed from *SIM* Output OUT File</u>

<u>Time Series Tables in Optional Formats or HEC-DSS File</u>

IDEN – control point, water right, reservoir, and water right group identifiers
2NAT – naturalized stream flow
2REG – regulated stream flow
2UNA – unappropriated stream flow
2CLO, 2CLC – channel loss (CLO) and channel loss credits (CLC)
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 *PX* record cp limit option
2ASF – available stream flow
2TIF, 2IFT – instream flow target before (2TIF) and after (2IFT) combining with junior target at cp
2IFS, 2IFF – instream flow shortage and the portion of target supplied (2IFF = 2IFT – 2IFS)
2FSV, 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

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Table 5.2 (Continued)
Input Records and Associated Tables

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2RIR – inflows to reservoir from releases from other reservoirs
2RAH and 2RNA – releases accessible and 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
5CR2 – develop incremental probability array
5COR – correlation analysis

Type 6 Records − Tables Developed from *SIMD* Daily Output SUB file

Daily time series tables in TOU file or DSS records in DSS file
6REL – reliability summary by control point, water right, water right group, or reservoir
6FRE – frequency table for stream flow, storage, or instream flow shortage

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Table 5.2 (Continued)
Input Records and Associated Tables

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<u>Type 7 Record− Probability Analyses of Annual Data series from DSS or AFF Files</u>

7DSS – statistical frequency analyses of annual series from a DSS file
7FFA – flood frequency analysis of annual peak storage and stream flow from AFF file
7VOL and 7DAM – economic analysis supplement to 7FFA flood frequency analysis

<u>Type 8 − Salinity Simulation Results from *SALT* SAL File (Salinity Manual)</u>

8SAL – time series tables of *SALT* results
8FRE – frequency tables for salinity loads and concentrations
8REL – diversion reliability summary considering salinity constraints

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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. Almost 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 in the TOU file. Zero to five TITL records are placed at the beginning of the TIN file. The PAGE record creates a title page at the beginning of the TOU file.

COMM or **** 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 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*.

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 FILE record provides optional information for DSS files and also indicates that the *SIM* OUT or CRM output file is in binary machine language specified by *JD* record field 7.

DSSM and DSSD records read monthly and daily data from a DSS file that may be input for time series, frequency, and reliability records or converted to *SIM/SIMD* input record format.

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 TEST record activates tests of the *SIM* output OUT file that are described in the *Reference Manual* Chapter 9 designed for use only in rare instances in which *TABLES* is not able to read an OUT file for unknown reasons.

Type 1 Record Tables Developed from *SIM* or *SIMD* Input DAT File

1REC, 1RCT, 1SRT, 1SUM, 1RES, 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 signifying that the source of data is a *SIM* input DAT file. All six type 1 records create tables from data read from the main *SIM* input DAT file. The 1CPT record includes options that read additional information from the *SIM* input DIS file.

Inclusion of a 1REC record in a *TABLES* input file results in a listing of specified *SIM* input records from a DAT file. A 1RCT record activates a routine that reads the DAT file and counts the number of records of each of the 80 possible different input record types found in the DAT file.

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. 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 1SUM table includes the number of rights, diversion amounts, number of reservoirs, storage capacity, and range of priorities.

The 1RES record routine tabulates information regarding reservoirs obtained by *TABLES* by reading the *WS* records and their associated *WR* or *IF* records from a *SIM* input DAT file.

The 1CPT record activates a set of routines that reord 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 with various sets of information from the *CP* records. Channel loss factors from the *CP* records and reach deliver factors and cumulative delivery factors computed from the channel loss factors may be tabulated. Watershed area read from *WP* records in the DIS file may also be included in the tabulations.

Type 2 Record Tables Developed from *SIM* Output OUT File

Type 2 records result in tables being developed from the time series of monthly simulation results contained in the water right, control point, and reservoir/hydropower records of a *SIM* OUT or DSS file as defined 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.

Type 2 records include 35 time series records, reliability analysis 2REL, frequency analysis 2FRE and 2FRQ, reservoir storage statistics 2RES, summary table 2SCP, 2SWR, 2SGP, 2SRE, and 2SBA, and volume budget 2BUD records as discussed in the following paragraphs.

Creation of Time Series Tables and/or DSS Records

The *SIM* simulation results described in *Reference Manual* Chapter 5 are tabulated as a set of time series tables by 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2RFR, 2URR, 2CPI, 2STO, 2EVA, 2DEP, 2DIV, 2TAR, 2SHT, 2RFL, 2XAV, 2ASF, 2ROR, 2TIF, 2IFT, 2IFS, 2IFF, 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: (1) tables with annual rows and monthly columns with headings shown in Table 5.3, (2) tabulations in a columnar format, or (3) records in a DSS file designed to be read by *HEC-DSSVue*

Table 5.3
Annual Rows with Monthly Columns Format Headings for Time Series Tables

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

Water Supply Diversion Reliability or Hydropower Reliability Tables

A 2REL reliability table may be developed for either selected water rights, water right groups, control points, or reservoir/hydropower projects. The table includes volume reliabilities and period reliabilities indicating the percentage of time that certain percentages of demand are met. The table headings are replicated as Table 5.4. Fixed percentages of target amounts are tabulated in the headings, and the computed exceedance frequencies are shown in each row of the table.

Table 5.4
Table Heading for Reliability Summary Specified by 2REL Record

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

Reliability metrics are discussed in Chapter 7 of the *Reference Manual.* 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 as the percentage of 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.

TABLES

Frequency Analysis Tables

Frequency analysis methods are described in of the *Reference Manual* Chapter 7 and *Daily Manual* Chapter 9. Examples of tables created with monthly 2REL, 2FREQ and 2FRQ and daily 6REL, 6FRE, and 6FRQ records are found in the *Reference*, *Fundamentals*, and *Daily Manuals*.

2FRE or 6FRE records compute the mean, standard deviation, and frequency relationships for naturalized, regulated, or unappropriated flows, reservoir storage or water surface elevation, instream flow targets or shortages for specified control points, water rights, or reservoirs, without DSSM, DSSD, or DATA records, and many other variables when combined with a DSSM, DSSD, or DATA record. Quantities are computed for each of the specified exceedance frequencies 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, storage, or other variable equals or exceeds the amounts shown in the table.

2FRE tables can be created in several alternative formats. The default option 1 table format has the headings shown in Table 5.5. The flow or storage amount is computed for each of the exceedance frequencies shown in Table 5.5. The other table format options tabulates the metrics in columns rather than rows and allow a greater number of frequencies. Options are also provided for mathematically manipulating the time series data prior to performing the frequency analysis.

Table 5.5
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											MAXIMUM
			100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	

The 2FRQ record also develops an exceedance frequency relationship for the same variables as the 2FRE record. The frequencies associated with up to seven user-specified flow, storage. or other variable amounts are computed based on relative frequency counts. The 2FRQ and 2FRE records differ as follows. The 2FRE record determines quantities for a pre-selected set of frequencies. Conversely, the 2FRQ record determines frequencies for quantities 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. Any number of 2FRQ records may be included in the input file.

Reservoir Storage Statistics

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 data contained on *SIM* control point, water right, or reservoir/hydropower output records. The headings for a monthly summary table created by a 2SWR record and annual summary table created by a 2SBA record are shown as Tables 5.6 and 5.7. Each row of data in the tables corresponds to either a month or a year of the period-of-analysis.

Table 5.6
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)

Table 5.7
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)

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 on their *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 5.7. 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 5.7.

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.

Type 3 Records for Developing Input Records from *SIM* Output OUT 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 *TABLES* DSSM record provides an option for compiling datasets of any variables read from DSS files in the format of standard text file *SIM* hydrology input records. *HEC-DSSVue* can be used to convert *SIM* or *SIMD* simulation results to DSS input records stored in a DSS file.

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 Record Tables Developed from 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 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.

Type 5 Record 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 8 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, 5CR1, 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 5CR1 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 5CR1 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 5CR1 records is to develop a flow-frequency (FF) or storage-flow-frequency (SFF) relationship from the results of a conventional long-term *SIM/SIMD* 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*.

Type 6 Record Tables Developed from *SIMD* Output SUB File

The type 6 time series records and 6REL, 6FRE, 6FRQ, and 6RES records are daily versions of the monthly type 2 time series, 2REL, 6FRE, 6FRQ, and 6RES records. The type 6 daily versions of these records have the same input parameters as the type 2 records and perform the same computational analyses. The type 6 records work with time series of daily quantities read from a *SIMD* SUB file rather than the corresponding monthly data read from a *SIM* or *SIMD* OUT file.

Type 7 Record Probability Analyses of Annual Data from DSS and AFF Files

Flood flow and storage frequency and damage analysis capabilities are covered in *Reference Manual* Chapter 7 and *Daily Manual Chapter* 9. These *TABLES* analyses activated by 7FFA, 7VOL, and 7DAM records employ data from a *SIMD* annual flood frequency AFF file. The 7FFA record controls a routine which applies the log-Pearson type III probability distribution to the annual series of maximum naturalized flow, regulated flow, or reservoir storage read from an AFF file created by *SIMD* to develop an annual frequency table. The *RANK* parameter in 7FFA record field 4 also creates a table assigning an exceedance frequency computed with the Weibull formula to each peak annual flow or storage volume.

The 7DSS record employs the log-Pearson type III or log-normal probability distributions and relative frequency and Weibull formulas for statistical frequency analyses of any annual time series variable read from any DSS file.

Format and Content of Input Records in TIN File

Program *TABLES* reads *SIM* or *SIMD* input and output files and builds a set of user-specified tables and data listings which are written to the *TABLES* output TOU output file. *TABLES* can also convert simulation results from *SIM/SIMD* OUT and SUB files to a DSS file.

A *TABLES* input file with the filename extension TIN is required containing the records described by this chapter which specify the tables to be built and the options to be employed. 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 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. Control point and reservoir identifiers may contain a maximum of six characters and are entered in 8-character fields (format A8). Water right group identifiers may contain a maximum of eight characters and are entered in 8-character fields (format A8). Water right identifiers may contain a maximum of 16 characters entered in 16-character fields (format A16).

Character variables input to Fortran programs are often right justified to prevent the trailing blanks from being read. However, the WRAP programs incorporate a feature that automatically deletes the trailing blanks when reading most of the 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. 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.

The recommended standard format for text input files for all of the WRAP programs is the fixed-width format presented throughout this manual. Essentially all WRAP applications to date have adopted the fixed-width for text input files. This discussion does not apply to DSS files, which are in a binary machine format rather than text file format. The input record descriptions in this manual are generally applicable to binary DSS files as well as to text files, but the fixed versus comma delineated options are not applicable for DSS records.

Format Column of Following Tables

The format for each variable on the TIN file input records is specified in the fourth column of the tables for each record type presented in the remainder of this chapter. The formats are defined below.

A4	Alphanumeric (AN) label (character variable) in a field that is 4 characters wide.
8A8	Up to 8 alphanumeric labels of up to 8 characters each in fields 8 characters wide.
2x	Two blank spaces.
2x,A6	Two blank spaces followed by alphanumeric label of up to six characters.
20(2x,A6)	Twenty 8-character fields consisting of 2 blank spaces followed by A6 variable.
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.
20F8.0	Twenty real numbers in fields of eight digits either with decimal or right justified.

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 ******** 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.

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 can be stored in the same TIN file after the ENDF record. The applicable set of records is moved to the beginning of the TIN file as needed.

TABLES

UNIT Record – Information for Table Headings

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

A *UNIT* record is applicable to all subsequent records in the *TABLES* input data set. Several table headings include volume and/or energy units. If a *UNIT* record is not used, the defaults are:

$$UNIT = \text{AC-FT}$$
$$UNHP = \text{MW-HR}$$

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

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

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

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 9. The OUT file must be in the default text format, not the optional unformatted binary version.

FILE Record – Data Storage System (DSS) Input and Output File Options

field	columns	variable	format	value	description
1	1-4	CD	A4	FILE	Record identifier
					DSS Message File Options
2	5-8	DSSMES	I4	−1	Messages are written only if *TABLES* is terminated due to some DSS related problem.
				1	Messages that DSS file has been opened or closed.
				blank, 2	Error or warning messages if DSS problems occur.
				3	Trace of all DSS records written to DSS files.
				4	Trace of all DSS records read from DSS files.
				7	Beginning level of debugging messages.
				8	Intermediate level of debugging messages.
				9	Maximum level of debugging messages.
					DSS Record Parameters
3	13-16	DSSUNIT	4x,A4	AN	Units for DSS data. Default = AC-FT
4	20-24	DSSTYPE	3x,A5	AN	Data type. Default = PER-CUM
					Label of First Month of DSS File Records
5	30-32	DSSMON	5x,A3	blank	Default is for first month to be January.
				AN	First month in DSS file (JAN, FEB, MAR, ... , DEC)
					Binary SIM OUT or CRM Output File
6	33-40	OUTFORM	I8	blank, 0	Default text file version of SIM OUT or CRM file.
				1	Binary machine language version of OUT or CRM file.

The defaults for each field of the TEST record are in effect if the optional TEST record is not used. Fields 1 through 5 of the TEST record provide parameters for DSS files which are defined by the *HEC-DSSVue Users Manual* and Chapter 6 of this WRAP *Users Manual*. FILE record field 6 signals the use of a binary *SIM* output OUT and CRM file instead of the standard text file format.

Explanation of FILE Record Fields

Field 2: The DSSMES options controlling the level of DSS trace and error messages written to the TMS file are equivalent to the DSS(6) options in *SIM OF* record field 7 described in Chapter 3.

Field 3: DSSUNIT assigning units is equivalent to DSSUNITS in *SIM OF* record field 10.

Field 4: DSSTYPE is the data type as used within DSS and defined in Chapter 6.

Field 5: The beginning month DSSMON is same as DSSMONTH in *SIM OF* record field 9.

Field 6: The formatted text versus unformatted binary form of the *SIM* OUT or CRM output file is controlled in *SIM* by parameter OUTFILE in *JD* record field 7. The FILE record is required as a flag that the OUT or CRM file is in binary machine language. If the *SIM* output file is in standard text format, switch parameter OUTFORM on the FILE record is not relevant. The binary format activated in *SIM* by OUTFILE on the *JD* record and activated in *TABLES* by OUTFORM in FILE record field 6 is essentially obsolete, having been replaced by the HEC-DSS data storage system.

DSSM Record – Monthly Data from DSS File
DSSD Record – Daily Data from DSS File

field	columns	variable	format	value	description
1	1-4	CD	A4	DSSM	Record identifier for reading monthly data.
				DSSD	Record identifier for reading daily data.
				Criterion for Selecting Multiple DSS Records	
2	8	MID	I4	blank, 0	Single DSS record with IDCP(1) on this record.
				1	IDCP(I) identifiers on IDEN records match Part B.
				2	IDEN16(I) identifiers on IDEN records match Part B
				3	IDEN16(I) identifiers on IDEN records match Part F
				4	IDRES(I) identifiers on IDEN records match Part F.
				5	Control points IDCP(I) in OUT file match Part B.
				6	Water rights IDEN16(I) in OUT file match Part F
				7	Reservoirs IDRES(I) in OUT file match Part F.
				Options to Compile Data in TOU File	
3	11-12	CDOR	2x,A2	A2	First two characters of monthly data output records.
4	16	ORO	I4	blank, 0	Output records option (ORO) is not employed.
				1	Monthly data written to TOU file grouped by years.
				2	Monthly data to TOU file grouped by control points.
				3	DSSD record daily data tabulated in the TOU file.
				Years Covered By Data Series	
5	17-20	YRBEG	I4	+	Beginning year.
				blank	Default is YRST from 5th row of OUT file.
6	21-24	NYEARS	I4	+	Number of years.
				blank	Default is NYRS from 5th row of OUT file.
				DSS Pathname Parts that Match DSS File Records	
7	25-40	PARTA	A16	AN	Pathname Part A.
8	41-56	PARTB	A16	AN	Pathname Part B if not replaced by MID 1, 2, or 5.
9	57-64	PARTC	A8	AN	Pathname Part C or RELIAB for reliability tables.
10	65-80	PARTF	A16	AN	Pathname Part F if not replaced by MID 3, 4, 6, or 7.

DSSM and DSSD records can be used with any DSS file, including but not limited to *SIM* or *SIMD* hydrology input files or simulation results output files. DSSM and DSSD records read monthly and daily data, respectively. A single DSSM or DSSD record specifies reading DSS records for any number of pathname Part B identifiers (typically control points) or Part F identifiers (usually water rights or reservoirs). The dataset is stored in computer memory as an array that can be accessed by type 2 (monthly) and type 6 (daily) time series records (pages 202-208, 236), 2FRE, 2FRQ, 2REL, 6FRE, 6FRQ, and 6REL records. Input parameters CDOR and ORO in fields 3 and 4 control an optional feature that compiles monthly data in standard text file hydrology input record format (such as *IN* or *EV* records) in the *TABLES* output TOU file or tabulates daily data in the TOU file with monthly rows of daily quantities.

DSSM and DSSD record capabilities and applications are discussed in Chapter 6 of this manual. The data array created by a DSSM or DSSD record is referenced by 2DSS or 6DSS in field 1 of the 35 time series records (page 205); FRE, 2FRQ, 6FRE, and 6FRQ record ID option 16; and 2REL

and 6REL ID option 5. A DSSM or DSSM record must precede referencing records in the TIN file. Any number of time series, frequency, and reliability records can access the same data array.

Neither left nor right justification is required for the identifiers entered in DSSM/DSSD record fields 7, 8, 9, and 10 for DSS pathname parts A, B, C, and F or the identifiers on IDEN records. DSS records are defined by pathname parts A, B, C, D, E, and F as explained in Chapter 6. Part D is the time period set by YRBEG and NYEARS in DSSM/DSSD fields 5 and 6 or read from an OUT file. Pathname Part E is 1MON and 1DAY for a DSSM and DSSD record, respectively. Parts A, B, C, and F are specified in DSSM or DSSD fields 7, 8, 9, and 10. Any number of DSS records can be read with a single DSSM or DSSD record with *TABLES* automatically changing pathname Part B or Part F identifiers as specified by multiple identifier MID options.

Identifiers IDCP(I), IDEN16(I), and IDRES(I) will normally be for control points, water rights, and reservoirs. However, any identifier of up to 16 characters can be specified in DSSM/DSSD fields 7, 8, and 10 or on IDEN records for PARTA, PARTB, and PARTF. Any identifier of up to 8 characters in length can be specified in DSSM/DSSD field 9 or on IDEN records for PARTC.

Explanation of DSSM and DSSD Record Fields

Field 2: The default MID option consists of reading a single DSS record with pathname parts defined in fields 7, 8, 9, and 10. MID options 1, 2, and 3 employ multiple identifiers for pathname Part B. MID options 1, 2, and 5 employ multiple identifiers for pathname Part B. MID options 3, 4, and 7 employ multiple identifiers for pathname Part F.

MID options 1, 2, 3, and 4 read identifiers for DSS pathname parts B or F from one or more IDEN records that follow immediately behind the DSSM or DSSD record in the TIN file.

MID options 5, 6, and 7 read identifiers for DSS pathname parts B or F from a *SIM/SIMD* output OUT file. *SIM/SIMD* input *OF* record field 2 DSS(1) option 2 creates an OUT file that contains only a list of the control points, water rights, and reservoirs selected for inclusion in output files and several parameters. MID options 5-7 and the fields 5 and 6 YRBEG and NYEARS defaults function the same with either the DSS(1) option 2 OUT file or a complete conventional OUT file.

Fields 3 and 4: *IN* and *EV* records or any other data can be converted from DSS to text file format. ORO options 1 and 2 compile a set of records in the TOU file with the DSS data converted to standard text file hydrology input record format. ORO options 1 and 2 correspond to *JO* record field 2 INEV record options 1 and 2. The first two characters are specified as CDOR in field 3. ORO option 3 converts the DSS data to a TOU file table with each row containing with 28, 29 (leap year February), 30, or 31 daily amounts.

Fields 5 and 6: By default (blank fields 5 and 6), the period-of-analysis is defined by NYRS and YRST read by *TABLES* from the *SIM* OUT file in either conventional or DSS(1) option 2 format. Optionally, the beginning year and number of years can be specified in DSSM/DSSD fields 5 and 6.

Fields 7, 8, 9, 10: Tables 6.4 and 6.5 of Chapter 6 define pathname parts for *SIM/SIMD* input and output files. DSS records are easily renamed in the *HEC-DSSVue* editor. The field 2 MID options are based on automatic reassigning multiple identifiers for pathname Parts B and F. Entering RELIAB in field 9 for PARTC activates an option used with 2REL and 6REL record reliability analysis ID option 5. Diversion and hydropower targets and shortages (TAR, SHT, HPE, HPS) labeled by pathname part C are read from *SIM/SIMD* simulation results for the reliability analyses.

Identifiers of Control Points, Reservoirs, Water Rights, and Water Right Groups

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

The following records share the same scheme for listing identifiers of control points (IDCP, ID=0), water rights (IDEN16, ID=1), reservoirs (IDRES, ID=2), or water right groups (IDEN8, ID=3) to include in the tables created by *TABLES*: time series, DATA, 2REL, 6REL, 2FRE, 6FRE, 2SCP, 2SWR, 2SRE, 2SGP, 4HRR, 4ZZF, and 4ZZZ records. The input parameter *NUM* partially controls the selection of which control points, reservoirs, water rights, or water right groups are included in the tables. 2REL, 6REL, 2FRE, and 6FRE records also have other input parameters that supplement *NUM* in controlling the selection process. Water right groups are handled similarly but a little differently for these different TIN file input records as described later in this chapter.

The default *NUM* of zero results in inclusion of all control points, water rights, or reservoirs contained in the *SIM* output OUT file. Alternatively, any number of control points, water rights, or reservoirs may be selected for inclusion in the tables created by *TABLES* by listing them on any number of IDEN records. Up to 12 identifiers may be listed on each IDEN record. Any number of identifiers may be entered as groups of IDEN records for either control points, water rights, or reservoirs. There is no limit on the number of identifiers with the exception of a maximum limit of 100 water right group identifiers. Up to eight identifiers may be listed directly on 2SCP, 2SWR, 2SGP, and 2SRE records as an alternative option to using IDEN records.

A −1 or any negative value for *NUM* specifies that identifiers from the last previously read IDEN records are to be repeated. The last control point, water right, reservoir, and group identifiers read during an execution of *TABLES* are stored in computer memory as IDCP, IDEN16, IDRES, and IDEN8 arrays until overwritten. Each of the four arrays contains the last set of identifiers of its type entered. For example, control point identifiers from a set of IDEN records accompanying a 2NAT or 2FRE record stored in the IDCP array are accessible until over-written by control point identifiers from another set of IDEN records accompanying a 2REG or some other input record. The repeat option activated by a negative *NUM* facilitates fewer IDEN records. The repeat option also allows the alternative placement of IDEN records at or near the beginning of the TIN file with ID specified by the extra IDEN record shown below.

IDEN Record – Specification of ID for IDEN Records (If ID is not specified by another record.)

field	columns	variable	format	value	description
1	1-4	CD	A4	IDEN	Record identifier
					Type of Identifiers
2	8	ID	I4	blank, 0	Control points
				1	Water rights
				2	Reservoirs
				3	Water Right Groups

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
2-13	5-68	IDCP(I) IDRES(I) IDEN8(I)	12A8 12A8 12A8	AN	Identifiers of control points (ID=0), reservoirs (ID=2), water rights (ID=1), water right groups (ID=3). Used for non-zero positive NUM.
2-13	5-132	IDEN16(I) I = 1, 12	12A16		Twelve identifiers per record. Maximum of 100 identifiers. Blank fields are skipped over.

If the parameter *NUM* is greater than zero on the time series (page 205), 2REL, 6REL, 2FRE, 6FRE, DATA, 4HRR, 4ZZF, or 4ZZZ records, a set of control point, reservoir, water right, or water right group identifiers are listed on one or more IDEN records following behind the referencing record. DSSM and DSSD records with MID options 1,2,3,4 reference IDEN records with IDCP(I), IDRES(I), and IDEN16(I) identifiers but do not use water right group IDEN8(I) identifiers.

IDEN records contain only the *CD* of IDEN and the identifiers. IDEN records follow if and only if *NUM* is a positive non-zero integer. The actual value of the positive non-zero *NUM* is not relevant since the number of identifiers on the IDEN records is automatically counted. Any number of identifiers up to a maximum 100 may be included in each set of IDEN records. Any number of IDEN records with any number up to 12 identifiers or blank fields on each record may be included in each set of records. Only the non-blank fields of the IDEN records are read.

Any negative value for *NUM* adopts the last identifiers stored in memory in the IDCP, IDRES, IDEN8, or IDEN16 array. Identifiers entered once may be repeatedly used any number of times.

The first form of IDEN record shown on the preceding page is unnecessary since IDEN records can be attached directly to time series, 2REL, 2FREQ, DSSM, DSSD, DATA, 2HRR, 4ZZF, or 4ZZZ records. This optional extra ID-selection IDEN record allows identifiers to be listed on IDEN records at the beginning of the TIN file ahead of their referencing TIN file input records.

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 time series variables from the *SIM* or *SIMD* simulation results 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.

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 205	Time series identifier from page 205
3	12	DR(1) = ID	I4	0	Develop data for default ID or for control points.
				1	Develop data for water rights.
				2	Develop data for reservoirs.
				3	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 control points, rights, reservoirs, or right groups listed on last previous IDEN records.
				+	Control points, water rights, reservoirs, or water right groups are read from the following IDEN records.
					Time Interval for Array to be Created
5	20	DR(3)	I4	blank,0,1	Annual.
				2	Monthly or sub-monthly (daily).
				3	Create both annual and monthly or daily arrays.
					Variable for Monthly or Sub-Monthly (Daily) Series
6	24	DR(4)	I4	blank,0	Original data from *SIM/SIMD* simulation results.
				1	Moving averages for DR(5) time steps.
				2	Moving totals for DR(5) time steps.
7	28	DR(5)	I4	blank,0	Default is one time step.
				+	Number of time steps.
					Variable for Annual Series
8	32	DR(6)	I4	blank,0,1	Total annual or seasonal summation.
				2	Minimum DR(4) volume occurring each year.
				3	Maximum DR(4) volume occurring each year.
					Specification of Season
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.
					Arrays Written to Output File
13	52	DR(11)	I4	blank,0	Arrays are not recorded in message TOU file.
				1	Annual array recorded in message TOU file.
				2	Monthly or daily array recorded in TOU file.
				3	Both arrays recorded in TOU file.
				4	Annual array with dates recorded in TOU file.
					$X2 = (XF)(X1) + AF$
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

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 205, 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 205 and defined on pages 202-208 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 205) 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.

Type 1 Records Creating Tables from SIM Input DAT File Information

The six type 1 records have identifiers that begin with the integer one. These TIN file input records activate *TABLES* routines that create tables or listings in the TOU file using information read from the *SIM* input DAT file. Type 2 input records described later control routines that create tables based on information read from the *SIM* output OUT file. The 1REC and IRCT record routines read all of the DAT file records. The routines activated by the 1SRT and 1SUM records read selected fields of the *UC*, *CP*, *WR*, *IF*, *WS* and *OR* records to compile water rights information. The 1RES record reads certain data from *WS* and *WR* records. The 1CPT record reads selected fields of the *CP* records and optionally *WP* records from the DIS file to compile control point information.

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

field	columns	variable	format	value	description
1	1-4	CD	A4	1REC	Record identifier
2	8	KK	I4	blank, 0, 1	List specified records.
				2	List all records except specified records.
3	12	LL	I4	blank, 0, 1	Record length is limited to 128 characters.
				2	Record length is limited to 200 characters.
4	15-16	NR	I4	1,2,3,...,30	Number of record identifiers to follow (30 maximum).
5-34	17-136	REC(I) I=1,NR	30(2x,A2)	AN	Two-character identifiers of specified records in *SIM* or *SIMD* input DAT file.

The *SIM* or *SIMD* input DAT file is read by *TABLES.* All input records with the two-character identifiers listed (default KK option 1) or not listed (alternative KK option 2) on the 1REC record are copied to the *TABLES* output TOU file.

With the default LL option 1, the first up to 128 characters of the records are read and copied. LL option 2 increases this maximum limit to 200 characters. With the exception of certain options on several *SIM* input record types that are usually not employed, *SIM* input records typically do not exceed 128 characters in length. However, comments may be added to the right of input data record fields. The 1REC feature copies a DAT file to a TOU file with all records limited to 128 or 200 characters, removing comments written to the right of these limits.

1RCT Record – Counts of Each Type of Record in *SIM* or *SIMD* DAT File

field	columns	variable	format	value	description
1	1-4	CD	A4	1REC	Record identifier
2	8	KK	I4	blank, 0, 1	Counts of record types found in the DAT file.
				2	Include all record types even if not found in the file.

Counts of the 63 possible types of records in a *SIM* input DAT file and 17 additional record types in a *SIMD* DAT file are tabulated. KK option 2 includes all records, even those with counts of zero.

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	Listing of water rights in priority order.
				2	Listing of rights by control point in priority order.
				3	Listing of rights by type-of-use in priority order.
				4	Listing of rights by water right type in priority order.
				5	Listing of rights by first group in priority order.
				6	Listing of rights by second group in priority order.
				7	Listing of rights by both groups in priority order.
3	12	WRIF	I4	blank,0,1	Both *WR* and *IF* record water rights are included.
				2	Only *WR* record rights are included in the listing.
				3	Only *IF* record rights are included in the listing.
4	16	HEP	I4	blank,0,1	Both hydropower rights and non-hydropower rights.
				2	Only non-hydropower rights are included in the listing.
				3	Only hydropower rights are included in the listing.
5	20	ART	I4	blank,0,1	Artificial water rights are included in the listing.
				2	Artificial water rights are not included in the listing.
				3	Only artificial rights are included in the listing.
6	21-28	XAMT	F8.0	+	Lower limit on annual diversion or instream flow.
7	29-36	XPS	I8	+	Include only rights that are senior to priority XPS.
8	37-44	XPJ	I8	+	Include only rights that are junior to priority XPJ.
9	45-52	XUSE	A6	AN	Include only rights with water use identifier XUSE.
10	53-60	XGROUP	A8	AN	Include only rights with group identifier XGROUP.
11	64	TABLE	I4	blank,0,1	Complete larger table (listing).
				2	Smaller table (listing) with fewer columns.

The 1SRT record sorts the water rights in the DAT file in priority order as defined by the priority numbers read from field 5 of the *WR* and *IF* records. One of two alternative forms of data listings is selected by TABLE options 1 and 2 in 1SRT field 11 with headings as follows. Other header information not shown below includes counts of the total number of *WR* and *IF* records in the DAT file and count of the total number of water rights included in the 1SRT listing.

```
---------------------------------------------------------------------------------------------
WATER RIGHT    WR                    AUTHORIZED  HYDRO !+++PRIMARY RESERVOIR++++!-SECONDARY-! GROUP IDENTIFIERS
 IDENTIFIER  TYPE PRIORITY   CP   USE   AMOUNT    POWER ! ID    TOTAL  INACTIVE NUM  ACTIVE ! WRIDS(1) WRIDS(2)
                                      (AC-FT/YR) (MW-HR)        (AC-FT) (AC-FT)     (AC-FT)
---------------------------------------------------------------------------------------------


-----------------------------------------------------------------------
WRID(wr,1)            CP           AMOUNT  USE    PRIORITY  WRIDS(1)  WRIDS(2)
                                (AC-FT/YR)
-----------------------------------------------------------------------
```

Both versions include: water right identifier (WRID(wr,1)) from *WR* field 12 or *IF* field 11; control point (CP) from *WR/IF* field 2; annual amount (AMT) from *WR/IF* field 3; type of use (USE) from field 4; priority from field 6; and group identifiers from *WR* record fields 13 and 14 or *IF* record fields 12 and 13. The expanded table format adds reservoir information from *WS* and *OR* records.

Explanation of 1SRT Record Fields

Field 2: With the default KK option 1, all water rights are listed in the TOU file in priority order. The water rights may also be listed in groups defined by control point identifiers from *WR* or *IF* record field 2 (KK=2), water right type from *WR* record field 6 (KK=3), type of use from *WR* or *IF* record field 4 (KK=4), or by water right group identifiers (KK = 5, 6, 7). Within each KK option group, the water rights are listed in priority order.

The first and second water right group identifiers are read from *WR* record fields 13 and 14 or *IF* record fields 11 and 12. With KK option 5, only *WR* or *IF* record rights with non-blank first group identifiers are included in the 1SRT listing, which is organized by groups based on the first group identifier. Likewise, with KK option 6, only rights with non-blank second group identifiers are considered. KK option 7 includes rights with either non-blank first or second group identifiers.

Water right type employed by KK option 3 is defined by *WR* record field 6. *IF* records have no water right type and are arbitrarily assigned the type label 9 in the 1SRT listing.

Field 3: WRIF options select whether only *WR*, only *IF*, or both *WR* and *IF* record water rights are included in the 1SRT listing.

Field 4: Selection parameter HEP controls whether or not hydropower rights (*WR* record water right type 3 or 5) are included in the 1SRT listing (table).

Field 5: The 1SRT record parameter ART controls the inclusion or omission of artificial water rights in the 1SRT listing. Water rights are designated "artificial" in the *SIM* input DAT file either by the parameter ARTIF on the *WO* record or by assigning the water right to a control point designated as artificial by the parameter ARTIF on the *CO* record. Designation of water rights and control points as artificial serves the sole purpose of excluding the rights from the *SIM* simulation results output files unless their inclusion is specifically specified on the *JD* record.

Fields 6, 7, 8, 9, and 10: The table (listing) can be shortened by selectively limiting the water rights that are listed. Water rights are omitted from the 1SRT table if one or more criteria defined by fields 6-10 are activated by non-blank entries. Rights are omitted if the annual diversion, hydropower, or instream flow target in *WR* or *IF* record field 3 does not exceed the XAMT in 1SRT field 7. Only rights with priorities (*WR/IF* field 5) between XPS and XPJ (1SRT fields 8 and 9) are included. If 1SRT fields 9 or 10 are not blank, the listing is limited to only the water use (*WR/IF* field 4) or group (*WR* fields 13, 14 or *IF* fields 12, 13) specified by XUSE and/or XGROUP.

Field 11: The selection parameter TABLE provides two alternative formats for the data listing as noted on the preceding page. Both include the same water rights and much of the same data for each water right. The option 2 table is abbreviated, omitting some of the information included in the default option 1. The amount column of the option 1 table and authorized amount column of the option 2 table refer to the annual diversion or instream flow target in acre-feet/year read from field 3 of the *WR* and *IF* records. Use and priority are from *WR* or *IF* record fields 4 and 5. As indicated by the table headings on the preceding page, the option 1 table includes an additional column for the annual hydroelectric energy target from *WR* record field 3 and five columns with reservoir information from *WS* and OR records.

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	Summary by control point with only totals printed.
				2	Summary by control point.
				3	Summary by type of use.
				4	Summary by water right type.
				5	Summary by first water right group identifiers.
				6	Summary by second water right group identifiers.
				7	Summary by both water right groups.
3	12	WRIF	I4	blank,0,1	Both *WR* and *IF* record water rights are included.
				2	Only *WR* record rights are included in the table.
				3	Only *IF* record rights are included in the table.
4	16	HEP	I4	blank,0,1	Both hydropower rights and non-hydropower rights.
				2	Only non-hydropower rights are included in the table.
				3	Only hydropower rights are included in the table.
5	20	ART	I4	blank,0,1	Artificial water rights are included in summary table.
				2	Artificial water rights are not included in the table.
				3	Only artificial rights are included in summary table.
6	21-28	XAMT	F8.0	+	Lower limit on annual diversion or instream flow.
7	29-36	XPS	I8	+	Include only rights that are senior to priority XPS.
8	37-44	XPJ	I8	+	Include only rights that are junior to priority XPJ.
9	45-52	XUSE	2x,A6	AN	Include only rights with water use identifier XUSE.
10	53-60	XGROUP	A8	AN	Include only rights with group identifier XGROUP.

Tables created with the 1SUM table have the following heading with the first column containing identifiers of control points (KK = 0, 1, 2), use types (KK = 3), or water right groups (KK = 5, 6, 7).

```
WATER RIGHTS INPUT DATA SUMMARY BY CONTROL POINT (or USE or GROUP)
-------------------------------------------------------------------------------
            NUMBER      ANNUAL      NUMBER      RESERVOIR       PRIORITIES
            OF          AMOUNT      OF          STORAGE         RANGE
CONTROL     OF          AMOUNT      OF          STORAGE         RANGE
 POINT      RIGHTS     (AC-FT/YR)   RESERVOIRS  (AC-FT)     FROM        TO
-------------------------------------------------------------------------------
```

The second column is the number of *WR* and/or *IF* record water rights included in the summations. The third column is a tabulation of summations of AMT from *WR* and/or *IF* record field 3, with hydropower included only for HEP option 3. Priorities are read from *WR/IF* field 5. Reservoir storage capacities are read from field 3 of the *WS* records. Since multiple rights can be associated with the same reservoir and multiple reservoirs with the same water right, storage capacities may be double-counted unless KK option 1 or 2 which aggregates water rights by control point is selected. Correct reservoir counts and volumes without double-counting are provided for control points.

WRIF, HEP, ART, XAMT, XPS, XPJ, XUSE, and XGROUP in fields 3-10 are defined the same for both the 1SUM and 1SRT records. These input parameters are defined in the 1SRT record description on the preceding page.

1RES Record – Reservoir Information from *WS* Records in a DAT File

field	columns	variable	format	value	description
1	1-4	CD	A4	1RES	Record identifier
2	5-16	XLIMIT	F12.0	+	Minimum reservoir storage capacity.

The heading for the 1RES record tabulation is replicated below with no actual lines of data shown. Each line in the tabulation consists of information from a water right storage *WS* record and its associated water right *WR* or instream flow right *IF* record.

```
RESERVOIR INFORMATION COMPILED WITH 1RES RECORD
Each line in the table represents a WS record. The data were read
from each WS record and its preceding WR or IF record.
The DAT file contains __ WS records representing __ reservoirs.
          -----------------------------------------------------------
                    Storage  Inactive    Water          Control    WR       WR
          Reservoir Capacity  Storage    Right           Point   Priority  Type
          -----------------------------------------------------------
          Table contains a line of WS and WR record data for each WS record.
          -----------------------------------------------------------
          Number of WS records included in the tabulation = ___
          Number of reservoirs included in the tabulation = ___
          Total storage capacity (acre-feet) =          _____
          Number of reservoirs included in the DAT file =   ___
          Total storage capacity (acre-feet) =          _____
```

The reservoir or reservoirs associated with a *WR* record or *IF* record water right is provided on a *WS* record inserted in the DAT file following the *WR* or *IF* record. The *TABLES* routine activated by the 1RES record reads the following data from each *WS* and associated *WR* or *IF* in the DAT file.

WS field 2	reservoir identifier
WS field 3	total storage capacity
WS field 7	inactive storage volume
WR/IF field 2	control point identifier
WR/IF field 12	water right identifier
WR/IF field 5	priority

A *WS* record is required for any water right with reservoir storage capacity. Multiple rights can be associated with the same reservoir and multiple reservoirs with the same water right. Each line in the 1RES table represents a *WS* record with its associated *WR* or *IF* record information. Multiple *WS* records for the same reservoir are grouped together in the 1RES table. The lines of *WS* record information are grouped by reservoir but otherwise listed in the sequential order that the *WS* records are read from the DAT file. With a blank 1RES record field 2 (XLIMIT=0.0), the number of lines of data in the 1RES tabulation equals the number of WS records in the DAT file. The summary following the table shows the number of reservoirs and their total capacity.

All reservoirs with total storage capacities less than XLIMIT in 1RES field 2 are omitted from the tabulation. With multiple *WS* records for the same reservoir, the total storage capacity of a reservoir is the maximum capacity entered in field 3 of the *WS* records associated with the reservoir.

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

field	columns	variable	format	Value	description
1	1-4	CD	A4	1CPT	Record identifier
2	8	KK	I4	blank, 0	Reproduction of *CP* records in rearranged order.
				1	Listing of only control point identifiers CPID(cp,1).
				2	Listing of cp and next downstream cp identifiers.
				3	Listing of cp and next upstream cp identifiers.
				4	Listing of INMETHOD and CL from *CP* records.
				5	Option 4 listing with DA from *WP* records added.
				6	Data from options 2-5 are combined in output listing.
				7	Listing of channel loss factors and delivery factors.
				8	No written output. ICP(I) array for 2BUD record.
3	12	OO	I4	blank,0,1	Order based on listing cp before all downstream cps.
				2	Order based on full-length stream tributaries.
4	15-16	LIM	I4	blank,0,1	Include all control points in the output listing.
				2	List only control points with INMETHOD = 0 or 1.
5	17-24	CPLIM	2x,A6	blank	Include all control points.
				AN	Include only cps located downstream of this cp.

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 located downstream. This order is required by *WRAP-SALT*. With OO option 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 *CP* records in the *SIM* input file. The *LIM* option in field 4 limits the listing 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. CPLIM is required for KK option 7 and is optional for the other KK options.

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 lists the reordered control points with each line of the table tabulating the following variables in the order shown below. Options 1-5 provide some but not all of the option 6 data listed below. The drainage area is read from *WP* records in the DIS file. The other data are read from *CP* records in the DAT file.

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

KK option 7 creates an upstream-to-downstream control point list beginning with CPLIM from field 5 that includes channel loss factors, delivery factors, and cumulative delivery factors.

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* and *IF* input records that are reproduced in the water right output records.

Table 5.8
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		
2TIF	CP field 14	IF field 13		
2IFT	CP field 14	IF field 11		
2IFS	field 14–field 10	IF field 12		
2IFF	lesser of 10&14	IF field 11 − 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 5.8 and brief descriptions of the corresponding variables from the *SIM* simulation results output OUT file. All of these time series variables 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 206-208.

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.

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

2IFT Instream flow targets after combining with junior IF target, if any, at the same control point.

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

2IFF Lesser of the instream flow target and regulated flow which is same as target less shortage.

2FSV Accumulated total volume of flow switch variable during *FS* record flow switch period.

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 5.3. 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. *TABLES* also works with *SIMD* daily simulation results as described in the *Daily Manual*.

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 pts, w 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 Flow due to *PX* Record CP Limit Option (water rights)
2ASF Record – Available Stream Flow (water rights)
2ROR Record – Releases from Other Reservoirs (water rights)
2TIF Record – Instream Flow Target (instream flow rights, control points)
2IFT Record – Instream Flow Target After Combining (instream flow rights, control points)
2IFS Record – Instream Flow Shortage (instream flow rights, control points)
2IFF Record – Instream Flow Target Supplied (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 *EV* 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)

Time Series Records – Record Types Listed on Preceding Page

field	columns	variable	format	value	description
1	1-4	CD	A4	page 205	Record identifier from the list on the preceding page.
				2DAT	Monthly or daily data from a DATA record array.
				2DSS	Monthly data is read from DSSM record array.
				6DSS	Daily data is read from array created by DSSD record.
2	8	TA	I4	blank,0	Do not develop annual row/monthly column table.
				1	Develop table with annual rows and monthly columns.
3	12	PT	I4	blank,0	Do not activate either HEC-DSS or text file option.
				1	Develop columns of monthly data in TOU text file.
				2	Develop columns of annual quantities in text file.
				3	Develop columns of 12 monthly means in text file.
				4	Develop HEC-DSS monthly time series records.
				5	Develop HEC-DSS annual time series records.
				6	The mean for the entire simulation in TOU text file.
				7	Same as 6 but only summary total and mean written.
4	16	MORE	I4	0	Write columns; next record starts a new table.
				1	Add more columns to existing table or start first table.
5	20	ID	I4	0	Develop tables for default ID or for control points.
				1	Develop tables for water rights.
				2	Develop tables for reservoirs.
				3	Develop tables for water right groups.
6	24	NUM	I4	blank,0	Tables for all control points (ID=0), rights (ID=1), or reservoirs (ID=2). NUM cannot be zero if ID=3.
				−	Control points, water rights, reservoirs, or water right groups listed on last previous set of IDEN records.
				+	Control points, water rights, reservoirs, or water right groups are assigned by the following IDEN records.
7	28	INPUT	I4	blank,0,1	Annual dataset from DATA record.
				2	Monthly or daily dataset from DATA record.
8	32	DECIMAL	3x,A1	blank	Standard number of digits.
				0,1,2,3,4	Number of digits to the right of the decimal.
9	36	TOTALS	I4	1,+	Totals for all control points, water rights, or reservoirs.
10	40	CFS	I4	1, +	Conversion from acre-feet/period to cfs.
11	44	MAT	I4	blank,0	Moving average/total option is not adopted.
				1	Moving averages are computed for TIME months.
				2	Moving totals are computed for TIME months.
12	45-48	TIME	I4	+	Number of months for moving averages or totals.
13	49-56	XF	F8.0	+, −, blank	Multiplier factor. Default multiplier factor = 1.0
14	57-64	AF	F8.0	+, −, blank	Addition factor. Default addition factor = 0.0

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

field	columns	variable	format	value	description
15	65-72	XUL	F8.0	+, −, blank	Upper limit defining selected range of values.
16	73-80	XLL	F8.0	+, −, blank	Lower limit defining selected range of values.

Explanation of Time Series Input Record Fields

Field 1: Variables are selected by this record identifier. A variable is selected by entering one of the 35 alternative record identifiers listed on page 205 or the equivalent daily type 6 identifier. Alternatively, the data array developed by a DATA record can be accessed by entering 2DAT or 6DAT for CD in field 1. The data array created from a DSS file with a DSSM or DSSD record is accessed by entering 2DSS or 6DSS in field 1. In these cases, a DATA, DSSM, or DSSD record is located ahead of the time series record in the input TIN file.

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 (type 2). Field 3 is activated for daily data (type 6 records). 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 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/ which are described in Chapter 6.

PT options 6 and 7 condense 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.

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 4.9. 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. The ID options that are applicable for each type of time series record are tabulated in Table 4.9.

Field 6: The default is to include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) found in the *SIM* OUT file. Optionally, control points, rights, reservoirs or water right groups (ID=3) may be selected by listing identifiers on IDEN records. IDEN records are read if *NUM* is 1 or any positive integer. The number of identifiers on the IDEN records is automatically counted. The default *NUM*=0 is not applicable for water right groups (ID=3). For ID option 3, water right groups must be listed on IDEN records. A −1 or any negative value for *NUM* indicates that the identifiers assigned by the last previous set of IDEN records are repeated. This same information provided on DSSM or DSSD records replace NUM in field 1.

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) as described in Chapter 5 of the *Reference Manual*.

Field 9: The values for all the control points, rights, or reservoirs are summed in each month. The TOTALS option is valid for ID of 0, 1, or 2 and NUM of 0 in fields 5 and 6.

Field 10: The CFS option converts time series quantities from volumes in acre-feet to mean flow rates in ft^3/s considering the different number of days in each of the 12 months of the year.

Fields 11 and 12: A non-zero *MAT* in field 11 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 12. 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 13 and 14: 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.

Fields 15 and 16: The variable is changed to zero for all time periods in which the values falls outside of the range defined by the optional specified upper and lower limits.

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	N = number of months with non-zero targets
				1,+	N = (years)(12 months/year) for $R_P = (n/N) \times 100\%$
					Control Points, Rights, Hydropower, WR Groups
4	16	ID	I4	blank,0	Control points are selected in fields 5 and 6.
				1	Water rights are selected in fields 5 and 6.
				2	Hydropower reservoirs are selected in fields 5 and 6.
				3	Summations for selected right groups or use types.
				4	Water rights are selected by fields 6,7,8,9,10,11,12.
				5	DSSM or DSSD record data array and identifiers.
5	20	NUM	I4	blank,0	Include all control points (ID=0), all water rights (ID=1), or all reservoirs (ID=2) or all up to 100 water right groups (ID=3) in reliability table.
				1	Water right, reservoir, water right group, or control point identifiers follow on IDEN record(s).
				−1	Identifiers assigned by last previous IDEN records.
					Minimum Limit on Annual Target for ID 1, 2, 3, 4
6	21-28	FAMT	F8.0	blank,0.0	All water rights with non-zero target are included.
				−1.0	All rights included even those with zero target.
				+	Minimum limit on annual computed OUT file target.
					Limits on Selection of Water Rights for ID Option 4
7	29-36	XAMT	F8.0	+	Limit is annual target from *WR* or *IF* record field 3.
8	37-44	XPS	I8	+	Include only rights that are senior to priority XPS.
9	45-52	XPJ	I8	+	Include only rights that are junior to priority XPJ.
10	56	XCP	I4	1	Match XCP control points from IDEN records.
11	60	XGROUP	I4	1	Match XGROUP group identifiers from IDEN records.
12	61-68	XUSE	A8	A8	Include only rights with water use identifier USE.
					Additional Supplemental Tables
13	69-76	TAR	F8.0	blank,0.0	Optional supplemental reliability table is not created.
				+	Annual diversion or hydropower target.
				−1.0, −	Adopt total of targets from *SIM* output file.
14	80	VUL	I4	≥ 1	Optional vulnerability and resiliency table is created.

The 2REL record routine computes reliability metrics for *WR* record diversion targets and hydroelectric energy targets but does not include *IF* record instream flow rights. Reliability analysis methods and examples are found in the *Reference* and *Fundamentals Manuals*. Each *WR* record water right may include water supply diversion specifications, hydroelectric energy generation specifications, or neither, but not both. Diversion or hydropower targets are computed by *SIM* for each month of the simulation based on information provided on *WR*, *UC*, *SO*, *TO*, *TS*, *FS*, *DI*, and other input records. *SO* record field 9 specifies the intermediate or final

targets and shortages to be written to the OUT file. *TABLES* uses these targets and shortages to compute reliability metrics. The targets tabulated in the second column of the reliability table are annual means computed by summing the monthly amounts for the entire simulation.

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 simulation results from only the months with non-zero targets or using all months including those with zero target. The default RFLAG is to use only those months with zero targets. For example, for an agricultural irrigation diversion right, only months during the irrigation season with non-zero demands are considered.

Field 4: *TABLES* reads *SIM* simulation results for individual water rights (ID=1), control points (ID=0), or reservoir/hydropower projects (ID=2) from control point, water right, and reservoir output records in the OUT file. With ID options 1 and 4, reliabilities are tabulated for individual water rights. With default ID option 0, reliabilities are tabulated for the aggregation (summation) of all water rights at selected individual control points. For control points, reliabilities are for the summation of the diversions for all the rights located at each control point. Likewise, with the ID option 2, reliabilities are presented for the aggregated totals of all water rights at selected individual reservoirs/hydropower plants.

With ID option 3, reliabilities are tabulated for the total target amounts computed by summing the targets and shortages of all water rights identified with specified groups of water rights. Water right group identifiers are defined by fields 12 and 13 of the *WR* records in the *SIM* input DAT file and are included on the simulation output records written by *SIM* to the OUT file.

Activation of GOUC option 1 in *GO* record field 2 in the DAT file results in water use identifiers being treated as group identifiers as simulation results are recorded in the *SIM* output OUT file. These are the use types that connect *UC* records and the parameter USE in *WR* record field 4. Thus, water use types can be treated as group identifiers in employing 2REL record ID options 3.

2REL or 6REL record ID option 5 requires a preceding DSSM or DSSD record with RELIAB entered for PARTC in field 9. The data array created by the DSSM or DSSD record contains the diversion or hydropower targets and shortages labeled TAR, SHT, (HPS+HPE), and HPS on pages 202-205 and numbered 12, 13, 20, 21, (34+35), and 34 on page 47. Diversions are associated with control point and water rights output records, and hydropower is associated with reservoir output.

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, 4) 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 reservoir 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.

TABLES works directly with data read from the *SIM* output OUT file. *SIM* parameters control the water rights, control points, and reservoir/hydropower projects for which simulation results are recorded in the OUT file. In discussing *TABLES*, all water rights or all control points or all reservoirs mean all of these output record types included by *SIM* in its OUT file. All water rights are assigned a control point in a *SIM* simulation. However, some or many water rights typically do not have reservoirs or water right group identifiers.

The 2REL record reliability metrics are computed by *TABLES* from the target and shortage data from the simulation results read by *TABLES* from the *SIM* OUT file. The targets and shortages in the 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 water rights (ID=1), control points (ID=0), reservoir/hydropower projects (ID=2), or water right groups (ID=3) in the *SIM* OUT file being included in the reliability table. *NUM* and IDEN records are not applicable for ID option 4.

Optionally, lists of control points, water rights, reservoir/ hydropower projects, or water right groups may be entered in IDEN records. Time series (page 205), 2REL, and 2FRE records employ IDEN records in identically the same way. With a 1 or any positive non-zero *NUM*, one or more IDEN records follow immediately behind the time series, 2REL, or 2FRE record. The number of identifiers on the IDEN records are automatically counted as the records are read.

A −1 or any negative integer in field 5 results in the identifiers assigned by the last previously read IDEN records being repeated. IDEN records enter identifiers into memory that may be then used repeatedly any number of times 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 with ID option 3.

Field 6: Field 6 and fields 7-12 reduce the size of the reliability table. Control points (ID=0), water rights (ID=1,4), reservoir/hydropower projects (ID=2), or water right groups (ID=3) are omitted from the reliability table if the mean annual target is less than the final annual target limit FAMT entered in field 6. The annual target volume is computed within *TABLES* by summing the monthly target volumes for each month of the simulation from the *SIM* simulation results output OUT and dividing the resulting total volume by the number of years in the simulation. The monthly targets are computed by *SIM* as specified by *WR*, *UC*, *TO*, *SO*, *TS*, *FS*, and other input records. The final computed annual target volume is compared to the minimum limit criterion volume FAMT entered in 2REL field 6.

The FAMT limit is applied to the mean annual target tabulated in the second column of the reliability table and is applicable to all of the ID options. With a blank field 6 (FAMT=0.0), the otherwise selected control points, water rights, or groups are included in the reliability table if their mean annual target is greater than zero. Those with zero targets are omitted. A FAMT entry of −1.0 or any negative number results in all water rights, control points, reservoirs, or groups being included in the table, even those with zero targets. With a positive FAMT in field 6, all lines of the reliability table that would have a mean annual target quantity of less than FAMT in the second column of the reliability table is simply omitted from the table.

Fields 7-12: The criteria for selecting water rights for inclusion in the reliability table activated by fields 7, 8, 9, 10, 11, and 12 are applicable only if ID option 4 is activated in field 4. Parameters XAMT, XPS, XPJ, XCP, XGROUP, and XUSE in fields 7-12 provide criteria for reducing the number of water rights included in the reliability table.

ID options 1 and 4 both mean that the reliability metrics are for individual water rights. Options 1 and 4 differ as follows. For ID option 1, the specification of ID options in field 4, NUM in field 5, and FAMT in field 6 define a set of control points, water rights, or water right groups for which reliability metrics are to be included in the reliability table. For ID option 4, water rights are selected by the parameters in fields 6, 7, 8, 9, 10, 11, and 12. A water right is omitted from the table if one or more criteria defined in fields 6-12 is not met.

TABLES reads all of the *WR* records in the *SIM* input DAT file for ID option 4. The selection criteria described below are based on the following *SIM* input parameters read by *TABLES* from the *WR* records in the DAT file: control point in field 2, AMT in field 3, USE in field 4, priority number in field 5, and group identifiers WRIDS(wr,1) and WRIDS(wr,2) in fields 13 and 14.

Field 7: A water right is excluded from the reliability table if the annual target amount in *WR* record field 3 is less than XAMT in 2REL record field 7.

Fields 8 and 9: A water right is excluded from the reliability table if the priority number in *WR* record field 6 is greater than XPS and/or smaller than XPJ in 2REL record fields 8 and 9.

Field 10: Only water rights at the control points listed on the following IDEN records are included in the reliability table. Fields 10 and 11 cannot both be activated for same 2REL record.

Field 11: Only water rights with either WRIDS(wr,1) or WRIDS(wr,2) in *WR* record fields 13 and 14 corresponding to group identifiers on the following IDEN records are included in table.

Field 12: Only water rights with use type USE of XUSE in *WR* record field 4 are included.

Fields 13 and 14: Additional tables activated by TAR and VUL supplement the reliability table.

Field 13: A positive number entered for *TAR* in field 13 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 −1.0 in field 13 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 14: Another optional table with vulnerability, resiliency, and other shortage related metrics designed primarily for CRM is described in Chapter 8 of the *Reference Manual*.

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 ID	I4	1	Naturalized flows (ID=0)
				2	Regulated flows (ID=0)
				3	Unappropriated flows (ID=0)
				4	Reservoir storage associated with control points (ID=0)
				−4	Reservoir storage associated with control points with only totals included in table (ID=0)
				5	Reservoir storage associated with water rights (ID=1)
				−5	Reservoir storage associated with a water rights with only totals included in table (ID=1)
				6	Reservoir storage associated with reservoirs (ID=2)
				−6	Reservoir storage associated with reservoirs with only totals included in table (ID=2)
				7	Reservoir water surface elevation (ID=2)
				8	Instream flow target for control points (ID=0)
				9	Instream flow shortage for control points (ID=0)
				10	IF shortage as % of target for control points (ID=0)
				11	Instream flow target for *IF* record rights (ID=1)
				12	Instream flow shortage for *IF* record rights (ID=1)
				13	IF shortage as % of target for *IF* record rights (ID=1)
				14	DATA record monthly or daily array.
				15	DATA record annual array
				16	Data from array created with DSSM or DSSD record.
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.
				+	Control points, rights, or reservoirs on IDEN records.
				−	Identifiers from previous IDEN records are repeated.
5	20	TABLE	I4	blank, 0, 1	Frequency table is created in standard row format.
				2	Frequency results are tabulated as columns.
				3	Abbreviated frequency results tabulated as columns.
				4	Quantities are expressed as a percentage of maximum.
6	24	METHOD	I4	blank, 0, 1	Relative frequency $P = (n/N)\ 100\%$
				2	Log-normal probability distribution.
				3	Normal probability distribution.
				4	Weibull formula.
7	28	CFS	I4	1, +	Conversion from acre-feet to cfs.
8	32	MAT	I4	blank, 0	Moving average/total option is not adopted.
				1	Moving averages are computed for TIME months.
				2	Moving totals are computed for TIME months.
9	36	TIME	I4	+	Number of months for moving averages or totals.

Continued on next page.

2FRE Record – Flow-Frequency or Storage-Frequency Relationships (continued)

field	columns	variable	format	value	description
10	37-44	XF	F8.0	+, −, blank	Multiplier factor. Default multiplier factor = 1.0
11	45-52	AF	F8.0	+, −, blank	Addition factor. Default addition factor = 0.0
12	53-60	XLIMIT	F8.0	+	Minimum limit of monthly mean for inclusion in table.

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 (ID options 1 through 13) or through use of a DATA record for any of the simulation results variables or transformations thereof (ID options 13 and 14) or through use of a DSSM or DSSD record to compile a dataset from a DSS file (ID option 16). As discussed on page 213, the 6FRE record is the daily version of the monthly 2FRE record.

Explanation of 2FRE Record Fields

Field 2: 2FRE and 6FRE frequency tables are developed for the variable selected in field 2 which may be associated with either control points IDCP(I)), water rights IDEN16(I), or reservoirs IDRES(I). With ID options 14 and 15, the simulation results data being analyzed are accessed from an array created with a DATA record. ID option 16 consists of computing the frequency statistics for a dataset compiled from a DSS file with a DSSM or DSSD record. The other ID options analyze simulation results read by *TABLES* from an OUT, CRM, or SUB file.

Storage frequency tables also include frequency metrics for the summation of storage associated with all the control points, rights, or reservoirs 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, rights, or reservoirs.

Instream flow shortages may be expressed as either a monthly or daily volume (variable 9 or 12) or percentage of target volume ranging from zero to 100% (variable 10 or 13).

ID options 13 and 14 require a DATA record located ahead of the 2FRE or 6FRE record in the *TABLES* input TIN file to create the data array. ID option 16 requires a DSSM or DSSD record inserted in the input TIN file someplace before the 2FRE or 6FRE record to read the DSS file.

Essentially any DSS file of monthly or daily time series data can be read with a DSSM or DSSD record. Thus, the *TABLES* 2FRE, 6FRE, 2FRQ, 6FRQ, and time series (page 205) records can be employed with essentially any variable including any of the variables found in *SIM/SIMD* input and output files but also any other variables that may be stored in a DSS file. Since identifiers are already provided with DSSM and DSSD records, parameter NUM in 2FRE field 5 is not used.

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: The parameter *NUM* is identical in 2FRE/6FRE record field 4, 2REL/6REL 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. A blank or zero field 4 results in all of either the control points (variables 1, 2, 3, 4, −4, 8, 9, or 10 in field 2), water rights (variables 5, −5, 11, 12, or 13), or reservoirs (variables 6 or 7) being included in the frequency table. Optionally, lists of control points, water rights, or reservoirs may be entered on IDEN records.

Parameter NUM in field 4 is not relevant when the 2FRE record is applied to analyze a dataset compiled with a DSSM record, since the control points, water rights, or reservoirs are selected with parameters entered on the DSSM record.

Field 5: Four alternative formats are available for the frequency tables. The option 2 columnar format contains a 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 based on rank (m).

$$\text{Exceedance Frequency} \quad = \quad \frac{m}{N}(100\%)$$

For a specified exceedance frequency (90% for example), if a particular flow value 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. Option 4 is based on estimating exceedance frequencies using the Weibull formula and then again applying linear interpolation.

$$\text{Exceedance Frequency} \quad = \quad \left(\frac{m}{N+1}\right)(100\%)$$

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.

Field 7: The CFS option converts time series quantities from volumes in acre-feet to mean flow rates in cfs (ft^3/s) in the same manner for both the 2FRE record and time series records.

Fields 8 and 9: 2FRE record fields 8 and 9 (*MAT* and *TIME*) are identical to fields 11 and 12 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 10 and 11: The multiplier *XF* and addition *AF* factors in 2FRE record fields 10 and 11 are the same as *XF* and *AF* in fields 13 and 14 of the time series records described on pages 205-208.

Field 12: Frequency metrics are omitted for data sequences with means of less than XLIMIT. If field 12 is blank meaning no limit, all control points, water rights, or reservoirs are included.

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	+	Variable selections in field 2 are the same for 2FRE and 2FRQ records except for −4, −6, and −5.
3	12	MONTH	I4	0,blank +	All months are included in the computations. The month for which the analysis is performed.
4	16	NM	I4	+	Number of flows or storages entered for *TABLES* to determine frequencies (NM may range from 1 to 7)
5	17-24 17-32	IDEN IDEN16	2x,A6 A16	AN	Identifier of control point (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 target or shortage amounts or the variable defined by a preceding DATA record or DSSM or DSSD record. The daily 6FRQ record is the counterpart to the monthly 2FRE record, as discussed on page 213.

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 activated by variable ID = −4, −6, or −5. The variables recorded in the *SIM* water right, control point, and reservoir/hydropower output records are defined in Chapter 5 of the *Reference Manual*. The DATA record is described on pages 193-195 of this *Users Manual*. The DSSM and DSSD records are described on pages 190-191.

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

Second 2RES Record – Total Storage Capacity (required)

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

Third 2RES Record – Inactive Storage Capacity (optional)

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

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

Explanation of 2RES Records

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

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

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

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

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

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

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

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

2SCP Record – Summary Tables for Control Points

field	columns	variable	format	value	description
1	1-4	CD	A4	2SCP	Record identifier
2	8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank,0	Develop tables for all control points.
				1,2,3,...,8	Control points are listed in 2SCP fields 4 through 11.
				99	Control points identifiers on following IDEN records.
				–	Identifiers from previous IDEN records are repeated.
4-11	13-76	IDCP(I) I = 1,NUM	8(2x,A6)	AN	Identifiers of control points for which to develop tables. Fields used only if NUM is 1, 2, 3, 4, 5, 6, 7, or 8.

2SWR Record – Summary Tables for Water Rights

field	columns	variable	format	value	description
1	1-4	CD	A4	2SWR	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank,0	Develop tables for all water rights.
				1,2,3,...,8	Water rights are listed in fields 4 through 11.
				99	Water right identifiers on following IDEN records.
				–	Identifiers from previous IDEN records are repeated.
4-11	13-140	IDEN16(I) I = 1,NUM	8A16	AN	Identifiers of water rights for which to develop tables.
				blank	Fields are not used if NUM is not 1, 2, 3, 4, 5, 6, 7 or 8.

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	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	1,2,3,...,8	Water right groups are listed in fields 4 through 11.
				99	Group identifiers on following IDEN records.
				–	Identifiers from previous IDEN records are repeated.
4-11	13-140	IDEN8(I) I = 1, NUM	8A8	AN	Identifiers of groups for which to develop tables. Fields used only if NUM is 1, 2, 3, 4, 5, 6, 7, or 8.

2SRE Record – Summary Tables for Reservoirs

field	columns	variable	format	value	description
1	1-4	CD	A4	2SRE	Record identifier
2	5-8	MNAN	I4	0	Annual table
				1	Monthly table
				2	Both annual and monthly tables
3	9-12	NUM	I4	blank,0	Develop tables for all reservoirs.
				1,2,3,...,8	Reservoirs are listed in fields 4 through 11.
				99	Reservoir identifiers on following IDEN records.
				–	Identifiers from previous IDEN records are repeated.
4	13-76	IDRES(I)	8(2x,A6)	AN	Identifiers of reservoirs for which to develop tables. Fields used only if NUM is 1, 2, 3, 4, 5, 6, 7, or 8.

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

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

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

The 2BUD record water budget computations performed by *TABLES* are described in Chapter 7 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 7.

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.

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

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	Record identifier for naturalized stream flows
				3REG	Record identifier for regulated stream flows
				3UNA	Record identifier for unappropriated stream flows
				3DEP	Record identifier for stream flow depletions
				3U+D	Record identifier for summation of stream flow depletions plus unappropriated stream flows
				3EPD	Record identifier for net evaporation depths
2	5-8	CDOUT	2x,A2	AN	Two-character identifier at beginning of each record
3	9-12	HEC	I4	blank, zero	Stream flow records grouped by control point
				1	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).

Grouped by Control Point (*HEC* = 0)		Grouped by Year (*HEC* = 1)	
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.

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	Hydropower is not included in the table.
				2	Hydropower is included in the table.
3	12	MNAN	I4	blank, 0	Annual table
				1	Monthly table
4	16	NUM	I4	blank,0	Develop tables for all water rights in HRR file.
				1,2,3,4,5	Reservoirs are listed in fields 5 through 9.
				≥6	Reservoir identifiers on following IDEN records.
				–	Identifiers from previous IDEN records are repeated.
5-9	17-96	IDEN(I) I=1,5	A16	AN	Water right identifiers for which to develop reservoir release tables (maximum of five)

The 4HRR record controls the only *TABLES* routine that reads data from a HRR file. *SIM* creation of a hydropower and system reservoir release HRR output file is activated by *JO* record field 10. The HRR file includes system rights that also fall within the criteria specified in *JD* record field 6. Water rights included by *SIM* in 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.

Water rights are selected for a 4HRR record table in the same as manner as for a 2SWR record using the parameter NUM in field 4 and optional IDEN 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	Reservoir releases.
				2	Regulated flows.
				blank, 0, 3	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.
				−	Tables are developed for the control points already listed on the last preceding IDEN records.
				+	Control points are listed on following 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, control points may be listed on supplemental IDEN records. A negative value for *NUM* may be entered in field 6 to indicate that the last list of identifiers read from a previous set of IDEN records record is to be repeated. IDEN records follow the 4ZZF record 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.

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	Do not develop annual row/monthly column table.
				1	Table with annual rows and monthly columns.
3	12	PT	I4	blank, 0	Do not activate either DSS or text file option.
				1	Develop columns of monthly data in text file.
				2	Columns of annual totals or means in text file.
				3	Develop columns of 12 monthly means in text file.
				4	Develop DSS monthly time series records.
				5	Develop DSS annual time series records.
4	16	MORE	I4	0	Write columns; next record starts a new table.
				1	Add columns to existing table or start first table.
5	20	VAR	I4	1	Reservoir releases.
				2	Regulated flows.
				blank, 0, 3	Available flows.
6	24	NUM	I4	blank, 0	Tables for all control points included in ZZZ file.
				−	Tables are developed for the control points already listed on the last preceding IDEN records.
				+	Control points are listed on following 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 205-208.

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 supplemental IDEN records. A negative value for *NUM* may be entered in field 6 to indicate that the list of identifiers from the last previously read set of IDEN records is to be repeated. IDEN records follow the 4ZZZ record 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.

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,+	CRM headings are inserted at top of each table.
				−1	CRM headings are not written.

Conditional reliability modeling (CRM) is covered in *Reference Manual* Chapter 8. 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	Control points for naturalized flows to be summed
				STCP	Control points for reservoir storage to be summed
				STRE	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 *5CR1FLOW* 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 *5CR1STCP* or *5CR1SRES* 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
					Control Points or Reservoirs for Flow and Storage
2	5-8	NFLOW	I4	+	Number of control points for naturalized flow
				blank,0	Flow at all control points is summed
3	9-12	NSTOR	I4	+	Number of control points or reservoirs for storage
				blank,0	Storage at all control points is summed
				−1	Storage at all reservoirs is summed
					Annual or Monthly Cycle Options
4	13-16	TCR2	I4	+	Starting month activates annual cycle option
				blank,0	Monthly or non-annual option adopted by default
					Months Used to Sum Flows
5	17-20	FM	I4	+	Number of months for naturalized flow volume
				blank,0	Default is simulation length CR1 from *CR* record if a CRM file has been opened providing CR1.
					Total Storage or Change in Storage
6	23-24	CRS	I4	blank,0	Total storage volume content is used.
				+	Change in storage during CRS preceding months.
					Option for Assigning Exceedence Frequencies
7	28	DIST	I4	Blank,0,1	Weibull formula
				2	Log-normal distribution
					Regression Options for Storage-Flow Function
8	31-32	FIT	I4	blank,0	FF relationship developed without storage regression.
				1, −1	Exponential regression for storage-flow function.
				2, −2	Combined function used for storage-flow function.
				3, −3	Linear regression used for storage-flow function.
				4, −4	Power function used for storage-flow function.
				5	Predicted flow set equal to long-term mean flow.
9	36	INTZERO	I4	blank,0	Intercept is not forced to zero
				1	Y-intercept (flow) is set at zero.
					Coefficients for $Q = a\,e^{S/b}$ or $Q = a + bS^{c}$
10	37-44	A	F8.0	+	Coefficient a
11	45-52	B	F8.0	+	Coefficient b
12	53-60	C	F8.0	+	Coefficient c
					Optional Storage Interval
13	61-68	LOWLIM	F8.0	+	Lower storage limit defining flow sequence selection.
14	69-76	UPLIM	F8.0	+	Upper storage limit defining flow sequence selection.
				blank, 0	Option is not applied.
					Options for Writing Results to SFF and TOU Files
15	80	FILE2	I4	blank,0	Nothing is written to the SFF and TOU files.
				1	The probability array is written to the SFF file.
				2	Regression and correlation statistics to TOU file.
				3	Both probability array and statistics are written.
				4	Storage and flow volumes are tabulated in TMS file. Both probability array and statistics are written.
				5	Storage, change in storage, and flow in TMS file

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: Flow is regressed with either preceding storage or change in storage during CRS preceding months. CSVO and CSV on the 5CR2 record must be consistent with CRS on the 5CR1 record.

Field 7: The two alternative options for assigning exceedance probabilities to $Q_\%$ (defined by *Reference Manual* Eq. 8.8) in developing the SFF relationship or to flow volume in developing the FF relationship are based on the log-normal probability distribution (Eq. 8.19) and Weibull formula (Eq. 8.20).

Field 8: A blank field 8 indicates that a FF relationship is being developed without considering storage. A SFF relationship relates predicted naturalized flow Q to storage or storage change S. With FIT 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 10, 11, and 12. FIT option 5 sets the predicted flow Q equal to the long-term mean flow without consideration of storage.

FIT Option 1	Exponential:	$Q = a \times e^{S/b}$	Eq. 8.9 in *Reference Manual*
FIT Option 2	Combined:	$Q = a + bS^c$	Eq. 8.12 in *Reference Manual*
FIT Option 3	Linear:	$Q = a + bS$	Eq. 8.11 in *Reference Manual*
FIT Option 4	Power:	$Q = bS^c$	Eq. 8.10 in *Reference Manual*

Field 9: The coefficient a representing the y-intercept (flow for zero storage) in the linear and combined regression equations (*Reference Manual* Equations 8.12 and 8.11) may be set equal to zero.

Fields 10, 11, and 12: 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 8.

Fields 13 and 14: 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 15: 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
					Control Points or Reservoirs for Flow and Storage
2	5-8	NFLOW	I4	+	Number of control points for naturalized flow.
				blank,0	Flow at all control points is summed.
3	9-12	NSTOR	I4	+	Number of control points or reservoirs for storage.
				blank,0	Storage at all control points is summed.
				−1	Storage at all reservoirs is summed.
					Starting Reservoir Storage Contents Volume
4	16	READINI	I4	blank,0	Initial storage volumes are not needed and not input.
				1	Initial storage volumes read from 5CP2INIT record.
				2	Initial storage volumes read from BRS file.
				3	Initial total storage is CSV in field 10. (CSVO is 0)
					Months Used to Sum Flows
5	17-20	FM	I4	+	Number of months for naturalized flow volume.
				blank,0	Default is simulation length CR1 from CR record.
					Preceding Change in Reservoir Storage Volume
6	23-24	CSVO	I4	blank,0	Preceding storage change is not used. (CRS is 0)
				88	Preceding storage change computed by multiplying total initial storage volume by CSV in field 10.
				99	Preceding storage change is CSV in field 10.
					Regression Options for Storage-Flow Function
7	28	FIT	I4	blank,0	FF relationship is created without storage regression.
				1	Exponential (Eq. 8.9) coefficients from 5CR1 record.
				2	Combined (Eq. 8.12) coefficients from 5CR1 record.
				−1, −2	Eq. 8.9 or Eq. 8.12 coefficients in fields 10, 11, 12.
				5	Predicted flow set equal to long-term mean flow.
					FF or SFF Relationship
8	32	FILE1	I4	blank,0,1	SFF or FF is created with preceding 5CR1 record.
				2	SFF or FF relationship is read from SFF file.
					Option to Write Probability Array to SFF File
9	36	FILEO	I4	blank,0	Nothing is written to the SFF file.
				1	The probability array is written to the SFF file.
					Sum of Storage Change or Storage for All Reservoirs
10	37-44	CSV	F8.0	+	Preceding change in storage or total storage.
					Multiplier Factor
11	45-52	MFACTOR	F8.0	+	Multiplier factor for initial storage or storage change.
				blank,0	default=1.0
					Coefficients for $Q = a\,e^{S/b}$ *or* $Q = a + bS^c$
12	53-60	A	F8.0	+	Coefficient a
13	61-68	B	F8.0	+	Coefficient b
14	69-76	C	F8.0	+	Coefficient c
					Optional Q Adjustment Factor (Default = 1.0)
15	77-84	QX	F8.0	+	Flow from regression equation is multiplied by QX.

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.

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: Options 1 and 2 consist of inputting initial storage for each reservoir on a *5CR2INIT* record or in a BRS file created by *SIM*. Option 3 consists of inputting the summation for all reservoirs as CSV in field 10. Field 4 is blank or 0 if storage change is adopted rather than storage.

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: Naturalized flow volume (Q) may be related to either preceding storage volume or change in storage volume during the CRS months preceding the initial month (S). Change in storage is provided by CSVO options 88 and 99. With CSVO option 88, the change in storage is computed by multiplying storage by CSV from field 10. With CSVO option 99, the change in storage is CSV.

Field 7: Field 7 is blank if a flow-frequency (FF) relationship is used to construct the incremental probability (IP) array without considering storage. FIT option 5 sets the predicted flow Q equal to the long-term mean flow without consideration of storage in applying the SFF array method. 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 7 indicates that *Reference Manual* Eq. 8.9 or Eq. 8.10 is used with coefficients determined by the previous *5CR1* record. Negative integers −1 or −2 activate the option of reading coefficients from fields 12, 13, and 14. 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. 8.9)	$Q = a \times e^{S/b}$
Power (Eq. 8.12):	$Q = b\,S^{c}$
Linear (Eq. 8.11):	$Q = a + b\,S$
Combined (Eq. 8.10):	$Q = a + b\,S^{c}$

Field 8: 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 a SFF file even if the file contains multiple SFF arrays.

Field 9: 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 10: CSV is used with READINI option 3 and/or CRS options 2 and 3 The sum of the change in storage volume in all reservoirs during the preceding month for CRS of 2 in field 6 and the sum of the storage volume in all reservoirs for CRS option 1.

Field 11: All starting storage volumes are multiplied by the factor entered in field 11 with a default of 1.0. With the default CRS option 1 and storage read from a BRS file (default READINI), MFACTOR serves the same function as *CR4* on the SIM *CR* record.

Fields 12, 13, and 14: These fields are used to enter values for the regression coefficients a, b, and c of Equations 8.9 or 8.12 of Chapter 8 of the *Reference Manual* if specified by a −1 or −2 entered in *5CR2* record field 7 for the parameter FIT.

Field 15: The optional (default=1.0) flow adjustment factor QX allows other considerations based on analyses performed outside of WRAP, such as climate teleconnection pattern indices, to be incorporated into the CRM computations. The expected value of the naturalized flow volume Q_S computed by regression is multiplied by QX entered in field 15.

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	Control points for naturalized flows to be summed
				STCP	Control points for reservoir storage to be summed
				STRE	Reservoirs for storage to be summed
				INIT	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.

For option 1 for READINI in field 4 of the main *5CR2* record, 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.

5COR Record – Correlation Coefficients

field	columns	variable	format	value	description
1	1-4	CD	A4	5COR	Record identifier
					Control Points or Reservoirs for Flow and Storage
2	5-8	NFLOW	I4	+	Number of control points for naturalized flow.
				blank,0	Flow at all control points is summed.
3	9-12	NSTOR	I4	+	Number of control points or reservoirs for storage.
				blank,0	Storage at all control points is summed.
				−1	Storage at all reservoirs is summed.
					Annual or Monthly Cycle Options
4	13-16	TCR2	I4	+	Starting month activates annual cycle option.
				blank,0	Monthly or non-annual option adopted by default.
					Months Used to Sum Flows
5	17-20	FM	I4	+	Number of months for naturalized flow volume.
				blank,0	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	Control points for naturalized flows to be summed.
				STCP	Control points for reservoir storage to be summed.
				SRES	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 *5CR1* record option. The optional *5CR1* 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.

Type 6 Record Tables Developed from *SIMD* SUB or DSS Output File

The type 6 time series records and 6REL, 6FRE, 6FRQ, and 6RES records are daily versions of the monthly type 2 time series, 2REL, 6FRE, 6FRQ, and 6RES records. The type 6 records have the same input parameters as the type 2 records and perform the same computational analyses. The type 6 records are designed to organize and analyze time series of daily quantities read from a *SIMD* output SUB file. Type 2 records organize and analyze time series of monthly quantities read from a *SIMD* output SUB file. Tables created with type 6 records include an extra line in the table heading indicating the time step and period-of-analysis of the simulation. Type 6 record identifiers and their type 2 counterparts are listed in Table 5.9. The record descriptions for the type 2 records found on the pages listed in the last column of Table 5.9 are also applicable to the type 6 records.

Table 5.9
Daily Type 6 Records and Corresponding Monthly Type 2 Records

Record Identifier	Type of Information in Table	Type 2 Record	Page Numbers
*	Time Series Records	**	205-208
6REL	Water Supply Diversion or Hydropower Reliability	2REL	209-212
6FRE	Flow or Storage Frequency Relationships	2FRE	213-215
6FRQ	Frequency for Specified Flow or Storage	6FRQ	216
6RES	Reservoir Storage and Drawdown Frequency	6RES	217-218
IDEN	Control point, Water Right, or Reservoir Identifiers	IDEN	192-193

* Type 6 daily time series record identifiers: 6NAT, 6REG, 6UNA, 6CLO, 6CLC, 6RFR, 6URR, 6CPI, 6STO, 6EVA, 6DEP, 6TAR, 6SHT, 6DIV, 6RFL, 6XAV, 6ASF, 6ROR, 6TIF, 6IFT, 6IFS, 6IFF, 6FSV, 6FSC, 6HPS, 6HPE, 6RID, 6RIR, 6RAH, 6RNA, 6EPD, 6EVR, 6WSE, 6RSC, 6RSD

** Type 2 monthly time series record identifiers: 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2RFR, 2URR, 2CPI, 2STO, 2EVA, 2DEP, 2TAR, 2SHT, 2DIV, 2RFL, 2XAV, 2ASF, 2ROR, 2TIF, 2IFT, 2IFS, 2IFF, 2FSV, 2FSC, 2HPS, 2HPE, 2RID, 2RIR, 2RAH, 2RNA, 2EPD, 2EVR, 2WSE, 2RSC, 2RSD

The values of volume reliabilities are same on the 2REL and 6REL tables developed from OUT and SUB files generated by the same *SIMD* simulation, but period reliabilities will differ. The definition and values of period reliabilities vary between daily, monthly, and annual time steps.

The parameters *ND* and *SHORT* in *SIMD* input *DW* record fields 4 and 5 activate an optional feature in which shortages incurred early in a month may be recovered later during the month. Shortages are recorded in the SUB file even though supplied later in the month. Thus, the 6REL record sub-monthly based reliabilities are **_not_** valid for water rights for which the *ND/SHORT* feature is applied in *SIMD*. However, reliabilities based on aggregated monthly simulation results are valid. The aggregated monthly targets and shortages are correct.

Type 7 Records for Probability Analyses of Annual Time Series

7FFA Record – Flood Frequency Analysis of Storage and Flows from AFF File

field	columns	variable	format	value	Description
1	1-4	CD	A4	7FFA	Record identifier
2	5-8	ID	I4	blank,0,1	Naturalized flows
				2	Regulated flows
				3	Reservoir storage
				4	Summation of reservoir storage and excess flow
3	12	TAB	I4	blank,0,1	Annual frequency table based on log-Pearson III.
				2	Both frequency table and statistics table.
				3	Frequency and economic damage table.
				4	Both frequency/damage table and statistics table.
				−1	Table is not created.
4	16	RANK	I4	blank,0,−1	Ranked tabulation is not included in output.
				1,+	Ranked annual peaks with Weibull probabilities.
5	20	NUM	I4	blank,0	Tables for all control points included in AFF file.
				+	Number of control point identifiers on IDEN records.
6	23-24	SKEW	I4	Blank,0,1	Skew coefficients are computed.
				2	Skew coefficients are provided on SKEW record(s).
				3	Weighted skew coefficient combining 1 and 2 above.
				4	Skew coefficient provided in field 7.
				5	Weighted skew coefficient combining 1 and 4 above.
				6	Skew coefficients are all zero.
7	25-32	SC1	F8.0	+ or −	Single skew coefficient for all control points.

IDEN Records – Control Point or Data Series Identifiers for a 7FFA or 7DSS Record

field	columns	variable	format	value	description
1	1-4	CD	A4	IDEN	Record identifier
2-13	5-100	IDCP(I)	12A8	AN	Identifiers (up to 100, 12 per record)

SKEW Record – Skew Coefficients for a 7FFA or 7DSS Record

field	columns	variable	format	value	description
1	1-4	CD	A4	SKEW	Record identifier
2-13	5-100	SC(I)	12F8.0	+ or −	Skew coefficients (up to 100, 12 per record)

7VOL Record – Flow or Storage Volume Causing Damages on Following 7DAM Record

field	columns	variable	format	value	description
1	1-4	CD	A4	DVOL	Record identifier
2	5-12	CPID	2x,A6	AN	Control point identifier.
3	15-16	N	I4	+	Number of values to read (1 to 20).
4-23	17-176	DV(I) I=1,20	20F8.0	+	Flow or storage volume corresponding to $ damage on the following 7DAM record (up to 20 pairs).

7DAM Record – Damage Corresponding to Quantities on Preceding 7VOL Record

field	columns	variable	format	value	description
1	1-4	CD	A4	$DAM	Record identifier
2	5-12		8x		Field is not read.
3	13-16		4x		Field is not read.
4-23	17-176	DAM(I) I=1,20	20F8.0	+	Flood damage in $ corresponding to stream flow or reservoir storage volume on preceding 7VOL record.

7FFA and 7DSS records perform the same frequency analyses of annual series, but read different input files (AFF versus DSS). 7FFA flood frequency analysis are applied to specific data from a *SIMD* annual flood frequency AFF file. The more generic 7DSS record employs the same computational routines as the 7FFA record but for any annual series read from any DSS file.

7FFA flood frequency analysis capabilities and the associated 7VOL/7DAM flood damage analysis option are covered in Chapter 7 of the *Reference Manual* and Chapter 9 of the *Daily Manual*. The log-Pearson probability distribution is applied to the annual series of maximum daily naturalized flow, regulated flow, or reservoir storage read from an AFF file created by *SIMD* to develop an annual frequency table and auxiliary statistics table. The *RANK* parameter in 7FFA record field 4 creates a table assigning an exceedance frequency computed with the Weibull formula to each peak annual flow or storage volume.

The *7FFA* record may be applied without the optional *IDEN*, *SKEW*, *7VOL*, and *7DAM* records. An *IDEN* record is required if and only if activated by NUM in *7FFA* field 5. A *SKEW* record is required if and only if activated by *SKEW* in *7FFA* field 6. Without *7VOL* and *7DAM* records, the frequency table includes only naturalized or regulated flow or storage volumes. With *7VOL* and *7DAM* records, the frequency table is expanded to include dollar damages. The table includes annual damages in dollars for each exceedance frequency and average annual damages.

IDEN records, if used, must follow immediately after the *7FFA* record. *SKEW* records, if used, must follow behind the *7FFA/IDEN* records. The set of all pairs of *7VOL* and *7DAM* records follow the *7FFA*, *IDEN*, and *SKEW* records. A *7DAM* record follows immediately after the corresponding *7VOL* record.

7DSS Record – Frequency Analyses of Annual Series from a DSS File

field	columns	variable	format	value	Description
1	1-4	CD	A4	7DSS	Record identifier
2	5-8	NUM	I4	+	Number of identifiers on IDEN records for Part B.
				blank, 0	Single identifier in IDEN field 12 for Part B.
3	9-12	NYRS	I4	+	Number of years in the period-of-analysis.
4	13-16	YRBEG	I4	+	Beginning year of the period-of-analysis.
					Output Tables of Analysis Results
5	20	TAB	I4	blank,0,1	Annual frequency table based on log-Pearson III.
				2	Both frequency table and statistics table.
				−1	Table is not created.
					Weibull Probability or Relative Frequency Table
6	24	RANK	I4	blank,0	Ranked tabulation is not included in output.
				1	Ranked quantities with Weibull probabilities.
				2	Ranked quantities with relative frequencies.
					Skew Coefficients
7	28	SKEW	I4	Blank,0,1	Skew coefficients are computed.
				2	Skew coefficients are provided on SKEW record(s).
				3	Weighted skew coefficient combining 1 and 2 above.
				4	Skew coefficient provided in field 6.
				5	Weighted skew coefficient combining 1 and 4 above.
				6	Skew coefficients are all zero (log-normal).
8	29-36	SC1	F8.0	+ or −	Single skew coefficient for all control points.
					DSS Pathname Parts
9	37-52	PARTA	A16	AN	DSS pathname Part A.
10	53-68	PARTC	A16	AN	DSS pathname Part C.
11	69-84	PARTF	A16	AN	DSS pathname Part F.
12	85-100	PARTB	A16	AN	DSS pathname Part B for blank field 2 (NUM=0).

The 7DSS record computes frequency statistics for annual time series datasets read from a DSS file employing a log-Pearson type III or log-normal probability distribution function. With a skew coefficient of zero, the log-Pearson type III distribution becomes the log-normal distribution. SKEW option 6 sets a zero skew coefficient. The log-Pearson III or log-normal frequency analysis is controlled by input parameters TAB, SKEW, and SC1 in fields 4, 6, and 7. RANK in field 6 activates options for tabulates the ranked quantities with estimates of exceedance probabilities.

7DSS and 7FFA records perform essentially the same statistical frequency analysis computations but read different input data files (AFF versus DSS). Any annual time series data from any DSS file can be analyzed using a 7DSS record. Examples of annual times series that could be analyzed with a 7DSS record include the maximum or minimum end-of-day reservoir storage volume in each year, maximum or minimum daily observed, naturalized, or simulated regulation streamflow volume in each year, minimum 7-day, 15-day, or 60-day stream flow volume in each year, minimum or maximum monthly precipitation or evaporation depth in each year, total annual precipitation or evaporation depth, or annual volume of any other variable of interest.

A 7DSS record frequency analysis can be performed for a single data series that has a DSS pathname precisely defined by entries in 7DSS record fields 9, 10, 11, and 12, which includes the Part B identifier entered in for PARTB in 7DSS record field 12. Alternatively, any number (NUM in field 2) of DSS pathname part B identifiers can be entered on one or more IDEN records. The IDEN record described on page 237 is the same for both 7FFA and 7DSS records.

The SKEW record described on page 237 is also the same for both 7FFA and 7DSS records. A single skew coefficient for a single data series can be entered in 7DSS record field 7, or the skew coefficient can be set equal to zero by selecting SKEW option 6 in 7DSS field 7 or 7FFA field 6. The SKEW record (page 237) allows skew coefficients to be entered for each of the data series that have identifiers listed on an IDEN record (page 237).

Explanation of 7DSS Record Fields

Field 2: The one or more identifiers are pathname component Part B of the DSS records. The 7FFA record deals with storage and flows at control points. The dataset identifiers for a 7DSS record could represent control points but are actually generic data series identifiers with lengths of not to exceed 8 characters. NUM is the number of identifiers listed on one or more IDEN records that follow immediately behind the 7DSS record. A blank 7DSS field 2 means there is only one data series and it has the identifier entered for PARTB in 7DSS field 12.

Fields 3 and 4: The period-of-analysis is defined by the number of years and the first year.

Field 5: The log-Person Type III frequency analysis results are presented as a frequency table. An auxiliary statistics table shows the mean, standard deviation, minimum, and maximum for the dataset and the mean, standard deviation, and skew coefficient for the logarithms of the data.

Field 6: RANK options 1 and 2 tabulate the data in ranked order with probability estimates computed with the Weibull formula $[P=(m/(N+1))100\%]$ or the relative frequency formula $[P=(m/N)100\%]$, where m is rank and N is the number of years in the period-of-analysis.

Fields 7 and 8: The parameters of the log-Pearson III probability distribution are the mean, standard deviation, and skew coefficient of the logarithms of the data. The skew coefficient of the logarithms of the data can either be computed with *TABLES* or entered as input. The default is for the skew coefficient to be computed within *TABLES*. The mean and standard deviation of the logarithms are always computed within *TABLES*. If only one annual data series is analyzed, the skew coefficient can be entered in 7DSS field 8. Skew coefficients for multiple annual data series can be entered on a SKEW record, which is described on page 237.

Fields 9-12: The entries in fields 9, 10, 11, and 12 replicate the DSS pathname components A, C, F, and B on the DSS records in the DSS file. The parameter NUM in 7DSS record field 2 and the IDEN record (page 237) allow multiple DSS records to be selected by rotating pathname component B. 7DSS record field 12 is read only if field 2 is blank or zero. DSS pathname components D and E are automatically set as the period-of-analysis and annual interval.

The four entries of up to 16 characters each for DSS pathname parts A, C, F, and B can be placed anyplace within 7DSS fields 9, 10, 11, and 12 without left or right justification. The identifiers of up to 8 characters entered on IDEN records likewise do not require right or left justification.

CHAPTER 6
HEC-DSS DATA STORAGE SYSTEM AND HEC-DSSVUE

The Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (USACE) maintains a suite of generalized hydrologic, hydraulic, and water management simulation models that are applied extensively by numerous agencies and consulting firms throughout the United States and abroad. The HEC-DSS (Data Storage System) is used routinely with HEC simulation models and is also used with other non-HEC modeling systems including WRAP. Multiple simulation models share the same data management and graphics software. Data are stored in DSS files in a direct access binary format. Capabilities for creating and accessing DSS files are incorporated in software such as the WRAP programs by linking during compilation to routines from a HEC-DSS library of computer code developed by the HEC.

The HEC-DSS Visual Utility Engine (*HEC-DSSVue*) is a graphical user interface program for viewing, editing, manipulating, and graphing data in DSS files and performing statistical analyses and mathematical operations. *HEC-DSSVue* is explained in detail by a user's manual available at the HEC website along with the software. http://www.hec.usace.army.mil/

HEC-DSS and *HEC-DSSVue* are designed for efficiently working with datasets of time series data, including extremely large datasets. The *HEC-DSSVue* component of HEC-DSS provides flexible capabilities for data storage and management, plotting graphs, frequency analysis, and arithmetic operations. Data can be conveniently exchanged between *HEC-DSSVue* and Microsoft Excel. *HEC-DSSVue* directly accesses the U.S. Geological Survey (USGS) National Water Information System (NWIS) website and other online data sources.

WRAP Use of Data Storage System (DSS) Files

WRAP programs are applied in combination with *HEC-DSSVue* to create and employ DSS files. The WRAP programs include optional features for reading hydrology input data from DSS files or writing simulation results to DSS files. The different WRAP uses of DSS files are listed in Table 6.1 and described below. Although this *Users Manual* focuses on *SIM*, *SIMD*, and *TABLES*, the following DSS discussion is generally also relevant for *HYD*, *DAY*, and *SALT*.

- *SIM* and *SIMD* read monthly naturalized flow volumes and net evaporation-precipitation depths from *IN* and *EV* records stored in a DSS file instead of FLO and EVA files if INEV option 6 is selected in *JO* record field 2. With DSSFA, DSSFI, DSSRU, and/or DSSTS options activated in *JO* record fields 4, 5, 6, and/or 7, the following time series input data are read from the *SIM* and *SIMD* hydrology input DSS file: flow adjustment (*FA*), regulated-unappropriated flow adjustment (*RU*), hydrologic index (*HI*), and target series (*TS*) record data along with the *IN* and *EV* record data.

- *SIM* and *SIMD* have options activated in *OF* record field 6 and *JO* record fields 4-7 that create a hydrology DSS file from the *IN* and *EV* record data read from FLO and EVA files and *FA*, *HI*, *RU*, and *TS* record data converted from FAD, RUF, HIS, and TSF files to DSS records in a DSS file. The resulting DSS file is designed for use as a *SIM/SIM*D input file.

- Daily flow applications are described in the *Daily Manual*. With default DFFILE option 1 in *JU* record field 3, *SIMD* reads daily flows from a DSS file. With DFFILE option 2, *SIMD*

reads daily flows from the DIF file instead of the DSS file. With DFFILE option 3, *SIMD* reads daily flows from the DIF file and then stores the daily flows as DSS records in a DSS hydrology file. Monthly and daily hydrology data are stored in the same DSS file.

- *SIM* and *SIMD* write monthly or daily simulation results to a DSS file as specified by DSS(3) on the *OF* record. Various DSS-related options are controlled by parameters on the *OF* record. DSS options are applicable to CRM as well as conventional simulation results.

- *TABLES* reads monthly or daily time series from any DSS file as specified by DSSM and DSSD records. Options include converting DSS records to text format. DSS file datasets read with DSSM and DSSD records are accessed within *TABLES* by monthly (type 2) and daily (time 6) time series, frequency analysis, and reliability analysis routines.

- The *TABLES* 7DSS record controls frequency analyses of any annual series retrieved from any DSS file, which can include *SIM/SIMD* input or output files or any other DSS file.

- *TABLES* writes monthly or daily simulation results or annual summations thereof to a DSS file if specified by PT options 4 or 5 in field 3 of time series records. The 4ZZZ record also stores its analysis results in a DSS file if specified by PT options 4 or 5 in 4ZZZ field 3.

- As discussed in the *Hydrology Manual*, program *HYD* reads monthly flow volumes and/or evaporation-precipitation depths from a DSS file instead of *IN* and *EV* records in FLO and EVA files if JC(1) and JC(2) option 6 is selected in *JC* record fields 5 and 6. *HYD* writes monthly flows volumes and/or evaporation-precipitation depths to a DSS file if JC(8) and JC(9) option 6 is selected in *JC* record fields 12 and 13. Program *HYD* also includes options for converting *FA* records from a FAD file, *RU* records from a RUF file, *HI* records from a HIS file, and *TS* records from a TSF file to DSS records in a DSS file.

- As discussed in the *Daily Manual*, DSS is the standard default file format for the *Daily Flows* program (DAY.exe). Daily flows can be converted between DIF and DSS files. *DAY* also includes options for converting monthly flows between FLO and DSS files.

- As discussed in the *Salinity Manual*, the salinity loads and concentrations resulting from a program *SALT* simulation can be transferred by *TABLES* to a DSS file.

The primary WRAP uses of DSS files listed above consist of either (1) storing time series of hydrology input data for the simulation models (2) converting non-DSS hydrology input files to DSS files or vice versa, or (3) storing time series of simulation results. The options of adopting DSS input or output files for the programs listed in the second column of Table 6.1 are activated by the parameters listed in the third column.

SIM and *SIMD* can read one DSS hydrology input file and/or create one DSS simulation results output file. DSS filenames have the extension DSS. The *SIM/SIMD* input file has the filename rootHYD.DSS. The *SIM/SIMD* simulation results output file has the filename root.DSS, with the same root as the DAT and OUT or SUB files. Program *TABLES* can read any DSS file as well as other *SIM/SIMD* input and output text files and create DSS and TOU output files. The DSS output file created by *TABLES* has the filename rootOUT.DSS, where the root for the DSS output file is the same as the root for the *TABLES* output TOU file. OUT added to the *TABLES* output DSS filename differentiates between input and output DSS files with the same name.

Table 6.1
Different Uses of DSS Files by the WRAP Programs

Function	Program	Activation Switch
Read monthly *IN* and *EV* records.	*SIM* or *SIMD*	*JO* record INEV=6
Read monthly *FA* records.	*SIM* or *SIMD*	*JO* record DSSFA = 1
Read monthly *HI* records.	*SIM* or *SIMD*	*JO* record DSSHI = 1
Read monthly *RU* records.	*SIM* or *SIMD*	*JO* record DSSRU = 1
Read monthly *TS* records.	*SIM* or *SIMD*	*JO* record DSSTS = 1
Convert *IN* and *EV* records to DSS.	*SIM* or *SIMD*	*OF* record DSS(5) = 1
Convert *FA* records to DSS.	*SIM* or *SIMD*	*JO* record DSSFA = −1
Convert *HI* records to DSS.	*SIM* or *SIMD*	*JO* record DSSHI = −1
Convert *RU* records to DSS.	*SIM* or *SIMD*	*JO* record DSSRU = −1
Convert *TS* records to DSS.	*SIM* or *SIMD*	*JO* record DSSTS = −1
Read daily flows from DSS file.	*SIMD*	*JU* record DFFILE=1
Convert daily flows to DSS file.	*SIMD*	*JU* record DFFILE=3
Output monthly simulation results.	*SIM* or *SIMD*	*OF* record DSS(3)=1
Output monthly CRM results.	*SIM* or *SIMD*	*OF* record DSS(3)=1
Output daily simulation results.	*SIMD*	*OF* record DSS(3)=2,3
Read monthly or daily data from any DSS file.	*TABLES*	DSSM and DSSD records
Convert records from DSS to text file format.	*TABLES*	DSSM and DSSD records
Statistical analyses of annual series from DSS.	*TABLES*	7DSS record
Output monthly or daily simulation results.	*TABLES*	Time Series PT = 4, 5
Output monthly CRM results.	*TABLES*	Time Series PT = 4, 5
Output monthly flows in priority loop	*TABLES*	4ZZZ record PT = 4, 5
Output salinity simulation results.	*TABLES*	8SAL record PT= 4, 5
Read *HYD* hydrology input data.	*HYD*	*JC* record JC(1&2) = 6
Output *HYD* hydrology data.	*HYD*	*JC* record JC(8&9) = 6
Program *Daily Flows* flow data	*DAY*	*JC* record options

DSS files and *HEC-DSSVue* are particularly usefully for daily simulations. Daily pattern hydrographs and daily simulation results can be massive. Daily pattern hydrographs can be compiled and analyzed using *HEC-DSSVue* and stored in the hydrology DSS input file read by *SIMD*. Daily *SIMD* simulation results can be written directly to a DSS file. Alternatively, simulation results can be written by *SIMD* to a SUB file and converted to a DSS file with *TABLES* with adjustments such as aggregation to annual totals or moving averages. Options for adjusting and analyzing time series data are provided by both *TABLES* and *HEC-DSSVue*.

The monthly simulation results DSS file created directly by *SIM* provides special capabilities for conditional reliability modeling (CRM). Each DSS record in a DSS file created by *TABLES* covers the entire hydrologic period-of-analysis. The DSS file created directly by *SIM* has separate records for the multiple CRM simulation sequences. The DSS features of *TABLES* are designed for a 12-month year. DSS records created with *SIM* can contain CRM sequences of any integer number of months. CRM simulation results recorded in the *SIM* DSS output file includes control point and reservoir output records but does not include water right output records.

SIM and *SIMD* DSS Input File

SIM and *SIMD* can read one DSS hydrology input file and/or create one DSS simulation results output file. The *SIM/SIMD* input file has the filename rootHYD.DSS where the "root" is by default the root of the filename adopted for the DAT and OUT files and other files, and "HYD" is appended to the "root" to highlight that the time series input data in the file is mainly monthly and/or daily stream flows other hydrologic data sequences. The *SIM/SIMD* simulation results output file has the filename root.DSS, with the same root as the DAT and OUT files.

The optional single *SIM* input file contains any or all of the time series input data listed in Table 6.2 and described on page 122 of Chapter 3. The record identifiers listed in the fourth column of Table 6.2 are placed in the first two columns of the text file records or as pathname part C in DSS records. The data are described on the pages of Chapter 3 of this manual listed in the last column of Table 6.2.

Table 6.2
Types of Data in the *SIM* or *SIMD* Input DSS File

Time Series Data	*JO* Record Switch	Alternative Input Files	Record Identifier	Manual Pages
monthly naturalized flow volumes	INEV	DSS, DAT, FLO	IN	123
monthly evaporation-precipitation depths	INEV	DSS, DAT, EVA	EV	123
monthly naturalized flow adjustments	DSSFA, FAD	DSS, FAD	FA	48, 127
regulated-unappropriated flow adjustments	DSSRU, RUF	DSS, RUF	RU	48, 129
monthly hydrologic index	DSSHI	DSS, HIS	HI	48, 131
water right targets or flow depletion limits	DSSTS	DSS, DAT, TSF	TS	132
SIMD daily flow pattern hydrographs	*JU* DFFILE	DSS, DIF	DF	146, 172

The same DSS hydrology input file can be read by both *SIM* and *SIMD*. The *DF* record daily flows are read only in a daily *SIMD* simulation. The DSS file can also include any other irrelevant data that are not actually read by *SIM* or *SIMD*. The programs read only those DSS records specified by input parameters entered on the *JO* and *OF* records in the DAT file. *IN* and *EV* records are read from the DSS file if and only if INEV option 6 is selected in *JO* record field 2. *FA*, *RU*, *HI*, and *TS* record quantities are read from the DSS file if and only if specified by DSSFA, DSSRU, DSSHI, and DSSTS, respectively, in *JO* record fields 4, 5, 6, 7. Otherwise, the time series data, if read, must be read from the files listed in the table above. Control point identifiers listed on *FA*, *RU*, *HI*, and *TS* identifier records in the DAT connect to *FA*, *RU*, *HI*, and *TS* record quantities in the DSS file.

A DSS file can be created, and the time series data listed in Table 6.2 can be converted to the DSS file from *IN, EV, FA, HI, RU,* and *TS* records stored in FAD, HIS, RUF, DAT, and/or TSF files. *IN* and *EV* records are read from FLO and EVA files and stored in the DSS file if activated by DSS(5) on the *OF* record. An entry of −1 for DSSFA, DSSHI, DSSRU, and DSSTS in *JO* record fields 4-7 specify that the *FA, HI, RU,* and *TS* time series, respectively, are included in the DSS file. The resulting DSS file serves as the rootHYD.DSS simulation input file.

DSS File *OF* Record

     SIM input and output files are described in Chapter 2. *SIM* and *SIMD* monthly hydrology input files are controlled by INEV in *JO* record field 2. *OF* record entries are used to activate *SIM* and *SIMD* output files and select simulation results variables to include in the output files. The functions and parameters of the *OF* record are described on pages 45-47 of Chapter 3. The input parameters entered on the *OF* record are listed below in Table 6.3.

Table 6.3
SIM/SIMD DSS File *OF* Record Input Parameters

Field	Parameter	Function Controlled by Parameter
1	CD	Record identifier OF.
2	DSS(1)	OUT output file activation.
3	DSS(2)	Multiple-reservoir tracking variables recorded in DSS file.
4	DSS(3)	DSS simulation results output file activation.
5	DSS(4)	Selection of variables included in the DSS output file.
6	DSS(5)	Conversion of FLO and EVA files to DSS file.
7	DSS(6)	DSS message file options.
8	DSS(7)	Option to exclude records with only quantities of zero.
9	DSSMONTH	First month in DSS file (JAN, FEB, ... , DEC). Default JAN
10	DSSUNITS(1)	DSS volume units. Default = AC-FT
11	DSSUNITS(2)	DSS evaporation-precip units. Default = FEET
12	DSSUNITS(3)	DSS daily pattern flow units. Default = AC-FT
13	DSSROOT	Filename root of DSS input file. Default is root of other files.
	Auxiliary *OF* Record Listing Output Variables	
1	CD	Record identifier OF.
2-44	DSSV(I) I=1,DSS(4)	Integer identifiers of variables listed on page 47.

SIM and SIMD Output OUT and DSS Files

     DSS(1) and DSS(3) in *OF* record fields 2 and 4 are switch parameters for selecting the types of output files created by *SIM* or *SIMD* for recording their time series of simulation results. The alternative output files that may be selected for activation are OUT or CRM and DSS with monthly results or DSS with daily results. Without an *OF* record, by default, the OUT is created automatically by *SIM* or *SIMD*. With an *OF* record inserted in the DAT file, the OUT file is created only if specified by DSS(1) options 1 or 2. A *SIMD* daily output SUB file is created by a positive entry for SUBFILE in *JT* record field 13. Otherwise, the default is to not create a SUB file. A DSS output file is created to store *SIM* or *SIMD* simulation results if and only if option 1 (monthly data), option 2 (both monthly and daily data), or option 3 (daily data) is selected with switch parameter DSS(3) in *OF* record field 4. DSS(2) activates an option that records additional information in the DSS output file for tracking *OR* record multiple-reservoir system operations.

The conventional OUT file activated with DSS(1) option 1 (or no *OF* record) includes all of the *SIM/SIM* monthly simulation results for the entire hydrologic period-of-analysis for the water rights, control points, and reservoirs selected by the output selection input parameters on the *JD*, *WO*, *GO*, *CO*, and *RO* records. DSS(1) option 2 consists of creating an OUT file that includes only a listing of the selected water rights, control points, and reservoirs without the simulation results. The DSS(1) option 2 OUT file also includes the beginning year (YRST) and number of years (NYRS) in the hydrologic period-of-analysis and the total number of water rights, control points, and reservoirs. The list of selected water rights includes the water right identifier, control point identifier, annual target, priority number, and group identifiers for each water right. The list of control points includes the identifiers of each control point and its next downstream control point. The list of selected reservoirs includes the reservoir identifier, control point location of the reservoir, and total conservation storage capacity.

The OUT created with *OF* record DSS(1) option 2 may be read by the *TABLES* DSSM or DSSD records (discussed later) with MID options 5, 6, or 7 (Table 6.4) to determine identifiers for DSS records to be read from a DSS file. The DSSM or DSSD record routines can read either a DSS(1) option 1 or DSS(1) option 2 OUT file. Whichever form of OUT file found by *TABLES* is read automatically for the DSSM or DSSD record routines, without users instructions. The OUT file listings created with DSS(1) option 2 may also be used simply for information purposes. These lists are useful for various purposes.

Simulation Results Variables Recorded in SIM/SIMD DSS Output File

DSS(4) options for selecting simulation results time series variables for inclusion in the DSS output file include a default selection of variables, all variables, or those variables listed on a second auxiliary *OF* record. The simulation results variables are listed on page 47.

Conversion of FLO and EVA Files to a DSS Hydrology File

DSS(5) activates a routine that converts monthly FLO and EVA files to a hydrology input DSS file. Similar options for *FA*, *RU*, *HI*, and *TS* records are activated by *JO* record entries.

DSS Record Parameters

DSS(6) in *OF* record field 7 controls the level of error checks and accompanying error messages activated when records are read from or written to DSS files. By default, DSS records start in January but can start in any other month as specified by DSSMONTH. DSSUNITS(1,2,3) specify the units of the quantities in the DSS input and output files, with the defaults shown in Table 6.3. Units are included in the headings of *HEC-DSSVue* tabulations and may affect some options but do not affect most *HEC-DSSVue* operations.

By default, *SIM/SIMD* assumes the DSS hydrology input file has the hydrology filename root specified during the execution process, which is the same as the DIS file, which defaults to the root of the DAT file. The file naming option in field 13 facilitates sharing the same hydrology input file by multiple *SIM/SIMD* input datasets. Many different simulations involving files with different filename roots can access the same hydrology input DSS file. The term *HYD* is automatically appended to DSSROOT entered in field 13 and the extension DSS is added.

SIM and *SIMD* Simulation Results DSS Output File

Control points, water rights, and reservoirs/hydropower projects are selected for inclusion in the *SIM* and *SIMD* output OUT, CRM, SOU, SUB, and DSS files in the same manner, which is described on page 23 of Chapter 2, page 50 of Chapter 3, and pages 139-141 of Chapter 4. Unlike the DSS output file, the other output files contain an automatically pre-determined set of *SIM/SIMD* simulation results variables to be output for each of the selected control points, water rights, and reservoirs. The DSS(4) options on the *OF* record allow the model-user to select which simulation results variables to include in the DSS and/or SOU output files.

SIM and *SIMD* can read only one DSS hydrology input file and/or create only one DSS simulation results output file. DSS filenames have the extension DSS. The term *HYD* is appended to the root of the filename of input file to distinguish it from the output file which would otherwise have the same default filename root. The *SIM/SIMD* simulation results output file has the filename root.DSS, with the same root as the DAT and OUT or SUB files.

In reading DSS files, the WRAP programs read only relevant DSS records. Any number of other DSS records with any other type of data contained in the DSS file are ignored.

With the exception of DSS files, the WRAP programs over-write existing output files with the same filename. The old file is replaced in its entirety. When recording data in an existing DSS file with a specified filename, the WRAP programs and *HEC-DSSVue* store new data records without removing the old data records already stored in the DSS file. Individual data records with the same pathnames are over-written, but new records with new pathnames are added.

The results of any number of *SIM* and/or *SIMD* simulations and other datasets can be stored in in the same DSS file for convenient comparative analyses performed with *HEC-DSSVue* and/or *TABLES*. The *HEC-DSSVue* editor includes options for renaming parts of pathnames for selected groups of DSS records. Pathname parts A and/or F can be quickly and easily renamed for all simulation results DSS records generated by a particular *SIM/SIMD* simulation for identification purposes when comparing results of multiple simulations. The results for only one single simulation can be recorded in an OUT or SUB file.

Input parameter DUALD in *JO* record field 16 includes an option for deactivating the dual simulation. *SIM* or *SIMD* can be simulated twice, with and without the dual simulation, with results of both simulations included in the same DSS file for comparison.

WRAP Program *TABLES* DSS Input and Output Files

Program *TABLES* can read any DSS file as well as other *SIM/SIMD* input and output text files and create a DSS file as well as TOU and other text-format output files. *TABLES* can create one DSS input file and/or one DSS output file. *TABLES* filenames can have three different roots (input root, output root, *SIM/SIMD/SALT* root), which default to the same filename root. The *TABLES* input DSS filename root is entered in the same WinWRAP input box as the *SIM/SIMD/ SALT* filename root. The DSS output file created by *TABLES* has the filename rootOUT.DSS, where the root for the DSS output file is the same as the root for the *TABLES* output TOU file.

Overview Inventory of TABLES Uses of an Input DSS File or Output DSS File

      TABLES employs DSS input and output files as follows.

- DSSM and DSSD records described on pages 190-191 read any monthly and daily time series records from any DSS file, which includes *SIM/SIM* input or output files or any other DSS file. The monthly and/or daily datasets are stored as arrays in computer memory that are accessed by time series analysis (pages 202—208), reliability analysis (pages 209-212), and frequency analysis (pages 213-216) records. The DSSM record also includes an option for converting data from a DSS file to text file records in *SIM* hydrology input text file format.

- The 7DSS file described on pages 239-240 reads any annual series data from any DSS file for purposes of performing statistical frequency analyses based on the log-Pearson type III or log-normal probability distribution functions and relative frequency formulas. Several examples of the many annual times series variables that are relevant for 7DSS record analyses include minimum 7-day, 15-day, or any period stream flow volumes in each year, peak daily flood flows in each year, minimum or maximum daily or monthly reservoir storage volumes in each year, minimum or maximum monthly precipitation or evaporation depths in each year, or total annual volumes, depths, or mean flow rates of any variable.

- Time series record PT options 4 and 5 (page 206) write monthly or daily values any of the 35 time series variables listed on pages 202-205, or other variables computed therefrom, to a DSS output file.

- The 4ZZZ record described on pages 226-227 records monthly time series of stream flows and reservoir releases in a DSS file if specified by PT options 4 or 5 in 4ZZZ field 3.

- The TABLES 8SAL record described in the *Salinity Manual* stores sequences of monthly salinity loads and concentrations in the *TABLES* output DSS file.

      TABLES can read monthly, daily, and annual time series from any DSS file as specified by DSSM, DSSD, and 7DSS records in the *TABLES* input TIN file. Any DSS file can be read. Pathnames can be renamed. However, many or most applications of *TABLES* input DSS files will likely involve reading *SIM* or *SIMD* input or simulation results output files with *TABLES*.

      The type 2 and type 6 time series records, 4ZZZ record, and 8SAL record include options for recording results in a *TABLES* output DSS file. Any of the variations of any of the 35 time series variables listed on page 205, time series variables created with a DATA record, time series variables read from a DSS file with DSSM or DSSD records, or other variables created by manipulations of these variables performed by *TABLES* can be included in the DSS output written by PT options 4 and 5 in field 3 of the time series records. The 4ZZZ and 8SAL records likewise include options for including time series of the results of their particular analyses of *SIM* or *SALT* simulation results in the DSS output file.

DSSM and DSSD Records

      DSSM or DSSD records are inserted in a *TABLES* input TIN file to read monthly or daily time series data from a DSS file which are stored by *TABLES* in computer memory as an array.

This time series array is employed by *TABLES*, similarly to *SIM* or *SIMD* simulation results read by *TABLES* from OUT or SUB files, in the following alternative ways.

- The DSSM record includes an option for writing the monthly time series dataset to the TOU file as a set of records in standard *SIM* hydrology input record format. For example, datasets of *IN* record naturalized flows and *EV* record evaporation-precipitation rates can be quickly and easily converted from a DSS file to FLO and EVA files.

- The DSSD record includes an option for creating daily time series tables in the TOU file in a format in which each row has 28, 29 (leap year February), 30, or 31 daily values.

- Entering 2DSS or 6DSS in field 1 of the time series records (pages 205-206) activates an option in which the array created by a DSSM or DSSD record is treated in the same manner as if the data series had been read from an OUT or SUB file.

- Variable ID option 16 in 2FRE, 2FRQ, 6FRE, 6FRQ record field 2 reads the array created by a DSSM or DSSD record and performs frequency analyses in the same manner as if the data series had been read from an OUT or SUB file.

- ID option 5 in 2REL and 6REL record field 4 reads the array created by a DSSM or DSSD record and performs reliability analyses in the same manner as if the data series had been read from an OUT or SUB file.

Combining a 2REL or 6REL record with a DSSM or DSSD record to perform reliability analyses requires an entry of RELIAB for parameter PARTC in DSSM/DSSD record field 9. Reliability analyses require two of the following three time series: (1) targets for water supply diversions or hydropower electric energy production, (2) shortages in supplying the targets, (3) actual diversion or energy generation defined as target less shortage. Entering RELIAB in DSSM or DSSD record field 9 activates the following strategy. Water supply diversions are associated with control points or water right output records read from the DSS file and resulting DSSM/DSSD array. Hydroelectric power is associated with reservoir output records. The variables included in *SIM/SIMD* output files are listed on page 47 of Chapter 3 and pages 202-205 of Chapter 5 of this manual. Referring to the simulation results variable list on page 47, the variables TAR (12 or 20) and SHT (13 or 21) are employed in reliability analyses of diversions. Variables HPE (35) and HPS (34) are read and applied in hydropower reliability computations.

Reliability analyses require specific variables as discussed in the preceding paragraph. However, the *TABLES* time series record operations and frequency analyses can be performed with many different variables, including quantities that are not included in the *SIM/SIMD* input and output files. For example, using DSSMM and DDSD records, *TABLES* time series and 2FRE/6FRE records can be employed with daily observed flows from the U.S. Geological Survey National Water Information System database or monthly precipitation or evaporation rates from the quadrangle databases maintained by the Texas Water Development Board. Entries for PARTA, PARTB, PARTC, and PARTF in DSSM/DSSD record fields 7, 8, 9, and 10 can be devised to fit the particular dataset of interest. However, many or most applications of the DSSM and DSSD record features of *TABLES* will involve *SIM* or *SIMD* input or output files. DSS pathname conventions for *SIM* and *SIMD* input and output files are shown in Tables 6.6 and 6.7.

The terms *control points*, *water rights*, and *reservoirs* have specific definitions when dealing with input and output records for a *SIM* or *SIMD* simulation. However, in general, the

DSSM and DSSD pathname parts are not necessarily restricted to these definitions, but are rather generic labels for the data sequences in the dataset which may be arbitrary identifiers.

Time series data sequences are labeled by pathnames with pathname parts A, B, C, D, E, and F, as discussed in the next section of this chapter. A single DSS pathname may be specified on a DSSM or DSSD record. Alternatively, any number of DSS records can be read with a single DSSM or DSSD record following labeling rules defined by multiple identifier MID options selected in DSSM/DSSD record field 2. Multiple DSS records are selected by either multiple pathname Part B identifiers or multiple pathname Part F identifiers. Control point (IDCP(I)), water right (IDEN16(I)), and reservoir (IDRES(I)) identifiers are read from either IDEN records following the DSSM or DSSD record in the TIN file or from the *SIM/SIMD* output OUT file. As noted in the preceding two paragraphs, the IDCP(I), IDEN16(I), and IDRES(I) identifiers listed on IDEN records will typically, but not necessarily always, represent control points, water rights, and reservoirs. The MID options are listed in Table 6.4.

MID options 5, 6, and 7 read IDCP(I), IDEN16(I), or IDRES(I) identifiers from an output OUT file created by *SIM* or *SIMD*. *OF* record field 2 DSS(1) option 2 creates a version of the OUT file that simply lists the identifiers of water rights, control points, and/or reservoirs selected for output with the normal *SIM* output selection input parameters, without recording the actual voluminous simulation results. The DSSM/DSSD routines automatically read whichever OUT file is found, which may be the conventional OUT file or the DSS(1) option 2 list of identifiers.

Table 6.4
Multiple Identifier MID Options Selected in DSSM or DSSD Record Field 2

MID Option	Pathname Part	Identifiers	Source
1	Part B	IDCP(I)	IDEN records
2	Part B	IDEN16(I)	IDEN records
3	Part F	IDEN16(I)	IDEN records
4	Part F	IDRES(I)	IDEN records
5	Part B	IDCP(I)	OUT File
6	Part F	IDEN16(I)	OUT File
7	Part F	IDRES(I)	OUT File

Several DSS record parameters may be specified on the FILE record (page 189). With no FILE record inserted in the TIN file, defaults are activated for the DSS record specifications.

DSS Record Pathnames

DSS files store data records labeled with pathnames. For the DSS files used with WRAP, the DSS records are typically hydrologic period-of-analysis sequences of monthly or daily *SIM* or *SIMD* hydrology time series input data or simulation results or variables computed therefrom. DSS pathnames assigned to the data records facilitate convenient identification and selection. DSS records are identified, inventoried, and sorted in *HEC-DSSVue* by pathname, are connected to WRAP programs by pathname, and are referenced within WRAP programs by pathname.

DSS pathnames are defined with six standard components called Parts A, B, C, D, E, and F as explained in the *HEC-DSSVue* User's Manual. *HEC-DSSVue* automatically creates a catalog file with extension DSC listing all records in the DSS file by their pathnames. The pathnames for the output DSS file created by *SIM*, *SIMD* or *TABLES* are automatically defined within the programs, as shown in Tables 6.5 and 6.7. *SIM and SIMD* read a single DSS hydrology input file, with filename rootHYD.DSS. All relevant hydrology data are stored in the same DSS input file. The *SIM/SIMD* hydrology input DSS file records have pathname parts /A/B/C/D/E/F/ defined in Table 6.6. Daily flow *DF* records (part C) are read by *SIMD* only, not *SIM*. The *IN*, *EV*, *FA*, *HI*, *RU*, and *TS* records are read by both *SIM* and *SIMD*.

Table 6.5
DSS Pathname Parts for Output DSS File Created by *TABLES* Time Series Records

---

A − Filename root which is the same as the TOU filename root.

B − Control point identifier, water right or group identifier, or reservoir identifier.

C − Type of data such as 2NAT, 2REG, 2UNA, 2STO, 2IFT, 2DIV, 2EVA, as defined on pages 202-205.

D − Range of record blocks encompassing the hydrologic period-of-analysis.

E − 1DAY, 1MON, or 1YEAR specifying daily, monthly, or annual time interval.

F – CP, WR, Res, or WRG indicating the data record is for a control point, water right, reservoir, or water right group.

Table 6.6
DSS Record Pathname Parts for *SIM* and *SIMD* Input DSS File

---

A – Hydrology filename root without the appended HYD. This is the filename root entered at the initiation of the *SIM* or *SIMD* execution or optionally specified in *OF* record field 12.

B − Control point identifier that matches a control point identifier CPID(cp,1) found on a DAT file *CP* record. *TS* records allows other identifiers.

C – DF for daily flow
IN for monthly naturalized flow
EV for monthly net evaporation-precipitation
FA for monthly flow adjustments
HI for monthly hydrologic index
RU for monthly regulated-unappropriated flow adjustments
TS for monthly water right target series

D – Range of DSS record blocks that contain the data series.

E – 1MON for monthly data or 1DAY for daily data.

F – Part F is not used for the hydrology input file and is left empty.

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Table 6.7
DSS Record Pathname Parts for *SIM* and *SIMD* Output DSS File

---

A − Filename root which is the same as the DAT, OUT, or CRM filename root.

B − Control point identifier.

C − Type of data, such as NAT, REG, UNA, STO, IFT, DIV, EVA (page 47) combined with -CP, -WR, or -RE (control point, water right, reservoir).

D − Range of record blocks encompassing the hydrologic period-of-analysis.

E − 1DAY, 1MON, or 1YEAR specifying daily, monthly, or annual time interval.

F − Sequence identifier for conditional reliability modeling (CRM).
CP or CP Daily for non-CRM control point simulation output records.
Water right or reservoir identifiers for water right or reservoir output records.

Errors in Reading DSS Files

Chapter 9 of the *Reference Manual* is entitled *Detecting Errors and Irregularities in Data Files*. The last section of Chapter 9 entitled *Locating Errors in DSS Files* provides guidance in dealing with problems in accessing DSS files. The DSS-related errors that are most likely to occur in applying the WRAP programs are a missing file, one or more missing records in a file, or missing data in a record. If a WRAP program attempts to read a DSS input file that does not exist, the program will create an empty DSS file and then terminate execution with an error message similar to the following stating that data was not found.

```
-----DSS*** ZRRTS:  CAUTION - Data block not found in file.  Unit:   25
Pathname: /FUNDEXAM/PK/IN/01JAN1940/1MON//
ERROR: DSS IOSTAT error 5 occurred reading flows from DSS file: FundExam
```

A similar error message is generated by one or more missing records in an existing file or gaps of one or more periods of missing data in a DSS record. As explained in Chapter 9 of the *Reference Manual*, the *HEC-DSSVue* option path */Display/Tabulate/Edit/Show Missing/Find/* can be employed to find periods of missing data in DSS file records.

DSS(6) in *OF* record field 7 sets alternative levels of DSS information to be written to the *SIM/SIMD* message file. Likewise, the same error message options can be activated for *TABLES* using the parameter DSSMES on the FILE record. Basic DSS error and warning messages are included with default level 2. Higher levels provide additional trace and information in the MSS or TMS file. Message level 4 writes pathnames to the message file as the DSS records are read, which is useful in finding the record that causes the program to terminate with an error message.

HEC-DSSVue

The HEC-DSS Visual Utility Engine (*HEC-DSSVue*) software and its very detailed User's Manual can be downloaded free-of-charge from the USACE Hydrologic Engineering Center website: http://www.hec.usace.army.mil/. The program can be quickly installed and conveniently employed on computers operating under Microsoft Windows.

HEC-DSSVue can be used to create and analyze a variety of datasets in various types of studies. *HEC-DSSVue* provides efficient tools for compiling gaged stream flows and other data and employing these data to develop WRAP input datasets. Observed daily flows at pertinent gaging stations can be downloaded with *HEC-DSSVue* directly from the USGS NWIS website. Convenient capabilities are provided for working with large datasets containing any time series variables, including input data and simulation results for the WRAP programs.

HEC-DSSVue is used to develop and update *SIM*/*SIMD* hydrology input files and to organize, display, and analyze *SIM*/*SIMD* simulation results. Monthly *SIM* simulation hydrology input datasets always include monthly naturalized flows and evaporation-precipitation depths. Monthly time series stored in the DSS file may also include naturalized flow adjustments *FA*, regulated-unappropriated flow adjustments *RU*, hydrologic index *HI*, and/or water right target series *TS* quantities. Daily *SIMD* simulation hydrology input datasets also include daily flow *DF* record pattern hydrographs. *SIM* or *SIMD* simulation results recorded in a DSS output file include monthly and/or daily versions of hydrologic period-of-analysis sequences of any or all of the 42 time series quantities generated in the simulation which are listed on page 47.

HEC-DSSVue provides diverse and flexible time series data manipulation, plotting, analysis, and display features that include an extensive array of optional capabilities. Several basic capabilities that are particularly relevant to WRAP applications are noted as follows.

- Creating, accessing, viewing, and modifying DSS files.
- Sorting through large datasets to conveniently view and access data series of interest.
- Comprehensive flexible features for plotting time series for viewing and comparative analyses on a computer monitor and preparation of final report-quality graphs.
- Tabular display, comparison, summation, and editing of the time series data.
- Statistical analyses including basic statistics, duration or frequency analyses, frequency plots, and regression analyses.
- Time functions including (1) changing time intervals such as aggregating daily-to-monthly or monthly-to-annual, (2) finding minimum, maximum, or average values for specified time intervals, and (3) computing cumulative totals or moving averages.
- Mathematical computations applied to entire time series.
- Transporting data between DSS files, Microsoft Excel spreadsheets, and Word documents.
- Directly importing observed stream flow or other data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) website to a DSS file.

The last capability listed above is not currently functional until *HEC-DSSVue* is updated by the Hydrologic Engineering Center to accommodate recent modifications by the USGS of the NWIS. The Hydrologic Engineering Center's *Statistical Software Package (HEC-SSP)* includes a similar feature for downloading data from the USGS NWIS website that has been updated for consistency with the recent modifications to the USGS NWIS website.

The myriad of optional capabilities and variations of methods provided by *HEC-DSSVue* are explained in detail in its 490 page user's manual. Several basic features that are particularly relevant when working with WRAP datasets are briefly noted as follows.

HEC-DSS

Accessing DSS Files

DSS files are created and/or read by the WRAP programs, *HEC-DSSVue*, or other software with DSS access capabilities. DSS files have the filename extension DSS. *HEC-DSSVue* can be activated by all of the methods provided by Microsoft Windows for activating executable programs, assuming *HEC-DSSVue* has been installed on the computer. For example, mouse clicking a DSS file activates *HEC-DSSVue*.

When recording data in an existing DSS file with a specified filename, *HEC-DSSVue* and the WRAP programs store new data records with new pathnames without removing the old data records already stored in the DSS file. Individual data records with the same pathnames are over-written, but new records with new pathnames are added.

When a DSS file is created or accessed using *HEC-DSSVue*, an auxiliary catalog file with filename extension DSC is automatically created that provides a list of the pathnames of the DSS records contained in the DSS file. *HEC-DSSVue* updates the catalog DSC file with each revision or addition of DSS records automatically without the necessity of user directions. The DSC file is a text file that can be read with common text editors such as Microsoft WordPad.

Conventions for Specifying Data Time Interval, Type, and Units

Pathname Part E is the time interval, which is 1DAY, 1MON, or 1YEAR for daily, monthly, and annual data series. Other time intervals can also be adopted. Part D contains the range of data blocks based on standard block lengths of one year for daily, one decade for monthly, and one century for annual data. The range listed in the record catalog on the computer monitor is for complete time blocks that encompass the actual range of time covered by the data.

Each quantity is assigned an instant in time. In general, DSS files of daily or monthly data can function correctly with the instant in time being either the beginning or ending of the time interval. However, the WRAP programs employ the convention of assigning the time 24:00 hours (midnight) at the end of the time interval. Daily gaged flows imported from the USGS NWIS website by *HEC-DSSVue* employ this same convention. For example, the monthly flow for January 1940 has the date and time 31 January 1940, 2400 hours. The daily flow for January 1, 1940 has the date and time 1 January 1940, 2400 hours.

Datasets from different sources may define 24:00 hours (midnight) as the beginning versus the end of the time interval. Dates are adjusted for comparison consistency using the option path: *Tools – Math Functions – Time Functions – Shift in Time – Shift to date/time*.

The data type, units, and pathname components for selected DSS records can be changed within *HEC-DSSVue* using the *Tabular Edit* option from the *Edit* menu.

HEC-DSSVue recognizes four data types (PER-AVER, PER-CUM, INST-VAL, INST-CUM) as explained by the *HEC-DSSVue* User's Manual. The standard default conventions adopted for WRAP include labeling monthly or daily flow volumes and precipitation-evaporation depths with the type "PER-CUM", meaning cumulative during period. The data type can be changed

with the *TABLES* FILE record parameter DSSTYPE. Daily mean flow rates in cfs should be assigned the type "PER AVER", meaning the average rate over the period.

The standard default units adopted by the WRAP programs for DSS records are acre-feet for flow volumes and feet for precipitation-evaporation depths. Other units can be assigned to DSS data using entries for DSSUNITS(1), DSSUNITS(2), and DSSUNITS(3), in *SIM/SIMD OF* record fields 10, 11, and 12 or *TABLES* FILE record field 3.

Basic HEC-DSSVue Operations

The 490-page *HEC-DSSVue* User's Manual available at the HEC website provides detailed explanations of how to employ an extensive inventory of optional capabilities activated within the *HEC-DSSVue* menu structure (http://www.hec.usace.army.mil/). The *HEC-DSSVue* software is very intuitive allowing users to easily employ most of the basic features without needing to reference the user's manual. However, the *HEC-DSSVue* User's Manual enhances all applications of the software and is essential for more complex applications. The mechanics of employing several basic features useful in WRAP related applications are highlighted in the remainder of this chapter.

Cataloging and Searching DSS Records

HEC-DSSVue is organized based on DSS records with pathnames with component parts A, B, C, D, E, and F as illustrated in Tables 6.5, 6.6, and 6.7 and Figure 6.1. Pathnames facilitate organizing and searching large datasets for convenient data series identification, cataloging, sorting, and searching. The standard pathname conventions employed for *SIM/SIMD* input and output DSS files are described earlier in this chapter. However, other DSS datasets can be employed in WRAP-related studies in which the user assigns the pathnames.

Pathname parts D and E serve fixed purposes, but the other parts generally can be assigned at the user's discretion. The pathname parts can be named and renamed applying *HEC-DSSVue* editor options. Selected groups of records can be quickly renamed. For example simulation results from multiple *SIM* or *SIMD* simulations can be recorded in the same DSS file for comparative analyses, with parts of the pathname renamed to differentiate the alternative simulations. DSS records in a *SIM/SIM* input file must have pathnames as described in Table 6.5

For convenient searching, sorting, viewing, and comparison of data records, the following options are suggested for selection in the *View* menu of *HEC-DSSVue*: *condensed catalog* and *search pathnames by parts*. With these options, the main window has the organization format shown in Figure 6.1. Data records can be sorted in alphabetical and numerical order using any of the pathname parts. The list of data records shown on the monitor can be controlled by entries in the search boxes using any combination of the pathname parts. Any number of data records upon which to perform operations of interest can be selected using the *select*, *de-select*, and *clear selection* buttons. The *set time window* button can be used to narrow the time period considered in viewing and manipulating the selected time series records.

Figure 6.1 shows the *HEC-DSSVue* main menu with the *SIM* simulation results file for the *Fundamentals Manual* example opened. The DSS file contains 235 records of which the

pathnames for the first 45 records are seen in the main window replicated in Figure 6.1. The scroll bar is used to scroll through the 235 records. The search boxes are used to search for records by pathname parts A, B, C, D, E, and/or F. A record consisting of 1940-2016 (Part D) monthly (Part E) naturalized flows (Part C) for control point (Part F) BELTON (Part B) stored in the DSS file with filename root FundExam (Part A) is shown in the selection area at the bottom of the main menu window of Figure 6.1 as having been selected for performing some operation.

/FundExam/BELTON/NAT/31JAN1940-31JAN2016/1MON/CP

File Edit View Display Groups Data Entry Tools Advanced Help

File Name: C:/WRAP/AAA - Fundamentals Manual Example/FundExam.dss
Pathnames Shown: 235   Pathnames Selected: 8   Pathnames in File: 1880   File Size: 1.94 MB

FundExam.dss ×

Search A:
By Parts: B: C: D: E: F:

Number	Part A	Part B	Part C	Part D / range	Part E	Part F
1	FUNDEXAM	BELTON	EPD	31Jan1940 - 31Dec2016	1MON	RES
2	FUNDEXAM	BELTON	EVA	31Jan1940 - 31Dec2016	1MON	RES
3	FUNDEXAM	BELTON	NAT	31Jan1940 - 31Dec2016	1MON	CP
4	FUNDEXAM	BELTON	REG	31Jan1940 - 31Dec2016	1MON	CP
5	FUNDEXAM	BELTON	SHT	31Jan1940 - 31Dec2016	1MON	CP
6	FUNDEXAM	BELTON	STO	31Jan1940 - 31Dec2016	1MON	CP
7	FUNDEXAM	BELTON	STO	31Jan1940 - 31Dec2016	1MON	RES
8	FUNDEXAM	BELTON	TAR	31Jan1940 - 31Dec2016	1MON	CP
9	FUNDEXAM	BELTON	UNA	31Jan1940 - 31Dec2016	1MON	CP
10	FUNDEXAM	BELTON	WSE	31Jan1940 - 31Dec2016	1MON	RES
11	FUNDEXAM	BRYAN	NAT	31Jan1940 - 31Dec2016	1MON	CP
12	FUNDEXAM	BRYAN	REG	31Jan1940 - 31Dec2016	1MON	CP
13	FUNDEXAM	BRYAN	SHT	31Jan1940 - 31Dec2016	1MON	CP
14	FUNDEXAM	BRYAN	STO	31Jan1940 - 31Dec2016	1MON	CP
15	FUNDEXAM	BRYAN	TAR	31Jan1940 - 31Dec2016	1MON	CP
16	FUNDEXAM	BRYAN	UNA	31Jan1940 - 31Dec2016	1MON	CP
17	FUNDEXAM	CAMER	NAT	31Jan1940 - 31Dec2016	1MON	CP
18	FUNDEXAM	CAMER	REG	31Jan1940 - 31Dec2016	1MON	CP
19	FUNDEXAM	CAMER	SHT	31Jan1940 - 31Dec2016	1MON	CP
20	FUNDEXAM	CAMER	STO	31Jan1940 - 31Dec2016	1MON	CP
21	FUNDEXAM	CAMER	TAR	31Jan1940 - 31Dec2016	1MON	CP
22	FUNDEXAM	CAMER	UNA	31Jan1940 - 31Dec2016	1MON	CP
23	FUNDEXAM	GEORGE	EPD	31Jan1940 - 31Dec2016	1MON	RES
24	FUNDEXAM	GEORGE	EVA	31Jan1940 - 31Dec2016	1MON	RES
25	FUNDEXAM	GEORGE	NAT	31Jan1940 - 31Dec2016	1MON	CP
26	FUNDEXAM	GEORGE	REG	31Jan1940 - 31Dec2016	1MON	CP
27	FUNDEXAM	GEORGE	SHT	31Jan1940 - 31Dec2016	1MON	CP
28	FUNDEXAM	GEORGE	STO	31Jan1940 - 31Dec2016	1MON	CP
29	FUNDEXAM	GEORGE	STO	31Jan1940 - 31Dec2016	1MON	RES
30	FUNDEXAM	GEORGE	TAR	31Jan1940 - 31Dec2016	1MON	CP
31	FUNDEXAM	GEORGE	UNA	31Jan1940 - 31Dec2016	1MON	CP
32	FUNDEXAM	GEORGE	WSE	31Jan1940 - 31Dec2016	1MON	RES
33	FUNDEXAM	GRANG	EPD	31Jan1940 - 31Dec2016	1MON	RES
34	FUNDEXAM	GRANG	EVA	31Jan1940 - 31Dec2016	1MON	RES
35	FUNDEXAM	GRANG	NAT	31Jan1940 - 31Dec2016	1MON	CP
36	FUNDEXAM	GRANG	REG	31Jan1940 - 31Dec2016	1MON	CP
37	FUNDEXAM	GRANG	SHT	31Jan1940 - 31Dec2016	1MON	CP
38	FUNDEXAM	GRANG	STO	31Jan1940 - 31Dec2016	1MON	CP
39	FUNDEXAM	GRANG	STO	31Jan1940 - 31Dec2016	1MON	RES
40	FUNDEXAM	GRANG	TAR	31Jan1940 - 31Dec2016	1MON	CP
41	FUNDEXAM	GRANG	UNA	31Jan1940 - 31Dec2016	1MON	CP
42	FUNDEXAM	GRANG	WSE	31Jan1940 - 31Dec2016	1MON	RES
43	FUNDEXAM	HEMP	NAT	31Jan1940 - 31Dec2016	1MON	CP
44	FUNDEXAM	HEMP	REG	31Jan1940 - 31Dec2016	1MON	CP
45	FUNDEXAM	HEMP	SHT	31Jan1940 - 31Dec2016	1MON	CP

/FUNDEXAM/BELTON/NAT/31Jan1940 - 31Dec2016/1MON/CP/

Select   De-Select   Clear Selections   Restore Selections   Set Time Window

No time window set.

Figure 6.1 *HEC-DSSVue* Main Window

Plotting Time Series Graphs

Plot and *tabulate* are two of the basic options provided in the *Display* menu. The *edit plot properties* feature illustrated by Figure 6.2 provides flexible comprehensive capabilities for editing and refining the appearance of report-quality plots as well as graphical on-screen displays for analysis purposes. Plots can be *copied to clipboard* and inserted in Microsoft Word documents. Multiple time series such as observed, naturalized, and unappropriated flows can be easily plotted on the same graph for comparison.
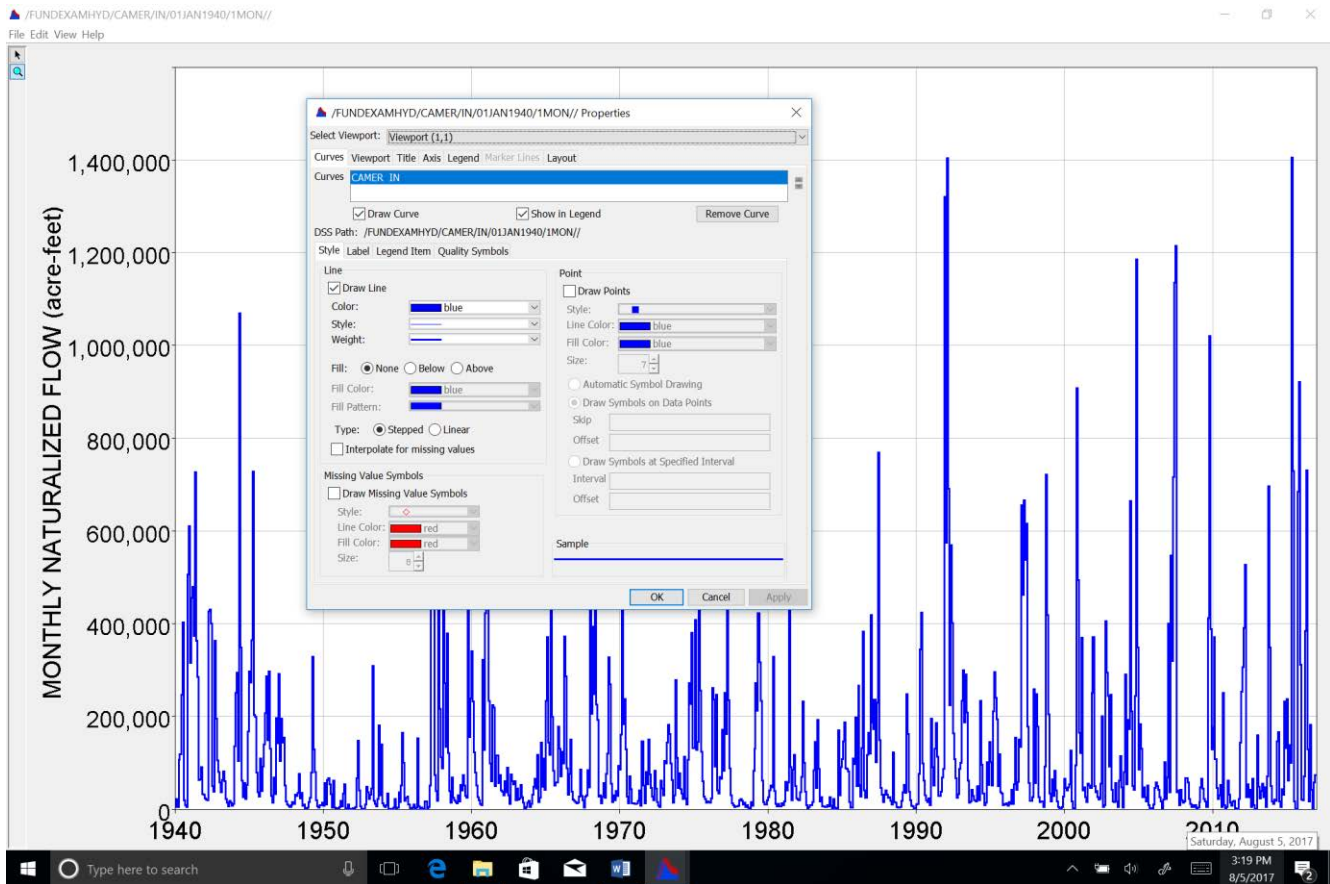
Figure 6.2 *HEC-DSSVue* Plot Window

<u>*Tabular Displays*</u>

The data in a *tabular display* can be revised by activating the *allow editing* option of the *Display – Tabulate* feature. Data records can be compared or combined, missing data identified and filled in, and the data otherwise modified by typing and copying within the tabular display. A right click of the mouse allows the highlighted portion of the columns of data to be summed, copied, exported, or printed.

<u>*Transporting Data between HEC-DSSVue and Microsoft Excel*</u>

Data are imported from a Microsoft Excel file using the option path:

Data Entry – Import – Excel.

DSS records selected from the catalog listing screen can be exported directly to Excel by clicking the Excel button within *HEC-DSSVue* to import and export data from and to Microsoft Excel. The alternative approach is to employ export and import features within Microsoft Excel. Add-ins are a commonly used feature of Excel implemented through the normal Excel menu structure. An Excel add-in allowing import/export of DSS files is available at the Hydrologic Engineering Center website along with documentation explaining its implementation in Excel.

HEC-DSS

Accessing Online Databases

Various online databases can be directly accessed. Observed flows are downloaded to a DSS file from the U.S. Geological Survey (USGS) National Water Information System (NWIS) website using the following *HEC-DSSVue* menu option path:

Data Entry – Import – USGS Web

This feature has been temporarily not functional recently due to modifications by the USGS of the NWIS. The *HEC-SSP Statistical Software Package* includes a similar feature that has been updated for consistency with the recent modifications to the USGS NWIS website.

Mathematical Operations and Statistical Analyses

Numerous statistical, arithmetic, and data management operations are implemented through the *Tools – Math Functions* option path which leads to an array of capabilities organized under the following tabs: *Arithmetic*, *General*, *Time Functions*, *Hydrologic*, *Smoothing*, and *Statistics*. Several of the many functions that may be useful in developing WRAP input datasets and performing WRAP simulation studies are highlighted below.

Arithmetic operations can be selected through the pull-down menu shown in the center of Figure 6.3 which begins with addition, subtraction, and multiplication. The mathematical operations may involve adding or otherwise combining entire data sequences or alternatively combining a constant with the individual data sequences. For example, the unappropriated flows at two or more control points could be added together in each month. The flows at an individual control point could be multiplied by a constant.

Figure 6.3 shows the math functions window in front with the main window in the back behind the math functions window. The 28 pathnames listed in the math functions worksheet of Figure 6.3 were selected using the search-by-parts feature of the main menu with STO entered in the pathname Part C box and WR entered in the pathname Part F box. These are the pathnames of records containing 1940-2016 end-of-month storage volumes associated with the 28 *WR* record water rights in the example from the *Fundamentals Manual*. Any sub-period of 1940-2016 could have been selected using the time window feature. The selected data set box in the math functions windows allows selections from these 28 pathnames. A variety of mathematical operations could be applied to this selected dataset.

The following statistical analysis routines are accessed through the type box in the statistics pull-down menu: basic, linear regression, cyclic analysis, duration analysis, and frequency plot. The basic statistics and flow duration analysis options are accessed through the following menu paths:

Tools – Math Functions – Statistics – Basic
Tools – Math Functions – Statistics – Duration Analysis

The basic statistics include: number of valid values, number of missing values, last valid value, minimum, mean, maximum, accumulated amount, standard deviation and skew coefficient. The *HEC-DSSVue* duration analysis feature presents results both as a frequency table and frequency plot. Various options can be selected for creating the table and/or plot using

the duration analysis window shown in Figure 6.4. The duration analysis can also be called a frequency analysis. Examples of employing the basic statistics, duration analysis, and frequency plots features of *HEC-DSSVue* are found in Chapter 9 of the WRAP *Daily Manual*. *HEC-SSP* is also employed in the frequency analysis examples of Chapter 9 of the *Daily Manual*.
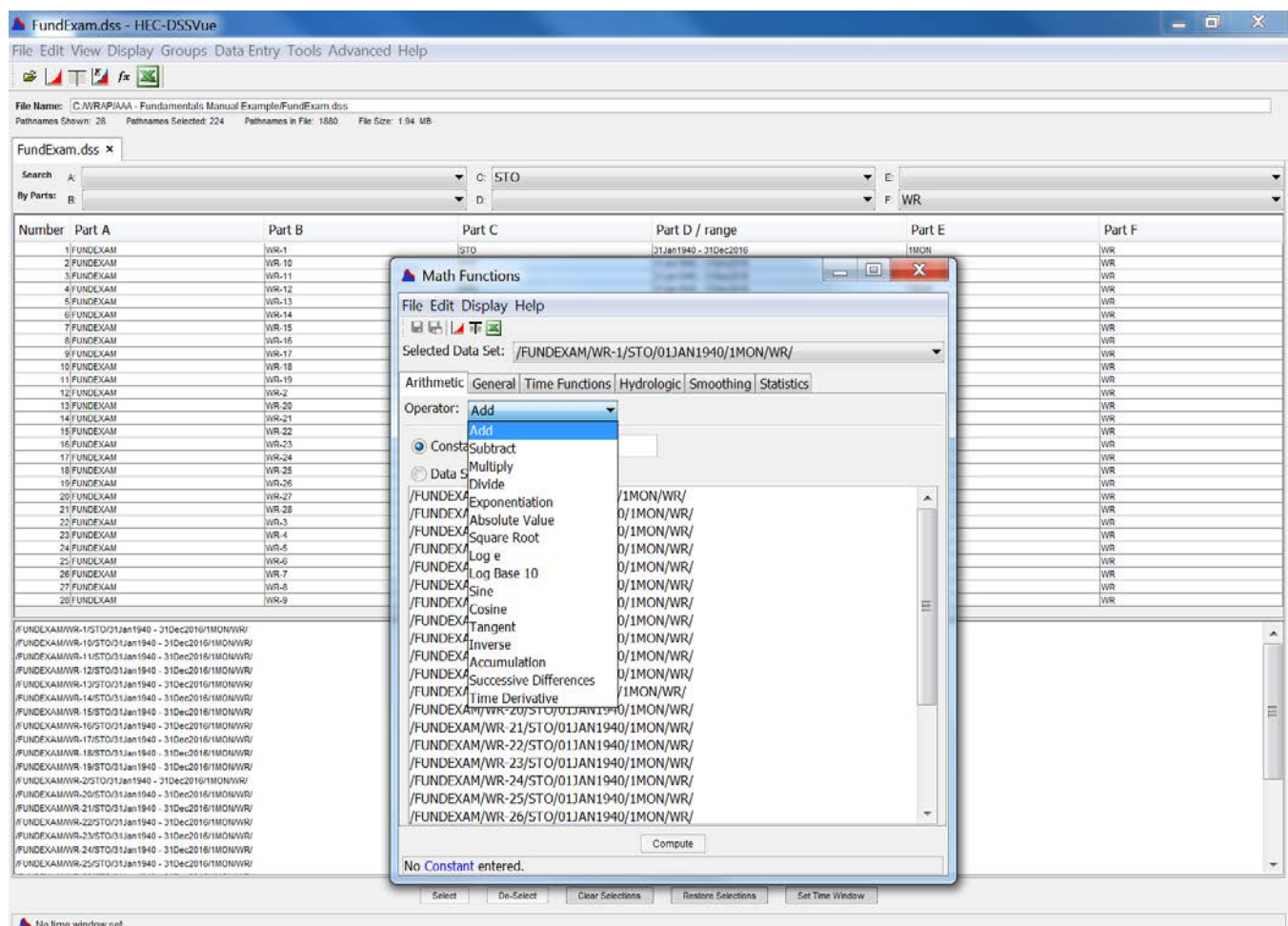

Figure 6.3 *HEC-DSSVue* Math Functions Window

Frequency analyses can be performed with either *HEC-DSSVue* or the WRAP program *TABLES*. *HEC-DSSVue* and *TABLES* include some of the same statistical analysis methods, and each provide some options not provided by the other. The terms "*duration analysis*" and "*frequency analysis*" refer to the same computational analyses. The resulting metrics represent the percentage of time that a particular quantity is equaled or exceeded. Frequency or duration analysis metrics also provide an expression of the probability that a particular quantity will be equaled or exceeded. *TABLES* develops frequency tables using the its default relative frequency formula P=m/N, and *HEC-DSSVue* performs duration analyses based on the Weibull relative frequency formula P=m/(N+1), where m is rank and N is sample size. Both of these options yield essentially the same frequency or duration analysis results for large sample size N. Both *HEC-DSSVue* and *TABLES* also include options for employing probability distribution functions.
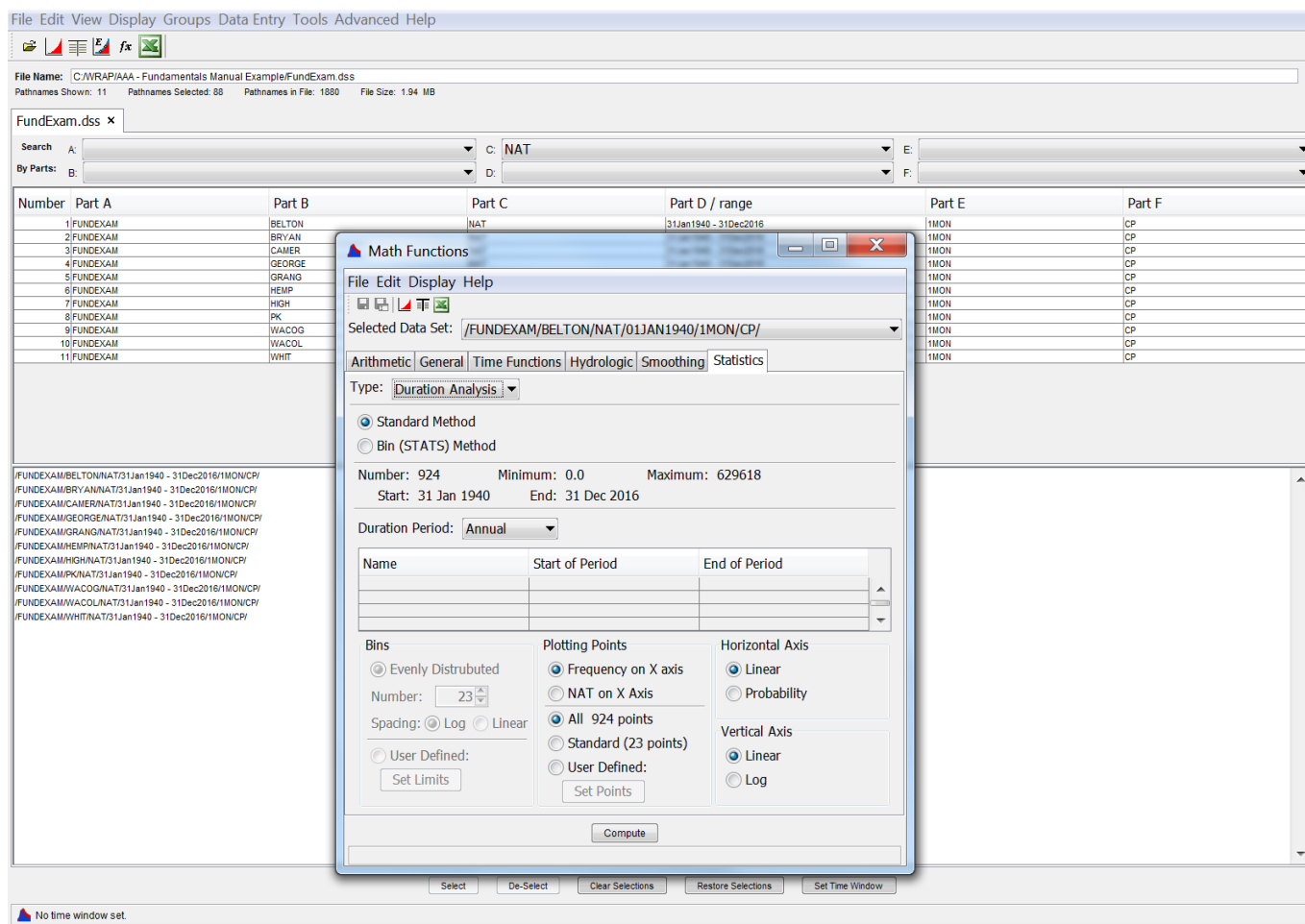
Chapter 6 DSS

Figure 6.4 *HEC-DSSVue* Duration Analysis Window

Records of 1940-2016 monthly naturalized flows at eleven control points are selected from the main window in Figure 6.4. The duration window shown in front of the main window is employed to specify the options adopted in the duration analysis. The standard duration table shows the quantities (naturalized monthly flow volumes) at the eleven selected control points associated with 24 automatically pre-selected standard exceedance frequencies.

The *General* options in the math functions window include unit conversions, changes in setting data types and units, comparing datasets, merging datasets, filling in missing data, and various other operations.

Converting between Time Intervals

Daily flow rates in cfs can be converted to monthly volumes in acre-feet using the *HEC-DSSVue* option path:

> *Tools – Math Functions – Time Functions – Min/Max/Avg/...over period*
> *– Volume for Period – 1MON*.

Daily or monthly flows are likewise aggregated to annual volumes. Similarly, datasets of minimum or maximum monthly or daily flow in each year can be created.

Summary of WRAP-DSS Integration

The USACE Hydrologic Engineering Center (HEC) Data Storage System (DSS) and the *HEC-DSSVue* component of DSS serves two primary roles in the WRAP modeling system.

1. Compilation, creation, analysis, updating, storage, and management of *SIM* and *SIMD* hydrology time series input datasets.

2. Storage, management, display, and analysis of *SIM* and *SIMD* simulation results.

These two different roles may be combined in certain applications in which *SIM*/*SIMD* simulation results are incorporated into *SIM*/*SIMD* simulation input datasets. *HEC-DSSVue* may be employed alone or in combination with other software.

WRAP DSS Files

SIM and *SIMD* read monthly time series input data on *IN*, *EV*, *FA*, *RU*, *HI*, and *TS* records from the DSS hydrology input file with filename rootHYD.DSS as specified by option selection parameters on the *JO* and *OF* records as explained in Chapter 3 of this *Users Manual*. Error messages are activated if the specified records are not found in the DSS file. The DSS file may contain any number of various types of records. Only the relevant records are actually read. The previously discussed pathname conventions (Table 6.6) are followed.

SIMD also reads daily flows from *DF* records stored in this same hydrology input DSS file. The default DFFILE option 1 defined in *JU* record field 3 specifies that the daily flows are read from the DSS file rather than the DIF file. *DF* record daily flows are read from the DSS file for all control points with identifiers listed on *DF* identifier records described on page 170 of Chapter 4 of this *Users Manual*. An error message is activated if one or more or the control points listed on the *DF* identifier records in the DAT file are not found in the DSS file.

SIM and *SIMD* store monthly and daily simulation results in a single DSS file with filename root.DSS. *SIM* and *SIMD* simulation results consist of daily and/or monthly sequences of the 43 variables listed with the *OF* record description on page 47 of Chapter 3. The simulation results output variables are defined in Chapter 5 of the *Reference Manual*. *SIMD* outputs the results of a daily simulation as daily quantities in a SUB file and/or monthly summations in an OUT file. *SIMD* outputs the results of a monthly simulation as these same time series variables in the OUT file. All monthly and daily results are recorded in the same DSS output file.

Simulation results are associated with either control points (16 variables), reservoirs (12 variables), or water rights (15 variables some of which vary between *WR* and *IF* record rights). Options for selecting control points, reservoirs, and/or water rights for recording monthly results in the OUT and DSS files are controlled by parameters on the *JD*, *CO*, *RO*, *WO*, and *GO* records.

Similar options for daily quantities to include in the SUB and DSS output files are controlled by parameters on *JT*, *C2*, *R2*, *W2*, and *G2* records. All simulation results variables are included in the OUT and SUB files for the selected control points, reservoirs, and/or water rights. Parameter DSS(4) on the *OF* record provides options for all variables or a subset of the variables to be included in the DSS file for the selected control points, reservoirs, and/or water rights. Thus, DSS provides additional flexibility for selecting variables for inclusion in the output.

HEC-DSS

OF record parameter DSS(3) activates the DSS output file and specifies that only monthly (option 1), both daily and monthly (option 2), or only daily (option 3) simulation results are included in the DSS file. Other DSS related options are also controlled by the *OF* record parameters listed in Table 6.3 and explained in Chapter 3.

DSS(3) option 2 specifies that both daily and monthly simulation results are recorded in the *SIMD* output DSS file. Monthly and daily output records are stored in the DSS file for the same control points, water rights, and reservoirs. The *JT*, *C2*, *R2*, *W2*, and *G2* records control the selection, and the corresponding monthly output control input is ignored.

OUT and SUB output files are over-written with each execution of *SIM/SIMD* and thus contain simulation results for only one simulation. DSS allows results for any number of *SIM/SIMD* simulations to be recorded in the same DSS file for convenient comparative analyses.

DSS files and *HEC-DSSVue* are employed with the WRAP program *HYD* in compiling *SIM* monthly hydrology input datasets as described in the *Hydrology Manual* and with program *DAY* in developing daily hydrology input data for *SIMD* as described in the *Daily Manual*. *HEC-DSSVue* can also be used alone in developing and updating WRAP hydrology data.

The WRAP program *TABLES* can both read a DSS input file and create a DSS output file. *TABLES* reads *SIM* and *SIMD* simulation results from either a monthly/daily DSS file or monthly OUT and daily SUB files, organizes and displays the *SIM/SIMD* simulation results, and performs frequency and reliability analyses. *TABLES* is not limited to only DSS files associated with WRAP programs, but rather by employing a DDSM, DSSD, or 7DSS record, can read DSS files with essentially any time series data and perform many of the same operations and analysis as for WRAP datasets. For example, DSS allows *TABLES* to be employed with datasets of observed stream flow, precipitation, and evaporation. *TABLES* can also be employed to convert datasets in FLO, EVA, OUT, CRM, SUB, or other text files to a DSS file or to convert DSS records from a DSS file to a text file in standard WRAP text file time series input record format.

HEC-DSSVue

HEC-DSSVue provides comprehensive, flexible, and efficient capabilities for managing and analyzing time series datasets, including extremely large datasets. DSS records are conveniently stored and inventoried and can be quickly searched, displayed, analyzed, and modified. *HEC-DSSVue* and *TABLES* can be used in combination. *HEC-DSSVue* provides comprehensive options for preparing time series plots. The other WRAP programs have no graphics. *TABLES* includes water supply reliability analyses and other optional capabilities not included in *HEC-DSSVue*. Similar statistical frequency analysis computations are performed by both *TABLES* and *HEC-DSSVue*, though the analysis results are displayed in different formats.

HEC-DSSVue is documented in detail by an *User's Manual* available for download along with the software from the USACE Hydrologic Engineering Center website. This WRAP *User's Manual* highlights and briefly explains the basic *HEC-DSSVue* features that are particularly relevant for WRAP applications. The Hydrologic Engineering Center's *User's Manual* for *HEC-DSSVue* can be consulted for complete detailed documentation of the features highlighted here as well as other DSS capabilities not mentioned in this WRAP manual.

INDEX OF SIM, SIMD, AND TABLES INPUT RECORDS

SIM		SIM (continued)		TABLES	
Record	Page	Record	Page	Record	Page
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AF	117	RU	48, 129	DATA	193
AX	108	SO	90	DSSD	190
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EV	123	WP	120	1REC	196
FA	48, 127	WR	69	1RES	200
FC	120	WS	82	1SRT	197
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HI	48, 131	C2	147	2REL	209
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IF	73	DC	168	2SBA	220
IM	116	DF	146, 170	2SCP	219
IN	123	DO	152	2SGP	220
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JD	39	FQ	165	2 Time Series	206
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LO	97	FV	165	Type 3	223
ML	97	G2	147	Type 4	224
MS	114	JT	139	Type 5	228
OF	45	JU	143	Type 6	236
OR	84	PF	155	Type 7	237
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PV	112	RT	166		
PX	107	SC	154		
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RG	59				