Water Rights Analysis Package
(WRAP)

Users Manual

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TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

WRAP-SIM

TABLES

WRAP-HYD

INTRODUCTION

The *Water Rights Analysis Package (WRAP)* is documented by a *Reference Manual* and this *Users Manual*. The *Reference Manual* explains *WRAP* capabilities and methodologies. This *Users Manual* provides the operational logistics for applying the model. The *Users Manual* describes the organization of input and output files and the content and format of input records.

WRAP Computer Programs

The software package includes the following programs.

WinWRAP facilitates execution of the *WRAP* programs within the *Microsoft Windows* environment.

WRAP-SIM simulates the river/reservoir water allocation/management system for input sequences of naturalized streamflows and net evaporation-precipitation rates.

TABLES develops tables, data listings, and reliability/frequency indices for organizing, summarizing, and displaying *WRAP-SIM* simulation results.

WRAP-HYD assists in developing the naturalized streamflow (*IN* records) and reservoir net evaporation rate (*EV* records) for the *WRAP-SIM* hydrology input files.

A simulation is performed with the program *WRAP-SIM* using input files of water rights and hydrology data. The program *WRAP-HYD* facilitates developing hydrology input data files for *WRAP-SIM*. The program *TABLES* reads a *WRAP-SIM* output file and manipulates/organizes the simulation results in optional formats specified in a *TABLES* input file. The organized simulation results are provided as a *TABLES* output file. *WinWRAP* is a user interface for executing the programs within the *Microsoft Windows* operating system in combination with use of Microsoft programs to access and edit *WRAP* input and output files.

The Fortran programs are compiled and executed as separate individual programs. Filenames for the executable programs are as follows.

Program *WinWRAP*	WinWRAP.exe
Program *WRAP-SIM*	Sim.exe
Program *TABLES*	Tab.exe
Program *WRAP-HYD*	Hyd.exe

WinWRAP facilitates running the programs within *Microsoft Windows*. The executable files may also be executed directly within the *Microsoft Disk Operating System (MS-DOS)*. In applying *WinWRAP*, the programs should all be located in the same folder (directory). A mouse click of the *WinWRAP* icon activates *WinWRAP*. Instructions for using *WinWRAP* are provided within its *Information* menu. The *Microsoft Programs* menu in *WinWRAP* activates the *DOS Editor*, *NotePad*, *WordPad*, *Word*, *Excel*, and *Access* which may be used to access and edit input and output files for the *WRAP* programs. Input files may be developed following the instructions provided in this manual using any editor, spreadsheet, or other software.

Input and Output Files

The types of input and output files are listed in Table 1. Filenames are in the format *root.ext* with a user-specified *root* and a standard extension *ext* denoting the type of file.

The main *WRAP-SIM* input file (filename root.DAT) may contain all of the *WRAP-SIM* input records and is the only absolutely required *WRAP-SIM* input file. However, typically the voluminous naturalized streamflow inflow *IN* records and evaporation *EV* records are stored in separate hydrology files, named root.FLO and root.EVA. The root.FLO filename for the flow (or inflow) file may also have the old INF version of the extension, root.INF. Optionally, the *IN* and *EV* records may be stored in a file named root.HYD in a format used in an older version of the model. The data needed to distribute flows from gaged to ungaged sites are provided in a file named root.DIS.

The standard *WRAP-SIM* simulation results are written to the OUT file (filename root.OUT). Messages to help locate errors and potential problems in the input data are written to the MSS file (filename root.MSS). Supplemental output related to multiple-reservoir system releases and hydroelectric energy generation are written to the optional HRR file (filename root.HRR). A yield-reliability and firm yield analysis option writes a table to a yield-reliability output file (filename root.YRO).

WRAP-SIM file options are specified on the file option *FO* record described later. The *FO* record is required if the default set of input files (DAT, FLO, EVA, DIS) and output files (OUT and MSS) are not used.

WRAP-HYD is used to develop hydrology input data files for *WRAP-SIM*. *WRAP-HYD* file options are specified on a *FO* record. *WRAP-SIM* simulation results are normally examined in the form of tables in a *TABLES* output file. *TABLES* reads the *WRAP-SIM* input file root.DAT and output files root.OUT and root.HRR and builds summary tables specified in a *TABLES* input file which are stored in a *TABLES* output file.

Organization of Users Manual

This *Users Manual* and the companion *Reference Manual* are designed for different types of use. Careful study of the *Reference Manual* is required to understand *WRAP*. For experienced users of *WRAP*, the *Reference Manual* continues to be useful in occasionally addressing specific questions that arise. The *Users Manual* is required for routine use any time anyone is working with *WRAP* input files. The input files consist of sets of required and optional records in specified formats. Application of *WRAP* requires developing and modifying these sets of input records. The purpose of this *Users Manual* is to provide the detailed explanation of record content and format required for building and revising input files.

The *Users Manual* includes a section for each of the three programs *WRAP-SIM*, *TABLES*, and *WRAP-HYD*. Each section begins with an overview of the content and format of input and output files, followed by a set of tables providing detailed descriptions of each type of input record. Instructions are provided specifying the data to be entered in each field of the input records.

Table 1
Input and Output Files

	WRAP-SIM Input Files
root.DAT	basic file containing all input ***dat***a, except the voluminous hydrology related data contained in the following files
root.FLO	inflow *IN* records with naturalized 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 for transferring flows from the *IN* records to other control points
root.HYD	*IN* and *EV* records provided in a single ***hyd***rology file in modified format in lieu of the root.INF and root.EVA files
root.FAD	***f***low ***ad***justment *FA* records for adjusting naturalized streamflows
	WRAP-SIM Output Files
root.OUT	main *WRAP-SIM* ***out***put file read by *TABLES*
root.MSS	***m****e****ss***ages reporting simulation progress and input data errors
root.HRR	optional ***h***ydropower and ***r***eservoir ***r***elease file read by *TABLES*
root.YRO	optional ***y***ield-***r***eliability analysis ***o***utput table
	TABLES Input Files
root1.DAT	*TABLES* input file with specifications regarding tables to be developed
root2.DAT	*WRAP-SIM* input DAT file
root2.OUT	*WRAP-SIM* output OUT file
root2.HRR	*WRAP-SIM* output HRR file
	TABLES Output File
root.OUT	*TABLES* ***out***put file with the tables developed
	WRAP-HYD Input Files
root1.DAT	file with all input ***dat***a not included in the following files
root1.FLO	inflow *IN* records with stream***flo***ws
root1.EVA	***eva***poration *EV* records with net evaporation-precipitation rates
root1.DIS	flow ***dis***tribution *FD & FC* and watershed parameter *WP* records
root1.HYD	*IN* and *EV* records in single ***hyd***rology file in modified format
	WRAP-HYD Output Files
root2.OUT	file with all ***out***put not included in the following files
root2.MSS	***m****e****ss***ages tracing the computations and reporting input data errors
root2.FLO	inflow *IN* records with naturalized stream***flo***ws
root2.EVA	***eva***poration *EV* records with net evaporation-precipitation rates

WRAP-SIM

The simulation program *WRAP-SIM* is basically an accounting system for tracking inputted naturalized streamflow sequences, subject to net reservoir evaporation-precipitation, channel losses, and specified diversion and instream flow requirements and reservoir storage capabilities. River/reservoir/use system water balance computations are performed for each time step of the hydrologic simulation period. The model provides flexibility for adaptation to a broad range of modeling approaches. Typically, a simulation will be based on the following premises.

1. Basin hydrology is represented by historical sequences of naturalized streamflows and reservoir net evaporation less precipitation rates.
2. Annual water use requirements, distributed over the 12 months of the year, are met as long as water is available from streamflow and/or reservoir storage.

The 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 streamflows and reservoir net evaporation rates for each month of the 720-month 1940-1999 hydrologic period-of-analysis. The historical naturalized streamflows and net evaporation rates are assumed to be representative of future basin hydrology. The annual water supply diversions, environmental instream flow requirements, and hydroelectric energy demands have a specified monthly distribution. They also may vary with reservoir storage content and/or streamflow.

WRAP uses a monthly time interval, but optional daily or other sub-monthly time-step features are currently being developed. Conditional reliability modeling capabilities are currently being developed for assessing short-term reliabilities conditioned on known preceding storage. These new features currently under development are not included in this manual.

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

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

This *Users Manual* provides instructions for developing and modifying sets of records for the input files. The information presented in the *SIM* section includes:

- overview of format and organization of *WRAP-SIM* input and output files
- description of the main simulation results file and supplemental output files
- set of tables describing the data entered in each field of each type of input record

Time Periods

WRAP uses a computational time step of one month. Features are currently being added to the model to allow daily or other submonthly time steps. *WRAP-SIM* does not limit the number of years that may be included in the hydrologic period-of-analysis. Naturalized streamflows and reservoir net evaporation-precipitation rates for one year at-a-time are read and kept in memory.

Units of Measure

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 are multipliers that may be used as unit conversions. Most of the input data are volumes, areas, or depths, including annual and monthly diversion volumes, volume/month streamflow rates, reservoir storage volume and surface area, and net evaporation-precipitation depths. The various flows must have volume per month or per year units that are consistent with the reservoir storage volume units. Net evaporation volumes are depths multiplied by reservoir water surface areas. Typical English units are acre-feet for storage volume and volume/month or volume/year quantities; acres for reservoir surface area; and feet for monthly net evaporation rates. Typical computationally-consistent metric units are million cubic meters for the reservoir storage and volume/month or volume/year quantities; square kilometers for reservoir surface area; and meters for monthly evaporation rates. Multipliers are used as needed to convert the input data to a consistent set of units.

The multiplication factors in fields 2 through 8 of the *XL* record are intended primarily for unit conversions. The factor *STX* 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 conversion of input data entered in any other units to the adopted unit. The variables *INX*, *EVX*, *CIX*, and *SAX* 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 mean precipitation in *WP* record field 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 multiplication 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 *Reference Manual* Chapter 3.

Dimension Limits

The arrays in the Fortran code are dimensioned to reserve memory space. The dimension limits may be changed by revising the Fortran code. The program currently contains the following maximum limits on the number of various system components. There is no limit on the number of years in the hydrologic period-of-analysis.

Table 2
WRAP-SIM Dimension Limits

total water rights *WR* and instream flow *IF* records	5,000
control point *CP* records	5,000
reservoirs	1,500
reservoirs associated with any single water right	20
hydroelectric power projects	100
reservoir storage-area tables (pairs of SV/SA records)	100
water use types with sets of water use coefficients (*UC* records)	300
sets of monthly return flow factors (*RF* records)	50
drought indices (*DI* records)	100
water rights with monthly varying depletion limits (*ML* records)	20
target options *TO* records plus *SO* record backup rights	650
evaporation allocation *EA* records	50
reservoirs with monthly varying capacity (*MS* records)	12
number of upstream gages on *FD* records	15

Input and Output Files

Input files are prepared using the user's choice of editor, spreadsheet, or other software. *WRAP-SIM* filenames consist of a *root* specified by the user and the extensions noted below. The model-user provides the filename root during the interactive session at the beginning of model execution, and the program opens the required existing input files. The standard default input files for *WRAP-SIM* are as follows.

root.DAT	basic file containing all input data, except the voluminous hydrology related data contained in the following files
root.FLO	inflow *IN* records with naturalized streamflows
root.EVA	evaporation *EV* records with net evaporation-precipitation rates
root.DIS	flow distribution *FD* and watershed parameter *WP* records for transferring flows from the *IN* records to other control point locations

The standard default output files are as follows.

root.OUT	simulation results
root.MSS	error/warning messages and traces

The file option *FO* record in the *WRAP-SIM* input file specifies optional input and output files. If the default files are used, a *FO* record is not required. The *FO* record is required only if

files other than the defaults are used and/or one or more default files are not used. In addition to the default files listed above, the following files are created as needed:

root.HYD	alternative to root.FLO and root.EVA input files
root.FAD	input file for *FA* record adjustments to naturalized flows
root.HRR	output file for additional hydropower and reservoir release data
root.YRO	output file for yield-reliability table

All input other than the *IN*, *EV*, *FD*, *FC*, *WP,* and *FA* records are stored in the *DAT* file. The flow distribution *DIS* file (filename root.DIS) contains the set of all *FD/FC* records followed by the set of all *WP* records. These data are used in distributing naturalized streamflows from gaged (known flow) to ungaged (unknown flow) control points. An optional naturalized streamflow adjustment file (filename root.FAD) contains flow adjustment *FA* records.

FLO and *EVA* files (filenames root.FLO and root.EVA) are the defaults for storing the naturalized streamflow *IN* and net evaporation-precipitation *EV* records. Optionally, the *IN* and *EV* records may be included in the *DAT* file (root.DAT). *WRAP-SIM* also includes an option for combining the *IN/EV* records in a *HYD* file (root.HYD) in a format originally developed for an earlier version of the model. The extensions *FLO* and *INF* may be used interchangeably.

Types of Input Records

The system for organizing sets of *WRAP-SIM* input is based on files, records types, and fields in each record. Input files contain a set of required and optional records controlling various simulation options and representing the stream/reservoir/rights system being modeled. The record types are labeled by a two-character identifier that is placed at the beginning of each record in the input files. These record types and associated identifiers provide a system for organizing the input data. The records are listed in Tables 3 and 4. Example input files presented in Appendix G of the *Reference Manual* illustrate the use of the various input records.

One each of six types of records (*T1*, *JD*, *ED*, *CP*, *WR* or *IF*, and *IN*) are required. The other records listed in Table 3 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 *WRAP-SIM* capabilities using less than half of the 43 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 *T1*, *T2*, *T3*, *FO*, *JD*, *XL*, *FY*, *WO*, *GO*, *CO*, and *RO* records are included only once at the beginning of the DAT file. The other record types may be repeatedly used numerous times in a data set. 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.

Table 3. **Types of WRAP-SIM Input Records**

Basic Input File (root.DAT)

Records for organizing the simulation

T1, T2, T3	*T*itles or headings at the beginning of the file that are reproduced in the output
**	comments or notes not read by the computer that may be inserted throughout
FO	*F*ile *O*ptions specifying which types of input and output files are to be used
JD	*J*ob control *D*ata with basic data and option switches
XL	Multiplication factors and parameter limits
FY	*F*irm *Y*ield and yield-reliability table
WO, GO	*W*ater right and water right *G*roup *O*utput
CO, RO	*C*ontrol point and *R*eservoir/hydropower *O*utput
ED	*E*nd of *D*ata

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

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

Records for entering water rights information

UC	monthly water *U*se *C*oefficients
RF	monthly *R*eturn *F*low factors
WR	*W*ater *R*ight requirements
IF	*I*nstream *F*low requirements
WS	*W*ater right reservoir *S*torage
SO	*S*upplemental water right *Options*
TO	*T*arget *O*ptions
TS	*T*arget *S*eries
ML	*M*onthly *L*imits on streamflow depletions
OR	*O*perating *R*ules for secondary reservoirs in a multiple-reservoir system
SD	*S*torage-*D*iversion relationship for a type 4 water right
DI	*D*rought *I*ndex reservoirs
IS/IP	drought *I*ndex *S*torage volumes (*IS* record) versus *Percentages* (*IP* record) table
EA/EF	*E*vaporation *A*llocation options for reservoirs shared by multiple entities

Records for describing additional characteristics of reservoirs

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

Hydrology Input Files (root.FLO, root.EVA, root.DIS, root.FAD)

IN	*IN*flows to the system (naturalized streamflows)
EV	*EV*aporation (reservoir net evaporation-precipitation depths)
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
FA	*F*low *A*djustments to be added to the streamflows
ED	*E*nd of *D*ata

Table 4
Input Records Associated with Component Features of WRAP-SIM

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

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

*Comment ** Record*.- Comment records beginning with a double asterisk may be entered almost anywhere within the input data after the three title records (*T1,T2,T3*). 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.

*File Options **FO** Record*.- The default file selection consists of four input files (DAT, FLO, EVA, and DIS) and two output files (OUT and MSS). If these default files are used, the *FO* record is not needed. If one or more of these files are not used and/or other optional files are used, the selection of files is defined by a *FO* record.

*Job Control Data **JD** Record*.- The *JD* record contains general information controlling the simulation. The number of years in the simulation and the year at which to start the simulation are specified on the *JD* record. Information regarding several *WRAP-SIM* computational features are entered, including negative incremental inflow options and system reservoir release decision options. This record also includes switches for output options and input error checking.

*Multiplication Factors and Parameter Limits **XL** Record*.- The *XL* record includes 8 multiplier factors used primarily for unit conversions, a set of limits on watershed parameters used in the NRCS CN method for transferring flows, and a limit for a warning message associated with a net evaporation-precipitation adjustment option.

*Firm Yield and Yield-Reliability Table **FY** Record*.- The *FY* record activates an optional computational routine that creates a yield-reliability table including the firm yield. Use of this record is explained near the end of the *SIM* section.

*Output Specification **CO**, **WO**, **GO**, **RO** Records*.- There are three types of output records: control point, water right, and reservoir/hydropower. The *JD* record and *CO*, *WO*, *GO*, and *RO* records control the selection of control points, water rights, groups of water rights, and reservoirs 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, as explained near the end of the *SIM* section.

*Use Coefficient **UC** Record*.- *UC* records provide three types of factors: (1) sets of 12 monthly water use factors for distributing annual diversion, energy generation, or instream flow requirements over the 12 months of the year, (2) priorities which override priorities on the *WR* records, and (3) multipliers for changing the water use requirements from the *WR* records. Different sets of monthly distribution factors, priority number, and/or multiplier are provided for various types of water use. 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 or use priorities. The water use distribution coefficients do not have to sum to one. *WRAP-SIM* sums the 12 factors and divides each by the sum to transform them to decimal fractions summing to unity.

*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 *WRAP-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 the naturalized streamflows (*IN* records) and net evaporation-precipitation rates (*EV* records) at 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 *CP* records.

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

*Instream Flow **IF** Record*.- Instream flow requirements specified on *IF* records are treated as a special form of water right. The *IF* record is similar to the *WR* record, except an instream flow target is entered rather than a diversion target, and several of the *WR* record fields are not applicable. A *WS* record may be attached to an *IF* record similarly as to a *WR* record. *UC* records are used the same with *IF* and *WR* records. The instream flow target restricts the amount of water available to junior rights. Any number of *IF* records may be assigned to a control point changing the flow target and priority.

*Supplemental Options **SO** Record*.- Information for defining supplemental water right requirements include monthly and annual limits on streamflow depletions; annual limit on diversion, monthly and annual limits on the amount of water that may be withdrawn from reservoir storage; alternate control point locations from which streamflow depletions may be made; and backup diversion capabilities allowing a water right to supply shortages incurred by another right.

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

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

*Water Right Reservoir Storage **WS** Record*.- Reservoir and hydropower information provided on a *WS* record includes active and inactive storage capacity, coefficients for a storage-area equation, and hydropower tailwater and efficiency factor. *WS* records are associated with specific water right *WR* records. One primary and up to 20 secondary reservoirs can be associated with a water right, with a set of *WS* and *OR* records 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.

*Secondary Reservoirs Operating Rules **OR** Record*.- One primary and up to 20 secondary reservoirs may be associated with a water right. *WS* records are provided for each reservoir. An *OR* record must follow the *WR* record for each secondary reservoir to specify multiple-reservoir operating rules. An *OR* record can also be provided for a single secondary reservoir associated with a water right, if needed to either specify the control point location or to activate the pump/pipeline conveyance option. The *OR* record includes the reservoir control point, storage zones used to define release rules, and the gravity-flow versus pipeline switch.

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

*Storage-Diversion **SD** Record*.- The type 4 water right option allows a diversion target to be specified as a function of reservoir storage content and naturalized streamflow. *SD* records define a storage versus diversion relationship for a type 4 water right. The storage volumes represent the total volume contained in all of the reservoirs associated with the right. The diversion amounts represent the permitted diversion amount of the right at any given storage level. Permitted diversion values are obtained within *WRAP-SIM* by linear interpolation of the table. This type of reservoir operating rules may also be modeled using the drought index feature with *DI*, *IS*, and *IP* records.

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

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

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

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

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

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

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

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

*Flow Distribution **FD**, Flow Coefficient **FC**, and Watershed Parameter **WP** Records*.- *FD*, *FC*, and *WP* records are stored in a flow distribution (filename root.DIS) file. These records provide information for transferring naturalized streamflows from gaged to ungaged 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. Coefficients for the optional coefficient equation flow distribution method are entered on a *FC* record. The drainage area, curve number, and mean precipitation are provided on a *WP* record for each gaged and ungaged control point for which this information is needed.

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

Format of Input Records

The record identifier is entered as the first two characters of each record. The title (T1, T2, T3) records include the two-character identifier and a 78-character alphanumeric field. Comment records are not read by the program, except for the ** identifier. The other records begin with a two-character identifier, followed by a 6-character wide field and usually several eight-character fields. Although most fields have a width of eight characters, a few records include some fields with other widths. The tables on the following pages outline input record format in terms of fixed-width fields. However, optionally, fields with integer *I* and real *F* numerical data formats may be delimited with commas.

Fixed Field Width Format

The Fortran format specifications found in the fourth column of the following tables describing each record type are defined as follows.

A6	alphanumeric (AN) label in a field that is 6 characters wide
4X	four blank spaces (Fields with the spacing descriptor X are skipped over and not read.)
F8.0	real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)
I8	integer number right justified in field of 8 characters (Decimal is not allowed.)
3I8	three integer numbers with each right justified in field of 8 characters

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

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

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

Comma Delimited Input Data

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

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

Note that the second field (CP1 in A6 format) can not be truncated with a comma since it has an alphanumeric A6 format. A comma delimits the third field, which is blank in integer I4 format.

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

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

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

Sequential Order of Input Records

The *T1*, *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 input records are organized in the files in the sequential order outlined in Table 5. The records for each input file are listed in the 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 *WRAP-SIM* input files contain information organizing the simulation and representing the river/reservoir/use system being modeled. Input files are prepared using any editor, spreadsheet, and/or other software. Only those records and those fields of a particular record are used as needed for the particular modeling application. Fields not needed are simply left blank. For fields with numeric entries, leaving the field blank is equivalent to entering a zero. The 2-character record identifiers are required. Records with the first two characters blank are not allowed in a data set; this includes totally blank records.

Detailed instructions regarding the format and content of each record of the input files are provided by the following series of tables. Table 6 is a quick reference chart for the most commonly used records. The subsequent tables describe the information to be entered in each field of each type of input record.

Table 5
Sequential Order of Input Records

Basic Input File (filename root.DAT)

T1,T2,T3	Titles or Headings	Required T1 is first record. Optional T2 and T3 follow.
**	Comments	Comments may be inserted throughout, after T1/T2/T3 records.
FO	File Options	Optional FD record is located just after or just before T1/T2/T3 records.
JD	Job Control Data	Required JD record follows FO or T1/T2/T3 records.
XL	Multiplication Factors	Optional XL record is located any place between JD and UC records.
FY	Firm Yield	Optional FY record is located any place between JD and UC records.
CO	Control Point Output	CO, RO, WO, GO records are optional and are inserted in any order following the JD record and preceding the UC records.
RO	Reservoir Output	
WO	Water Rights Output	
GO	Groups of Water Rights to Output	
UC	Monthly Use Factors	Set of all pairs of UC records follow JD and precede CP and RF records.
RF	Return Flow Factors	Set of all pairs of optional RF records follows UC and precedes CP records.
CP	Control Point	All CP records grouped together in any order; at least one.
CI	Constant Inflows	Set of all CI records in any order follows set of all CP records.
IF	Instream Flow	IF and WR records are grouped together in any order, with the set of WS/OR, SO, ML, TO, TS, and SD records immediately following corresponding WR or IF record. OR must follow WS. Otherwise, WS, SO, ML, TO, TS, and SD records may be in any order, but the set must immediately follow the pertinent WR or IF record.
WR	Water Right	
SO	Supplemental Options	
TO	Target Options	
TS	Target Series	
ML	Monthly Limits	
WS	Storage and Hydropower	
OR	Operating Rules for a Multiple-Reservoir System	
SD	Storage-Diversion Relationship for a Type 4 Water Right	
SV	Storage Volume	Set of all SV-SA tables grouped together in any order, with each SA immediately following corresponding SV.
SA	Surface Area	
PV	Storage Volume	Set of all PV-PE tables grouped together in any order, with each PE immediately following corresponding PV.
PE	Surface Elevation	
TQ	Tailwater Discharge	Set of all TQ-TE tables grouped together in any order, with each TE immediately following corresponding TQ.
TE	Tailwater Elevation	
MS	Monthly Varying Storage Capacity	Set of all MS records grouped together.
DI	Drought Index Reservoirs	Set of all DI/IS/IP records grouped together. Each DI record must be followed by an IS record followed by an IP record.
IS/IP	Index Storage/Percentage	

Table 5 (Continued)
Sequential Order of Input Records

	Basic Input File (filename root.DAT) (continued)	
EA/EF	Evaporation Allocation/Factors	Set of all EA/EF records grouped together.
ED	End of Data	Last record in root.DAT file except for IN/EV records.
	Streamflow (root.INF) and Evaporation-Precipitation (root.EVA) Files Standard Default Format (Optionally, IN and EV records may follow ED record in root.DAT file.)	
IN	Inflows	IN records are grouped together by year. The set of IN records for all control points for a particular year is followed by the set for the next year.
EV	Evaporation	EV records are organized the same as IN records.
	Flow Distribution File (root.DIS)	
FD	Flow Distribution	Each FC record follows the corresponding FD record.
FC	Flow Distribution Coefficients	The set of all WP records follows the set of all FD/FC records.
WP	Watershed Parameters	
ED	End of Data	The DIS file ends with a ED record.
	Flow Adjustment File (root.ADJ)	
FA	Flow Adjustment	Set of all FA records.

Table 6
Quick Reference Chart for WRAP-SIM

Fields											
1	2	3	4	5	6	7	8	9	10	11	
						Columns					
2	8	16	24	32	40	48	56	64	72	80	page
Basic Input Data File (filename root.DAT)											
T1											20
T2											20
T3											20
**											20
FO	INF	EVA	DIS	HYD	FAD	MSS	SYS				21
JD	NYRS	YRST	ICHECK	CPOUT	OUTWR	IDSET	ADJINC	NEGINC	EPADJ	NPOPT	22
XL	STX	INX	EVX	CIX	SAX	POWFCT	DEPTHX	CNLN	CNUB	MPLB	24
FY	FYIN1	FYIN2	FYIN3	FYIN4	FYIN5	FYWRID	FYGROUP				
CO	NCPOUT	CPOUID	CPOUID	CPOUID	CPOUID	CPOUID					26
RO	NREOUT	REOUID	REOUID	REOUID	REOUID	REOUID					26
WO	NWOUT		WROUT		WROUT		WROUT		WROUT		27
GO	NGOUT	GROUP	GROUP	GROUP	GROUP	GROUP					27
UC	USEID	Jan	Feb	Mar	Apr	May	Jun	YESUSE	YESUSE	YESUSE	28
UC		Jul	Aug	Sep	Oct	Nov	Dec	USEP	USEM	USEFAC	28
RF	RFID	Jan	Feb	Mar	Apr	May	Jun				28
RF		Jul	Aug	Sep	Oct	Nov	Dec				29
CP	CPID1	CPID2	CPDT1	CPDT2	INMETHOD	CPIN	CPEV	EWA	CL	INWS	30
CI	CIID	Jan	Feb	Mar	Apr	May	Jun				29
CI		Jul	Aug	Sep	Oct	Nov	Dec				29
WR	CP	AMT	USE	priority	Type RFM	RFAC	RCP	DINDEX		WRID	31
IF	CP	AMT	USE	priority	IFFLAG	DINDEX		WRID			32
SO	WSHED	MONDEP	ANNDEP	ACPID	BACKUP	MRW	ARW	ISHT			35
TS	TSL	TSYR2	QTS	QTS	QTS	QTS	QTS	QTS	QTS	QTS	39
ML	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	40
WS	RES	capacity	A	B	C	INACT	BEGIN	tw	eff	LAKESD	41
OR	CP	capacity 2	factor1	factor2	SYSNUM2						43
MS	RES	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	43
SV	RES	TARA	TARA								44
SA		TARB	TARB								44
PV	RES	TARA	TARA								45
PE		TARB	TARB								45
DI	DI	DINUM	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	DIRES	46
IS	NS	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	DISTO	46
IP		DIPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	DISPER	46
ED											20
Flow File (filename root.FLO)											
IN	ID	NYR	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	49
Net Evaporation-Precipitation File (filename root.EVA)											
EV	ID	NYR	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	49
Flow Distribution File (filename root.DIS)											
FD	ID	IDDS	NGAGE	UGID(1)	UGID(2)	UGID(3)	UGID(4)	UGID(5)	UGID(6)	UGID(7)	51
FC	COEF1	COEF2	COEF3								51
WP	ID	DA	CN	MP	DAF						51
ED											20

Flow Adjustment File (filename root.FAD)

FA	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	52

T1, T2, and T3 Records - Titles or Headings (T1 is required. T2 and T3 are optional.)

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

**** Record** - Comments

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

Comment (**) records are not read by the program, except for the ** identifier. They are used to insert notes in the input data set or to inactivate a record. Any number of comment records may be placed at the following locations.

- almost any logical place in the DAT file after the three title records (*T1,T2,T3*). 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 root.FLO and root.EVA files
- before the *FD* records and between the *FD* and *WP* records in the root.DIS file

ED Record - End of Data (required for both DAT and DIS files)

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

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

FO Record - File Options

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

The model-user provides the filename *root* during the interactive session at the beginning of model execution, and the program adds standard extensions. The message file (root.MSS) should essentially always be opened (blank field 7). The optional *FO* record is not required if all of the following six default files are used, and no other optional files are used.

Filename	*Input File Description*
root.DAT	Basic input data file includes all input except hydrology-related data.
root.FLO	Streamflow file consists of *IN* records in current version format.
root.EVA	Evaporation-precipitation file consists of *EV* records in current format.
root.DIS	Flow distribution file contains *FD* and *WP* records.
	Output File Description
root.OUT	Main simulation results output file
root.MSS	Message file

The old filename extension root.INF may still be used instead of root.FLO for the streamflow (inflow *IN* record) file.

JD Record - Job Control Data (required)

field	columns	variable	Format	value	description
1	1-2	CD	A2	JD	Record identifier
2	3-8	NYRS	I6	AN	Number of years in simulation
3	9-16	YRST	I8	+	First year of simulation. All *IN* and *EV* records before year YRST will be skipped.
					Level of Error Checks
4	24	ICHECK	I8	-1	Minimal trace messages and reduced error checks
				blank,0	Normal trace and reduced error checks
				1	Normal error checks and input trace
				2	Copy *UC* and *RF* records to MSS file
				3	Copy *CP* records to MSS file
				4	Copy *WR/IF* records to MSS file
				5	Copy *SV/SA* records to MSS file
				6	Copy *IN/EV* records to MSS file
				7	Copy *FD/FC/WP* records to MSS file
					Data Written to WRAP-SIM Output File
5	31-32	CPOUT	I8	-1	Control point data is output for all control points.
				-2	Control point data is output only for cp's with *IN* records plus those cp's listed on *CO* records.
				+	Control point output is limited to first CPOUT control points plus those cp's listed on *CO* records.
				blank,0	Control point output is specified only by CO records, with no CP output without a *CO* record.
6	39-40	OUTWR	I8	-1	Water rights data is output for all rights.
				+	Water right output is limited to first OUTWR rights plus those listed on *WO* and *GO* records.
				blank,0	Water rights output is specified by *WO* and/or *GO* records, with no wr output without these records.
7	48	IDSET	I8	blank,0,1	First set of identifiers on *WR* input records are used.
				2	Second set of identifiers on *WR* records are used.
					Negative Incremental Naturalized Flow Options
8	56	ADJINC	I8	blank,0,1	Option 1 - No adjustments are performed.
				2	Option 2 – Downstream flow adjustments.
				3	Option 3 - Upstream adjustments applied at all cp's.
				-3	Option 3 with secondary control points excluded.
				4	Option 4 - Adjustment only at cp of the water right.
				-4	Option 4 with secondary control points excluded.
				5	Option 5 - Alternative simulation approach.
9	64	NEGINC	I8	blank,0,1	No adjustments written.
				2	Downstream adjustments written to MSS file.
				3	Upstream adjustments written to MSS file.

Continued on Next Page

JD Record - Job Control Data (Continued)

field	columns	variable	Format	value	description
					Set Default for Evap-Precip Adjustment
10	71-72	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)
					Natural Priority Option Switch
11	73-80	NPOPT	I8	blank,0	Natural priority option is not used.
				+	Natural priority option is activated.
					System Reservoir Releases
12	88	SYSOUT	I8	blank,0, 1	Water right identifier written to *HRR* output file.
				2	First group identifier written to *HRR* output file.
				3	Second group identifier written to *HRR* output file.
13	96	STOFLG	I8	blank,0	End-of-period storage is used for system release decisions for secondary reservoirs.
				1	Beginning-of-period storage is used.

Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries on the *JD* record. All other fields are left blank unless the options activated by each field are needed.

Field 10: *EPADJ* in field 10 sets the default used to correct the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir. The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 9 of a *CP* record supercedes the default set in field 10 of the *JD* record. *EPADJ* of -1 or -2 results in the runoff depth adjustment being computed by dividing the naturalized streamflow by watershed area as defined by *FD* records. For *EPADJ* = -1, the ungaged control point in field 2 of the *FD* record is used. For *EPADJ* = -2, the gaged control point in field 3 of the *FD* 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.

Field 11: Any integer entered in field 11 will activate the natural priority option with water rights being considered in upstream to downstream order instead of in water right priority order. With the natural priority option activated:

- *WRAP-SIM* makes each water right senior to all other rights located at downstream control points.
- For streams in parallel, priorities are set by the order that control point records are entered in the DAT file.

Field 12: *SYSOUT* in field 12 specifies the type of water right identifiers to be written to the hydropower and multiple reservoir system release output file (filename root.HRR), which is opened only if specified by the *FO* record.

XL Record - Multiplication Factors and Parameter Limits

field	columns	variable	format	value	description
1	1-2	CD	A2	XL	Record identifier
					Multiplication Factors Applied to Input Data
2	3-8	STX	F6.0	+	Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, *IS*, and *SD* records.
				blank, 0	Default = 1.0
3	9-16	INX	F8.0	+	Multiplier of flows on *IN* records, subject to being superceded by non-blank *CP* record field 4.
				blank, 0	Default = 1.0
4	17-24	EVX	F8.0	+	Multiplier of E-P rates on *EV* records, subject to being superceded by non-blank *CP* record field 5.
				blank, 0	Default = 1.0
5	25-32	CIX	F8.0	+	Multiplier of flows on *CI* records.
				blank, 0	Default = 1.0
6	33-40	SAX	F8.0	+	Multiplier of reservoir surface areas on *SA* records.
				blank, 0	Default = 1.0
					Multiplication Factors Used in Computations
7	41-48	POWFCT	F8.0	+	Multiplier factor for hydropower computations.
				blank, 0	Default = 0.0010237
8	49-56	DEPTHX	F8.0	+	Multiplier factor for runoff depth in NRCS CN method flow distribution computations.
				blank, 0	Default = 0.01875
					Limits on CN and Mean Precipitation
9	57-64	CNLB	F8.0	+	Lower limit on CN
				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
				blank, 0	Default = 2.0 feet or other depth unit in effect

The optional *XL* record is inserted any place between *JD* and *UC* records.

FY Record - Firm Yield and Yield-Reliability Table

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

The *FY* record is placed between the *JD* and *UC* records.
If a *FY* record is used, a YRO output file must be opened by entering 2 in *FO* record field 8.

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

field	columns	variable	format	value	description
1	1-2	CD	A2	CO	Record identifier
2	7-8	NCPOUT	I6	1-30	Number of control point identifiers listed on *CO* records. NCPOUT is entered only on first *CO* record.
				blank,0	*CO* records are ignored if NCPOUT is zero. Field 2 should always be blank on the second and subsequent *CO* records.
3-7	9-48	CPOUID(J) J=1,30	5(2x,A6)	AN	Control point identifiers. Output records for cp's with these identifiers will be included in output file.

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

field	columns	variable	format	value	description
1	1-2	CD	A2	RO	Record identifier
2	7-8	NREOUT	I6	1-30	Number of reservoir identifiers listed on *RO* records. NREOUT is entered only on first *RO* record.
				-1	All reservoirs are included in output.
				blank,0	*RO* records are ignored if NREOUT is zero on first. *RO* record. Field 2 should always be blank on the second and subsequent *RO* records.
3-7	9-48	REOUID(J) J=1,30	5(2x,A6)	AN	Reservoir identifiers. Output records for reservoirs with these identifiers will be included in output file.

The *CO*, *RO*, *WO*, and *GO* records are used to select data to include in the simulation results and are all organized in the same way. Each provides a set of one to 30 identifiers or specification (field 2) of all control points, reservoirs, water rights or water right groups to include in the simulation results. For each, up to 30 identifiers may be provided on up to 6 records, with five identifiers per record. However, no more than one CO, one RO, one WO, and one GO record can be used to specify in field 2 the number of control points, reservoirs, water rights or water right groups, respectively, to include. 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. All are optional. It does not matter which of the four sets of records precede or follow the others.

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

field	columns	variable	Format	value	description
1	1-2	CD	A2	WO	Record identifier
2	7-8	NWOUT	I6	1-30	Number of water rights identifiers listed on *WO* records. NWOUT is entered only on first WO record.
				blank,0	*WO* records are ignored if NWOUT is zero. Field 2 should always be blank on the second and subsequent *WO* records.
3-7	9-88	WROUT(J) J=1,30	5A16	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

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

field	columns	variable	Format	value	description
1	1-2	CD	A2	GO	Record identifier
2	7-8	NGOUT	I6	1-30	Number of water rights identifiers listed on *GO* records. NGOUT is entered only on first *G*O record.
				blank,0	*GO* records are ignored if NGOUT is zero. Field 2 should always be blank on the second and subsequent *GO* records.
3-7	9-48	GROUP(J) J=1,30	5A8	AN	Water right identifiers. Water right output records for rights with these identifiers will be included in output.

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

UC Record - Water Use Coefficients

First UC Record - Water Use Identifier and Monthly Distribution Coefficients for Months 1 through 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* 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.
					Switches for Priorities and Multiplier Factors
9	57-64	YESUSE(I,1)	A8	YES	Priority number in field 9 of 2nd *UC* record is used.
				blank	Field 9 of 2nd *UC* record is ignored.
10	65-72	YESUSE(I,2)	A8	YES	Priority numbers are multiplied by factor in field 10.
				blank	Field 10 of 2nd *UC* record is ignored.
11	73-80	YESUSE(I,3)	A8	YES	Permitted amounts are multiplied by factor in field 11.
		I=1,NUSES		blank	Field 11 of 2nd *UC* record is ignored.

Second UC Record - Monthly Distribution Coefficients for Months 7-12 and Priority Coefficients

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.
					Priorities and Multiplier Factors
9	57-64	USEP(I)	I8	+	Priority number which overrides *WR* record field 5
10	65-72	USEM(I)	F8.0	+	Factor by which to multiply priority numbers
11	73-80	USEFAC(I) I=1,NUSES	F8.0	+	Factor by which to multiply permitted amounts

A pair of *UC* records is provided for each water use type. The use identifier in field 2 of the first *UC* record corresponds to the use identifier in field 4 of the *WR* and *IF* records. A set of 12 monthly use coefficients input on the two *UC* records is used to distribute an annual diversion, instream flow, or hydroelectric energy requirement over the 12 months of the year. *WRAP-SIM* divides each monthly coefficient by the sum of the 12 coefficients to obtain a set of 12 monthly multipliers.

The word *YES* in fields 9, 10, and 11 of the first *UC* record activates fields 9, 10, and 11, respectively, of the second *UC* record. Otherwise, the corresponding field on the second *UC* record is ignored. For all water rights with the identifier entered in field 2 of the first *UC* record, the water use priority entered in field 9 of the second *UC* record replaces the priority number in field 5 of the *WR* or *IF* record. *UC* record priorities supercede *WR* record priorities, assuming the *UC* record priority has been activated by the switch in field 9 of the first *UC* record.

Priorities set by *WR* or *UC* records are revised by multiplying by *USEM* entered in field 10 of 2nd UC record. Diversion, instream flow, or hydropower targets from *WR* and *IF* records are multiplied by *USEFAC* from field 11.

RF Record - Monthly Multipliers for Return Flows

First RF Record - Return Flow Coefficients for Months 1-6

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

Second RF Record - Return Flow Coefficients for Month 7-12

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.

The diversion amount for a month is multiplied by the appropriate factor from the *RF* record to obtain the return flow. The set of *RF* records follows the *UC* records. A pair of optional *RF* records is required for each *RFIDWR* entered in field 8 of *WR* records for return flow options 3 and 4.

CI Record - Constant Inflows and/or Outflows

field	columns	variable	format	value	description
1	1-2	CD	A2	CI	Record identifier
2	3-8	CIID	A6	AN	Control point identifier
3-8	9-56	CI(M=1,6) CI(M=7,12)	6F8.0	+,-	Flow added to naturalized flow at control point CIID for month M. Six entered on first CI record, six on second. Field 2 on the second CI record is not read.

The set of all pairs of *CI* records follows the set of all *CP* records. Any number of pairs of optional *CI* records may be entered for any control point in any order. *WRAP-SIM* adds flows on the *CI* records to the inflows to the naturalized streamflows at the specified control point and all downstream control points.

CP Record - Control Point Information

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

A *CP* record is required for each and every control point.

WR Record – Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	WR	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	0,+	Annual permitted diversion or hydropower target
4	19-24	USE	2x,A6	AN	Use type identifier to connect to *UC* records
				blank	Default constant uniform distribution over the year
5	25-32	WRNUM(wr,7)	I8	-,0,+	Priority number
					Water Right Type
6	36	WRNUM (wr,5)	I4	blank,0,1	Type 1 water right
				2	Type 2 water right (no refilling storage)
				3	Type 3 water right (no streamflow depletions)
				4	Type 4 water right (storage-diversion relationship)
				5,-1	Type 5 water right (hydroelectric power)
				6,-3	Type 6 water right (hydroelectric power)
				7	Type 7 water right (inflow to stream)
					Return Flow Specifications
7	40	RFMETH (wr)	I4		Return flow method
				blank,0,1	Constant factor, flows returned same month
				2	Constant factor, flows returned next month
				3	Monthly factors, flows returned same month
				4	Monthly factors, flows returned next month
8	41-48	RFAC	F8.0	+	Constant return flow factor
		RFIDWR	2x,A6	AN	Identifier on RF record for monthly factors
9	51-56	RCP	2x,A6	blank	Flow returned to next downstream control point
				AN	Identifier of control point to return flow
					Drought Index
10	63-64	DINDEX(wr)	6x,I2	blank,0	Drought index is not used for this water right.
				+,-	Integer identifier (1,2,3,...,15) of drought index. If positive, the drought index is applied as step 3 outlined on page 33. A negative sign switches to applying the drought index as step 6 on page 34.
					First Set of Identifiers
11	65-80	WRID(wr)	A16	AN	First water right identifier
				blank	Option not used
12	81-88	WRIDS (wr,1)	A8	AN	Second water right identifier (group identifier)
				blank	Option not used
13	89-96	WRIDS (wr,2)	A8	AN	Third water right identifier (group identifier)
				blank	Option not used
					Alternate Set of Identifiers
14	97-112	WRID(wr)	A16	AN	Alternate first water right identifier
				blank	Option not used
15	113-120	WRIDS (wr,1)	A8	AN	Alternate second water right identifier (group)
				blank	Option not used
16	121-128	WRIDS (wr,2)	A8	AN	Alternate third water right identifier (group)
				blank	Option not used

IF Record – Instream Flow Requirement

field	columns	variable	format	value	description
1	1-2	CD	A2	IF	Record identifier
2	3-8	CP	A6	AN	Control point identifier
3	9-16	AMT	F8.0	+	Annual instream flow requirement
4	19-24	USE	2x,A6	AN	Use type identifier to connect to *UC* records
				blank	Default constant uniform distribution over the year
5	25-32	WRNUM(,7)	I8	-,0,+	Priority number
					Water Right Type (used only if field 7 entry is 3 or 4)
6	36	WRNUM (wr,5)	I4	blank,0,1	*IFFLAG* in field 7 is not 3 or 4.
				2	Type 2 water right (used only if *IFFLAG* = 3 or 4)
				4	Type 4 water right (used only if *IFFLAG* = 3 or 4)
					Note: Other types are not applicable for *IF* record.
					Type of Instream Flow Computations
7	40	IFFLAG (wr)	I4	0	Shortages determined only
				1	Constraints on water availability during first pass
				2	Constraints on water availability during second pass
				3	Constraints during first pass, reservoir storage used
				4	Constraints during second pass, reservoir storage used
				5	Instream flow requirement is ignored
					Drought Index
8	47-48	DINDEX(wr)	I8	blank,0	Drought index is not used for this water right.
				+,-	Integer identifier (1,2,3,...,15) of drought index. If positive, the drought index is applied as step 3 outlined on page 33. A negative sign switches to applying the drought index as step 6 on page 34.
					Water Right Identifier
9	49-64	WRID(wr)	A16	AN	Water right identifier (optional)

WR and *IF* records may be in any order. The set of all *WR* and *IF* records, with supporting *SO*, *TO*, *TS*, *WS/OR*, *ML*, and/or *SD* records, follow the set of all *CP* records. The set of records for each water right (*WR* record) and instream flow requirement (*IF* record) consists of the *WR* or *IF* record followed in any order by optional *SO*, *TO*, *TS*, *WS/OR*, *ML*, and/or *SD* records.

Location of *SO*, *TO*, *TS*, *ML*, *WS/OR*, and *SD* Records in the DAT Input File

SO, *TO*, *TS*, *WS/OR*, *ML*, and *SD* records are all associated with a particular water right. The set of all *SO*, *TO*, *TS*, *WS/OR*, *ML*, and *SD* records must follow directly behind their *WR* or *IF* record. However, the relative order of the *SO*, *TO*, *TS*, *WS/OR*, *SO*, *ML*, and *SD* records within the set is arbitrary other than:

- All *TS* records must be grouped together in chronological order by year.
- *OR* records must follow directly behind the corresponding *WS* record. If multiple reservoirs are associated with the right (*WR* or *IF* record), a separate *WS* record and associated *OR* record is required for each secondary reservoir. Each *OR* record follows immediately behind its *WS* record.

Building Diversion, Instream Flow, and Hydropower Targets

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

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

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

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

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

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

5. A time series of monthly targets for each month of the hydrologic period-of-analysis may be entered on *TS* records. The manner in which a *TS* record target is combined with the preceding intermediate

(steps 1-4 above) target is specified by *TSL* entered in the second field of the *TS* record for the first year.

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

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

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

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

TO Record Lower and Upper Limits on Targets

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

- With option 10 in *TO* record field 2, the lower and upper limits are imposed upon the final computed target amount. If the final target would otherwise fall below the lower limit, it is set at the lower limit. If the final target would otherwise be greater than the upper limit, it is set at the upper limit.
- With option *LIM* entered in *TO* record field 4, the computed target is adopted if it falls between the lower and upper limits; otherwise the target is set at zero.
- The third option is in effect if the other two are not activated by *TO* record fields 2 or 4. The limits are imposed upon completion of the other adjustments specified by a particular *TO* record. Different limits may be specified for each individual *TO* record in a series of multiple *TO* records. At each step, if the target would otherwise fall below the lower limit, it is set at the lower limit. If the target would otherwise be greater than the upper limit, it is set at the upper limit.

SO Record Limits on Diversions and Streamflow Depletions

Streamflow depletions are the water amounts taken by water rights to fill storage and meet diversion requirements. MONDEP and ANNDEP in *SO* record fields 7 and 8 place monthly and annual limits on streamflow depletions taken by a particular water right.

Further constraints are placed on diversions by the annual diversion limit *ADL(wr)* from *SO* record field 10 and the monthly and annual reservoir withdrawal limits *MRW(wr)* and *ARW(wr)* from the *SO* record fields 7 and 8. Starting with the first month of each year, the total cumulative amount diverted by a right that year is recorded. Further diversions are curtailed upon reaching the limit *ADL(wr)*. Likewise, the cumulative annual amount diverted from reservoir storage each year is limited to *ARW(wr)*.

SO Record – Supplemental Water Right Options

field	columns	variable	format	value	Description
1	1-2	CD	A2	SO	Record identifier
					Option for Limiting Water Availability
2	3-8	WSHED (wr)	F6.0	+	Drainage area ratio or other naturalized flow multiplier.
				blank	Watershed flow limit option not used.
					Streamflow Depletion Limits
3	9-16	MONDEP (wr)	F8.0	+	Maximum limit on streamflow depletions each month.
				blank,0	Either there is no monthly limit on streamflow depletions or limits are entered on a *ML* record.
4	17-24	ANNDEP (wr)	F8.0	+	Maximum annual limit on streamflow depletions.
				blank,0	There is no annual limit on streamflow depletions.
					Alternate Control Point for Streamflow Depletions
5	27-32	ACPID	2x,A6	AN	Identifier of alternative control point for streamflow.
				blank,0	Control point specified in field 2 of *WR/IF* record.
					Backup Water Right
6	35-40	BACKUP	2x,A6	BACKUP	Diversion shortages for preceding right added to diversion target at end of target building process.
				BFIRST	Diversion shortages for preceding right added to target at beginning of target building process.
				RETURN	Diversion shortages for preceding right multiplied by RFAC (default=1.0) to be subtracted from target for type 7 right. Used only for type 7 right.
				blank	Backup option is not used.
					Reservoir Withdrawal Limits
7	41-48	MRW(wr)	F8.0	+	Monthly limit on withdrawals from reservoir storage.
8	49-56	ARW(wr)	F8.0	+	Annual limit on withdrawals from reservoir storage.
					Targets and Shortages Written to Output File
9	64	ISHT(wr)	I8	blank,0	Last target and shortage computed is in output file.
				1	Target and shortage written to output file based on *AMT* from *WR* record field 3 after step 1 described on the preceding pages.
				2	After applying drought index (step 2).
				3	After applying options on *TO* record (step 3).
				4	After *TS* records (step 4 on preceding pages).
				5	After applying drought index (step 5).
				6	After applying options on *TO* record (step 6).
				7	After applying BACKUP option (step 7).
10	65-72	ADL(wr)	F8.0	+	Annual diversion limit.
				blank	Limit not applied.

Explanation of SO Record Fields

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

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

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

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

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

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

Field 10: Starting with the first month of each year, the total cumulative amount diverted by a right that year is recorded. Further diversions are curtailed upon reaching the limit specified by *ADL(wr)*.

TO Record – Target Options

field	Columns	variable	format	value	Description
1	1-2	CD	A2	TO	Record identifier
					Streamflow at Control Point from Field 7
2	7-8	TOTARGET (n)	I6	1	Target based on same-month naturalized streamflow.
				-1	Target based on prior-month naturalized streamflow.
				2	Regulated streamflows same month used to set target.
				-2	Regulated streamflows prior month used to set target.
				3	Unappropriated streamflows same month.
				-3	Unappropriated streamflows previous month.
					Reservoir Specified in Field 8
				4	Target based on reservoir storage in same month.
				-4	Reservoir storage in previous month.
				5	Target based on reservoir drawdown in same month.
				-5	Reservoir drawdown in previous month.
					Water Right Specified in Field 9
				6	Target based on streamflow depletion that month
				7	Target based on annual streamflow depletion.
				8	Based on withdrawal from storage that month.
				9	Based on annual withdrawal from storage.
					Maximum/Minimum Limits Only
				10	Limits in fields 5 & 6 applied to *WR/IF/DI/TS* target.
					Multiplier Factor
3	9-16	FACT(n)	F8.0	+ or -	Factor multiplied by field 2 amount (default=1.0)
					Apply Limit or Combine with Intermediate Target
4	17-24	TOCOMB (n)	A8	blank, SET	This is the target, no preceding intermediate target.
				LIM	*AMT* from *WR/IF* field 3 and *UC/DI* records applied if target falls within limits of *TO* fields 5 and 6
				ADD	This target is added to the previous target.
				MAX	Maximum of this versus preceding target is adopted.
				MIN	Minimum of this versus preceding target is adopted.
					Lower and Upper Limits
5	25-32	TOLIM(n,1)	F8.0	blank	No lower limit.
				+	Lower limit on either target or quantity setting target.
6	33-40	TOLIM(n,2)	F8.0	blank	No upper limit.
				+	Upper limit on either target or quantity setting target.
					Control Point, Reservoir, or Water Right Identifier
7	43-48	TOFLOW	2x,A6	blank	Control point from *WR* record field 2 used for target.
				AN	Control point of streamflow used to set target.
8	51-56	TORES(n)	2x,A6	AN	Identifier of reservoir used to set target (*TO* field 2).
9	57-72	TOWR(n)	A16	AN	Identifier of water right used to set target (*TO* field 2).
					Continue with Another TO Record
10	73-80	TOCONT	A8	blank	Continuation option is not used.
				CONT	Following *TO* record continues building target.

Explanation of TO Record Fields

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

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

Field 4: *TOCOMB* specifies the manner in which the target resulting from this *TO* record is used. The default (blank field 4) is to simply set the target to the value computed (*TOCOMB* = SET). Alternatively, the *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 (*TOCOM* = LIM). The target resulting from a *TO* record may be combined with a preceding cumulative intermediate target specified by the preceding *TO* record. The two values may be added, or either the minimum or maximum adopted (*TOCOMB* = ADD, MAX, MIN).

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

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

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

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

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

TS Record – Target Series

field	columns	variable	format	value	Description
1	1-2	CD	A2	TS	Record identifier (required for first year, optional thereafter)
					Maximum or Minimum Limit
2	3-8	TSL (first record)	3X,A3	blank	*TS* record targets are the only option used.
				MAX, max	Maximum of two alternative targets is adopted.
				MIN, min	Minimum of two alternative targets is adopted.
				ADD, add	*TS* record number is added to preceding target.
				SUB, sub	*TS* record number is subtracted from preceding target
				MUL, mul	*TS* record number is multiplied by preceding target
				TSL is read with just the first year. This field is not read after first record.	
					Years Covered
3	9-12	TSYR1	I4	-	Beginning year (optional)
4	13-16	TSYR2	I4	+	Ending year (required)
5-16	17-112	QTS (YR,I,MT)	12F8.0	+	Targets for 12 months of the year YR=1,80; I=1,20; MT=1,12

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

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

WRAP-SIM is dimensioned to allow up to 80 *TS* records to be assigned to each of up to 20 water rights. The *TS* records covering all years are grouped together for a particular water right. The set of all *TS* records for a water right may be inserted any place within the set of *TS*, *TO*, *WS/OR*, *SO*, *ML*, and *SD* records that follow directly behind the *WR* or *IF* record for that right.

ML Record - Monthly-Varying Limits on Streamflow Depletions

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

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

SD Record - Storage versus Diversion Relationship for a Type 4 Water Right

field	columns	variable	format	value	description
1	1-2	CD	A2	SD	Record identifier
2	3-8	STOFLO(I,1)	F6.0	0	No reservoir releases
				-	No limit on reservoir releases
				+	Limit on reservoir releases expressed as a decimal fraction of naturalized streamflow at the CP
3	9-16	STOFLO(I,2)	F8.0	+	Reservoir system storage content
4	17-24	STOFLO(I,3)	F8.0	+	Diversion amount
5	25-32	STOFLO(I,4)	F8.0	+	Reservoir system storage content
6	33-40	STOFLO(I,5)	F8.0	+	Diversion amount
7	41-48	STOFLO(I,6)	F8.0	+	Reservoir system storage content
8	49-56	STOFLO(I,7)	F8.0	+	Diversion amount
9	57-64	STOFLO(I,8)	F8.0	+	Reservoir system storage content
10	65-72	STOFLO(I,9)	F8.0	+	Diversion amount

A maximum of 12 pairs of storage versus diversion may be entered on three *SD* records. Field 2 is blank on the second and third *SD* record. Subscript I represents the index of type 4 rights. A maximum of 50 type 4 rights is allowed.

WS Record - Reservoir Storage and/or Hydropower Data 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 (wr,3)	F8.0	+	Storage capacity
					Storage-Area Relationship
4	17-24	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
5	25-32	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
6	33-40	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below. surface area = A (storage)$^B + C$ If fields 4, 5 & 6 are all blank, a table on *SV* & *SA* records is required to define the storage-area relation.
					Optional Storage Specifications
7	41-48	INACT	F8.0	+	Storage capacity at top of inactive pool (bottom of active pool) or, for hydropower, bottom of power pool
8	49-56	BEGIN	F8.0	+	Storage volume at the beginning of the simulation
				Blank,0	Reservoir is full to capacity (field 3) at the beginning.
					Hydroelectric Power
9	57-64	WRSYS(I,1)	F8.0	+	Tailwater elevation for hydroelectric power
10	65-72	WRSYS(I,4)	F8.0	+	Energy efficiency for hydroelectric power
11	79-80	LAKESD	I8	Blank,0	Downstream releases generate hydropower.
				-	Lakeside diversions do not generate hydropower.
12	81-88	TCAP	F8.0	+	Turbine discharge capacity (optional)
13	89-96	TELEV	F8.0	+	Turbine inlet elevation (optional)
					Evaporation Allocation Reservoirs
14	97-104	EAR(wr)	I8	Blank,0	Option not used.
				1-20	*EA* record (1, 2, 3,..., 20). 1 for first *EA* record.
15	111-112	SA	I8	Blank,0	A separate storage-area relationship is provided.
				-1	Use *SV/SA* records for first reservoir on *EA* record.

Explanation of WS Record Fields

Field 3: A right refills a reservoir to the storage capacity entered in field 3 subject to water availability.

Fields 4-6: *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:

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

For multiple rights associated with a particular reservoir, the storage-area input only has to be provided once, with the first right (*WR/IF* record) read. Fields 4, 5, and 6 of the *WS* record may be left blank if the storage-area information has been specified on a previous *WS* record for that reservoir.

Field 7: Releases/withdrawals will not occur if 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 field 8.

Fields 9, 10 & 12: Fields 9, 10, and 11 are blank except for hydropower rights. A constant tailwater elevation may be entered in field 9. If field 9 is blank for a hydropower right, a tailwater rating table must be entered on *TE/TQ* records. Field 10 is a number, typically less than 1.0, representing the ratio of electrical energy to hydraulic energy. If field 12 for the optional turbine discharge capacity (water volume/month) is left blank, unlimited discharge capacity is assumed.

Field 11: Field 11 is relevant only if a senior water supply diversion is being met by releases from a reservoir at which a hydropower plant for a junior hydropower right is located. Field 11 is used to specify whether the water supply diversion incidentally generates hydropower.

Field 13: The inlet elevation in *WS* record field 13 sets a minimum pool level below which power generation is curtailed. Power generation with all releases for all rights is constrained by the turbine inlet invert (field 13). Releases for a particular right are also constrained by the specified inactive pool (field 7). For a hydropower right with the inactive pool set higher than the turbine inlet, power generation with pass-through flows and water supply releases for other rights (field 11) are constrained only by the turbine inlet elevation. Additional releases for the hydropower right are also constrained by the specified inactive pool.

Field 14: The integer identifier connects this reservoir to an *EA* record. A 1 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.

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

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
3	9-16	WRSYS(I,2)	F8.0	+	Storage capacity at top of zone 2 (bottom of zone 1)
4	17-24	WRSYS(I,5)	F8.0	+	Zone 1 priority factor [I=1,MAXSYS]
5	25-32	WRSYS(I,4)	F8.0	+	Zone 2 priority factor
6	33-40	SYSNUM (I,2)	I8	blank,0,+	Releases constrained to gravity flow in river channels
				-	Pump and pipeline conveyance as well as river flow

An *OR* record is required, following the *WS* record, for each secondary reservoir associated with a water right (*WR* or *IF* record) to define multiple-reservoir system operating rules. An *OR* record may also be used with a single secondary reservoir to activate the pump/pipeline option in field 6. 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). *OR* records are provided for all reservoirs for multiple-reservoir type 2 and 3 rights. Field 2 can optionally be left blank if the control point identifier has been assigned to the reservoir by a previous water right.

MS Record - Monthly Storage Limit

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

The set of *MS* records for up to 12 reservoirs follows the set of optional *SV/SA-PV/PE-TQ/TE* records. An optional *MS* record is entered for a reservoir to model a seasonal rule curve operating policy. The storage capacities on the *MS* record serve as upper limits constraining storage.

SV Record - Storage Volumes for Reservoir Storage versus Area Table

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

SA Record - Surface Areas for Reservoir Storage versus Area Table

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

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

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

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

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

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

TQ Record - Tailwater Discharge for Flow versus Elevation Table for Hydropower Right

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

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

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

DI Record - Drought Index Reservoirs

field	columns	variable	format	value	description
1	1-2	CD	A2	DI	Record identifier
2	7-8	NDI	I6	+	Drought index integer identifier
3	11-12	EMPTY (NDI)	I4	blank,0	Reservoir emptying option is not used.
				-1	Reservoir(s) is emptied at beginning of every month.
				1 - 12	The month in which emptying occurs each year.
4	15-16	NR	I4	+	Number of reservoirs
				-1	All reservoirs
5-16	17-112	DIRES (NDI,I)	12(2x,A6)	AN	Reservoir identifiers (NDI=1,25; 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
3-12	9-104	DISTO(I)	12F8.0	+	Reservoir storage corresponding to *IP* record DIPER

IP Record - Drought Index Percentages

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

The sets of all *DI/IS/IP* records are grouped together just before the *ED* record and following the *MS* records. For each drought index, an *IS* record must follow its *DI* record. The *IP* record follows the *IS* record. Up to 100 drought indices (sets of *DI/IS/IP* records) are allowed. Each is based on either the total storage in one to 12 specified reservoirs or all the reservoirs in the model.

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 ranging from 1 to 20 or may be blank, since *WRAP* automatically numbers.
					Allocation Method
3	16	NEAF (NEA)	I8	blank,0,1	Incremental based on water right priorities
				2	Based on beginning-of-month storage content
				3	Based on factors from following *EF* record
					Reservoirs
4-13	17-96	EARES (NEA,I)	10(2x,A6)	AN	Reservoir identifiers for from 2 to 10 reservoirs. NEA=1,20; I=1,10

EA records are used in situations where multiple water supply entities hold rights, with different priorities, to storage capacity in the same reservoir. The storage capacity owned by each entity may be modeled as a separate reservoir, with its own *WR* and *WS* records. The *EA* record allows the component separate *computational* reservoirs to share the same storage-area relationship, in the form of total storage in all component reservoirs versus total water surface area, for use in the computation of net evaporation-precipitation volumes. *WS* record field 2 identifiers of component computational reservoirs that compose the actual multiple-owner reservoir are listed in fields 4 through 13 of the *EA* record. The alternative method for allocating net evaporation-precipitation among the component reservoirs is selected in field 3. Each of the up to 20 *EA* records represent a multiple-owner reservoir modeled as from two to ten component reservoirs. Each has its own *WR* and *WS* records and is treated as a type 1 right (*WR* field 6).

If the storage volume versus water surface area relationship is provided on *SV/SA* records, the records must be input for the first component reservoir listed on the *EA* record but do not have to be repeated for the other reservoirs. 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.

WRAP-SIM numbers the *EA* record data sets in sequential order 1, 2, 3, ... , 20 as read. The optional *NEA* in field 2 must conform to this numbering system; otherwise, an error message is activated. The *EA* record integer identifiers connect to and must match the *EAR(wr)* in field 14 of the *WS* record.

EF Record - Net Evaporation-Precipitation Allocation Factors

field	columns	variable	format	value	Description
1	1-2	CD	A2	EF	Record identifier
2-3	3-16		14X		Not used
4-13	17-96	EAF(NEA,I)	10F8.0	+	Factors for NEAF option 3. (NEA=1,20; I=1,10)

An *EF* record must follow directly behind a *EA* record if and only if allocation method option 3 is selected in field 3 of the *EA* record. Each factor on the *EF* record corresponds to a reservoir on the *EA* record. The monthly net evaporation-precipitation volume allocated to a component reservoir is computed by multiplying the total monthly net evaporation-precipitation volume by its factor.

Alternative Formats for IN and EV Records

The default file selection includes FLO (or INF) and EVA files for storing *IN* and *EV* records. The *IN*/*EV* records may also be stored at the end of the DAT file following the *ED* record. Optionally, *WRAP-SIM* will also read *EV* and *IN* records in an old format adopted in *WRAP2* and *WRAP3* (*WRAP-SIM* predecessors) stored in a HYD file. The default record format and file organization are described first followed by a description of the old approach still maintained as an option.

With the standard default format, the *IN* and *EV* records are stored in separate files, with filenames root.FLO and root.EVA, respectively. In each 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. *WRAP-HYD* includes an option to convert *IN/EV* records grouped by control point to this standard format read by *WRAP-SIM*.

Optionally, the *IN* and *EV* records in the 12 months-per-record format may be stored in the root.DAT file following the ED record. The set of all *IN* records for a particular year must be followed by the set of all *EV* records for that year.

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.

All the *IN/EV* record format options in *WRAP-SIM* require that records be grouped by year. A group of records for all control points for the year 1941 will follow a similar set of records for all control points for the year 1940. Typically, developing a complete time series of *IN* and/or *EV* records covering the entire period-of-analysis for each individual control point is more convenient. The program *WRAP-HYH* includes an option for converting a file with records grouped by control point (which is more convenient to compile) into a file of records grouped by year (which is required by *WRAP-SIM*).

IN and EV Records in the Standard Default Format

IN Record - Inflows - Naturalized Streamflows at a Control Point

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

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

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

IN and EV Records in HYD File Format

In the old *WRAP2/WRAP3* format, *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. With this *WRAP-SIM* option, the records are stored in a HYD file (filename root.HYD).

First IN Record for Each Year - Inflows

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

Second IN Record for Each Year - Inflows

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

First EV Record for Each Year - Reservoir Evaporation Rates

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

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

FD Record – Flow Distribution

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

FC Record - Coefficients for Flow Distribution Equation

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

WP Record – Watershed Parameters

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

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

A *FC* record follows the *FD* record if the flow distribution method option 3 (field 6 of *CP* record) is applied for this control point requiring coefficients for the equation: $Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$

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

FD, *FC*, and *WP* records are stored in a DIS file that ends with an *ED* record.

FA Record - Flow Adjustments

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

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

Locating Errors in the Input Data

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

Two types of *WRAP-SIM* features facilitate locating errors.

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

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

Tracking Simulation Progress

The following features trace the progress of the simulation.

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

WRAP-SIM execution begins with an interactive session in which the root of the filenames is entered, and the files are opened. The program checks to confirm that the specified files do exist. If an input file is missing, a message to that effect appears on the monitor, and execution is terminated. An optional feature alerts the user if files with the output filenames already exist. The program requests verification from the user that these files are to be overwritten. The messages shown in Table 7 then appear on the monitor as the simulation is performed. Other similar messages related to specific modeling options appear only if those options are being used.

Progress in reading the input data is tracked by information written to the message file (filename root.MSS) showing which records were successfully read. If the entire DAT and DIS input files and the first year of *IN* and *EV* records are read without interruption, the pertinent messages shown in Table 8 will be found in the message file. If model execution is prematurely terminated, the last notation in the input trace message listing provides the approximate location

in the input files at which a problem occurred. The problem record will be after those records confirmed as being read successfully.

Table 7
Trace Messages on Monitor

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

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

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

Optional levels of input data traces are specified by input variable *ICHECK* in field 4 of the *JD* record. An *ICHECK* value of zero (blank field 4) or 1 results in the trace messages shown in Table 8. An *ICHECK* value greater than one results in the messages of Table 8 along with reproduction of a specified set of input records to the MSS file as they are read.

The types of records copied to the message file with each value of *ICHECK* is shown in Table 9. An *ICHECK* of one should normally be selected whenever a new or revised data set is initially run. If program execution is terminated by the operating system for some unknown reason, one of the other *ICHECK* options listed in Table 9 may be selected based on examining the *ICHECK*=1 trace in the message file. If the model runs correctly, changing *ICHECK* to zero (blank *JD* record field 4) will save a little computer time by not performing the more time-consuming error checks. An *ICHECK* of -1 will deactivate the trace messages but should probably never be used.

Program execution may be terminated due to a problem in an input record. As noted in the preceding paragraphs, the trace feature facilitates finding the erroneous record. *WRAP-SIM* reads all the records in sequential order starting with the DAT file. The *ICHECK=1* trace shown in Table 8 is used to find the general location of the problem record based on where the trace stops. The program is then rerun with a different *ICHECK* value to check which records in the groups noted in Table 9 are read and copied correctly.

Table 8
WRAP-SIM Trace Messages Written to Message File

*** Starting to read file root.DAT.
*** JD record was read.
*** Starting to read UC records.
*** Finished reading UC records.
*** Starting to read CP records.
*** Finished reading CP records.
*** Starting to read IF/WR records.
*** Finished reading IF/WR records.
*** Starting to read SV/SA records.
*** Finished reading SV/SA records.
*** Starting to read PV/PE records.
*** Finished reading PV/PE records.
*** Starting to read DI/IS/IP records.
*** Finished reading DI/IS/IP records.
*** Finished reading file root.DAT.
*** Finished ranking water rights in priority order.
****
Title records from input file:
(Titles from T1,T2,T3 records are reproduced here.)
****
System components counted from input file:
___ sets of water use coefficients (UC records)
___ control points (CP records)
___ water rights (WR and IF records)
___ hydropower rights
___ reservoirs
___ storage-flow tables (SD records)
___ storage-area tables (SV/SA records)
___ storage-elevation tables (PV/PE records)
___ tailwater rating tables (TQ/TE records)
___ drought indices (DI records)
****
*** Finished determining initial drought index multiplier factors.
*** Starting to read FD/WP records from file root.DIS.
*** Finished reading ___ FD and ___ WP records.
*** Determined watershed parameters for ___ control points
with INMETHOD(cp)>3 and/or EWA(cp)<0.
*** Beginning annual loop.
*** ___ IN and ___ EV records were read for the first year (____).
*** Flow distribution was performed for the first year.
*** Negative incremental flow adjustments were performed for the first year.
*** Flow adjustments from FA records were applied for the first year.
*** End of input data trace.

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

Table 9
Trace Information Copied to Message File for Various Values of ICHECK

ICHECK = -1	Minimal trace messages; many error detection routines in effect
ICHECK = 0	Messages shown in Table 8; many error detection routines in effect
ICHECK = 1	Messages shown in Table 8; all error detection routines in effect
ICHECK = 2	Messages shown in Table 8 plus all *UC* and *RF* records as read
ICHECK = 3	Messages shown in Table 8 plus all *CP* records as read
ICHECK = 4	Messages shown in Table 8 plus all *WR* and *IF* records as read
ICHECK = 5	Messages shown in Table 8 plus all *SV* and *SA* records as read
ICHECK = 6	Messages shown in Table 8 plus all *IN* and *EV* records as read
ICHECK = 7	Messages shown in Table 8 plus all *FD*, *FC*, and *WP* records as read

For ICHECK options 2 through 7, the features for *ICHECK*=1 are in effect. Additionally, the records noted in Table 9 are written to the MSS file immediately after each record is read. The records are copied to the MSS file almost verbatim as read, except most real numbers are written in a F8.0 Fortran format with zero digits to the right of the decimal point. If the program reads some but not all records of a particular record type, the problem will typically be associated with either the last record read and copied to the MSS file or more likely the next record in the input file. The types of records listed in Table 9 account for a majority but certainly not all of the records in a *WRAP-SIM* input set. ICHECK=6 applies to *IN/EV* records stored in DAT and INF/EVA files but does not apply to a HYD file.

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

Error and Warning Messages

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

1. The Fortran input/output status specifier *IOSTAT* is included in most of the read statements.
2. Many other specific error check algorithms are coded into various data input and computational routines.

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

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

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

Various other error checking routines are coded into *WRAP-SIM* with the error and warning messages shown in Tables 10 and 11, which are written to the message file. The error and warning checks take various forms. For example, essentially any identifier connecting records are checked to verify that they are on the other record. The control point identifiers on *WR*, *IF*, *CI*, *FD*, and *WP* records are checked to ascertain that they match identifiers on the *CP* records. Likewise, water use identifiers on *WR* records are matched against those on the *UC* records. Reservoir identifiers on *SV*, *PV*, *MS*, and *DI* records are checked to ascertain that the reservoirs have been entered on *WS* reservoirs. Upstream control points on *FD* records must actually be upstream of the specified control point as defined by *CP* records. Some checks involve detecting missing records or data. Other types of checks are indicated as well in Tables 10 and 11. As discussed in later in the *HYD* section, *WRAP-HYD* provides additional checking of *IN* and *EV* records.

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

Stopped in Subroutine _____ due to error.

Table 10
WRAP-SIM Error Messages

Written to Monitor from Subroutine FILINI before Opening MSS File
ERROR: No JD or FO record found when opening DAT file.
ERROR: Can not combine HYD with INF/EVA files.

Written to MSS File from main program
ERROR: CP output written for ___ control points but expecting ___
ERROR: TOTARGET of ____ on TO record is not valid. Water right: _____
ERROR: TOTARGET=10 can not be combined with TOCOMB=LIM. Water right: _____

Written to MSS File from Subroutine WRAPIN
ERROR: Missing title T1 record.
ERROR: Missing JD record.
ERROR: Number of years on JD record must be at least one.
ERROR: ADJINC of ___ and NEGINC of ___ on JD record are not compatible.
ERROR: ADJINC of ___ on JD record is not valid.
ERROR: EPDADJ of ___ in JD field 10 is not valid.
ERROR: Invalid data in JD record field 7, 11, 12, or 13.
ERROR: Missing WO, GO, RO, or CO record.
ERROR: FYIN(2) and FYIN(3) on FY record must be positive nonzero numbers. Read:_____
ERROR: The incremental decreases on FY record must each be less than previous level. Read:_____
ERROR: The YRO file must be open on the FO record for the FY record output table.
ERROR: Missing (UC,CP) record. Read CD of _____
ERROR: Control point _____ has an invalid INMETHOD of ___
ERROR: Downstream control point identifier [CPID(cp,2)] _____ on CP record for _____ matches no CPID(cp,1).
ERROR: Identifier _____ assigned to both control points ___ and ___
ERROR: Control point identifier ___ from (CI,WR,IF,SO) record ___ matches no control point identifier on CP records.
ERROR: Water use identifier _____ from WR or IF record matches no identifier on UC records.
ERROR: Return flow identifier _____ from WR record ___ matches no identifier on the RF records.
ERROR: Water rights _____ and _____ associated with reservoir _____ do not have cumulative storage capacities with respect to priorities.
ERROR: SO record field 6 is limited to blank or BACKUP, BFIRST, or RETURN. Read: _____
ERROR: ISHT of ___ in SO record field 9 is invalid.
ERROR: TO record field 10 is limited to blank or CONT. Read: _____
ERROR: TOTARGET=10 combined with TOCOMB=LIM is not valid. Water right:_____
ERROR: Reservoir identifier is missing from TO record field 8 for water right _____.
ERROR: Water right identifier is missing from TO record field 9 for water right _____.
ERROR: Reservoir _____ entered in field 8 of a TO record is not on any WS record.
ERROR: Water right _____ entered in field 9 of a TO record is not on any WR record.
ERROR: TOCOMB of ____ on TO record is not valid. Water right: _____
ERROR: Read CD of ___ instead of TO for a continuation TO record for water right: _____
ERROR: TS record is not valid for year ___ for water right _____ CD, TSYR1, TSYR2 read as follows:_____
ERROR: _____ read for TSL in field 2 of TS record for first year is not valid. Water right: _____
ERROR: Too many type 4 storage-flow rights.
ERROR: OR record is not valid for water right ____. For type 1 and hydropower rights, OR records are used only for secondary reservoirs.
ERROR: Missing (SV/SA,PV/PE,TQ/TE) record. Read CD of _____
ERROR: Missing or duplicate reservoir ID found while reading (SV/SA, PV/PE,TQ/TE) records.
ERROR: Both constant tailwater and tailwater rating table were specified for reservoir _____
ERROR: Missing storage area or elevation table.
ERROR: Reservoir _____ on (MS,DI,EA) record is not on any WS record.

Table 10 (Continued)
WRAP-SIM Error Messages

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

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

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

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

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

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

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

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

Table 11
WRAP-SIM Warning Messages

	Written to MSS File From Main Program
WARNING:	The beginning of simulation storage specified for reservoir _____ exceeds its capacity. The initial storage is set at the capacity.
WARNING:	Incorrect drought index identifier in field 2 of DI record.
WARNING:	Incorrect NEA identifier in field 2 of EA record.
	Written to MSS File from Subroutine WRAPIN
WARNING:	No output is specified on JD, CO, RO, WO, and/or GO records.
WARNING:	_____ on (CO,RO,WO,GO) record is not on any (CP,WS,WR) record.
WARNING:	TQ/TE records are provided but not assigned to a reservoir.
WARNING:	Incorrect NDI identifier in field 2 of DI record.
WARNING:	Incorrect NEA identifier in field 2 of EA record.
	Written to MSS File from Subroutine RESCAL
WARNING:	End-of-month storage did not converge to within 0.1 acre-feet in 50 iterations of iterative evaporation computations for water right _____ Reservoir: ___ CP: ___ Year: ___ Month: ___ Final Evap: ___
	Written to MSS File from Subroutine RELEASE
WARNING:	Unable to deliver releases to water right ____ from reservoir _____ due to channel loss factor of 1.0
	Written to MSS File from Subroutine POWER
WARNING:	Energy produced did not converge to within 0.01 percent of target in 50 iterations of iterative hydropower computations for water right _____. Reservoir: ___ Year:___ Month:___ Energy target:____ BPSTOR: ____ 49th POWPRO _____ 50th POWPRO adopted: _____
	Written to MSS File from Subroutines IACNP or FLDIST
WARNING:	The incremental CN and/or mean precipitation MP is negative for gaged ___ or ungaged ___ gaged CN, ungaged CN, gaged MP, ungaged MP = ____ ____ ____ ____
WARNING:	Convergence criterion of 0.5% was not met for flow distribution option 8 after 100 iterations at ungaged CP ____ for year ___ , month ____. Last flow computed of ____ was adopted.
WARNING:	Evap-precip adjustment at control point ____ for EWA(cp) of ___ for year ___, month ____ Runoff Adjustment (feet) = _____
	Written to MSS File from Subroutine BISECT
WARNING:	Subroutine BISECT stopped at 100 iterations in solving the NRCS CN equation for P.

WRAP-SIM Output Files

WRAP-SIM produces a main simulation results file and three optional additional output files.

- main simulation results output file (filename root.OUT)
- message file (filename root.MSS)
- hydropower production and multi-reservoir system release file (filename root.HRR)
- yield-reliability output table (filename root.YRO)

The program *TABLES* reads the main *WRAP-SIM* simulation output and input files and system release/hydropower output file, performs additional data manipulations and computations, and organizes the simulation results in user-specified tables. Additional computations, such as computing reliability and frequency statistics, are performed by *TABLES* in conjunction with organizing and presenting the *WRAP-SIM* simulation results. Program *TABLES* is discussed in detail later in the TAB chapter. The main *WRAP-SIM* simulation results file (root.OUT) may be viewed by the model-user but normally is not. Rather the simulation results are organized and summarized by program *TABLES*, and the model-user works with a *TABLES* output file. The MSS and YRO files are viewed directly by the model-user.

Basic Simulation Results Output File

Organization of the main simulation results file (filename root.OUT) is outlined in Tables 12 through 15. Chapter 2 of the *Reference Manual* provides an example of a *WRAP-SIM* output file. The output file begins with the five lines of information shown in Table 12. The one-line header is followed by the three title records *(T1,T2,T3)* read from the *WRAP-SIM* input file. The fifth line contains the five integers defined in Table 12. The simulation results are then written in monthly blocks of data.

Within each month of simulation results, output records for user-specified water rights are written first, followed by selected control point output records, followed by the output records for selected reservoir/hydropower projects. The monthly data associated with each specified water right, control point, or reservoir/hydropower project are listed in Tables 13 through 15. These records are all optional. The model-user specifies in the *WRAP-SIM* input file which types of output records and which water rights, control points, and/or reservoirs to include.

This file is designed to compactly store the voluminous output data in the order in which it is computed. Water right records are written in order of priority. Control point output records are in the same order as the *CP* records in the input file. The file can be examined directly by the model user and is useful for tracking problems occurring in the simulation. However, the format is not convenient for routinely interpreting simulation results. Program *TABLES* provides the capability to organize, tabulate, and summarize the simulation results in a variety of formats.

Some data are unique to either a water right, control point, or reservoir/hydropower record. For example, naturalized, unregulated, and unappropriated flows, and channel losses are associated only with control points. Hydroelectric energy is recorded only on reservoir/hydropower records. Other data are repeated on two or three of the record types. For example, reservoir storage and evaporation are written to all three records. If one water right with one reservoir is located at a control point, reservoir storage will be identical on all three records. However, the control point

records contain the summation of storage at all reservoirs assigned to the control point. Likewise, multiple water rights may be assigned to the same reservoir. Diversions and shortages on a control point record are the totals for all the diversion rights assigned to the control point. The diversions and shortages on a water right output record are associated with a single *WR* input record.

Water Right Output Records

Each record provides data for a water right for a given month. The records for all of the water rights are grouped together for a given month. The water right record for an instream flow requirement is different than the record for a regular diversion/storage right. As shown in Table 13, the 102 character records contain either 10 or 12 variables stored in the format indicated by the following Fortran format statements.

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

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

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

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

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

The entry for releases from other reservoirs consists of releases from secondary reservoirs to meet the storage and diversion requirements of the right. The amount that is released from the primary reservoir is not included.

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

Table 12
Organization of Main WRAP-SIM Output File

First Five Records of *WRAP-SIM* Output File

WRAP-SIM (September 2000 Version) Output File
TITLE1
TITLE2
TITLE3
YRST NYRS NCPTS NWROUT NREOUT

Definition of Variables on Fifth Record

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

Block of Records Repeated for Each Period (Month)

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

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

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

Table 13
Water Right Output Record

	Diversion/Storage Rights		Instream Flow Rights	
Field	Variable	Format	Variable	Format
1	Year	I4	IF	A2
2	Month	I2	month	I4
3	diversion shortage	F9.1	reservoir release shortage	F9.1
4	diversion target	F9.1	required reservoir release	F9.1
5	evaporation-precip volume	F9.1	evaporation-precip volume	F9.1
6	end-of-period storage	F9.1	end-of-period storage	F9.1
7	streamflow depletion	F9.1	streamflow depletion	F9.1
8	available streamflow	F10.1	available streamflow	F10.1
9	releases from other reservoirs	F9.1	releases from other reservoirs	F9.1
10	first identifier	A16	water right identifier	A16
11	second identifier	A8	instream flow target	F8.1
12	third identifier	A8	instream flow shortage	F8.1

Table 14
Control Point Output Record

Field	Variable	Format	Columns
1	control point identifier	A6	1-6
2	diversion shortage	F9.1	7-15
3	diversion target	F9.1	16-24
4	Evaporation	F9.1	26-33
5	end-of-period storage	F9.1	35-42
6	Streamflow depletion	F9.1	44-51
7	unappropriated streamflow	F10.1	53-61
8	return flow	F9.1	62-70
9	Naturalized streamflows	F10.1	71-80
10	regulated flows	F10.1	81-90
11	channel loss credits	F6.1	91-96
12	channel losses	F6.1	97-102

Table 15
Reservoir/Hydropower Output Record

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

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

Control Point Output Records

These records contain: (1) data not associated with a particular water right such as regulated and unappropriated flows and (2) water rights related data summed for all the water rights located at the control point. Each record provides data for a given month. The records for all the control points are grouped together for a given month. The 102-character record contains 12 variables stored in the format indicated by the following Fortran format statement.

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

As indicated in Table 14, each record contains, from left to right, the control point identifier, the sum of the shortages and permitted diversions for all water rights, evaporation-precipitation and end-of-period storage for all reservoirs, and streamflow depletions for all rights located at the control point. The next four fields contain the unappropriated flow remaining at the control point after all streamflow depletions have been made, the sum of the return flow returned at the control point from the current and previous month, and the naturalized and regulated streamflow. The last two fields contain the channel loss credits and channel losses discussed in the Chapter 6.

Reservoir/Hydropower Output Records

Each record provides data for a reservoir and/or hydroelectric power plant for a given month. All the reservoir/hydropower records are grouped together for a given period. The 80 character record outlined in Table 15 contains nine variables stored in the following format.

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

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

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

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

Message File

The use of information written to the message file (filename root.MSS) is discussed in the preceding section on locating errors. The extent of trace information to be provided is specified by input variable *ICHECK* entered on the *JD* record. The message file contains the following information designed to facilitate locating errors or problems in the input data:

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

Trace messages and input records are written as the input records are read. If program execution is terminated prior to completion of the simulation, the trace messages may be used to locate the last input record read prior to reaching the problem. *WRAP-SIM* includes a number of data check routines that write the error messages listed in Table 10 and stop program execution. Other routines in the model write the warning messages shown in Table 11 without terminating program execution.

Negative incremental streamflows are discussed in Chapter 3 of the *Reference Manual*. An option specified in field 9 of the *JD* record allows negative incremental flows to be written to the message file.

Hydropower Production and Multi-Reservoir System Release File

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

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

- water right or water right group identifier
- number of reservoirs associated with the right
- year and month
- energy target and energy generated
- reservoir releases listed in the same order as the *WS* records in the input file

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

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

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

SYSOUT in field 12 of the *JD* record specifies the type of water right identifier to be written to the *HRR* file. Creation of a *HRR* file is activated by field 8 of the *FO* record.

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

Yield Versus Reliability Table

The firm yield *FY* record activates a routine to develop a table of annual yield versus reliability, which is written to the *YRO* file (filename root.YRO). A file options *FO* record with the *YRO* file designated must be included in the *DAT* file any time a *FY* record is used.

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

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

Specification of Information to Include in the Simulation Results

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

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

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

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

Fields 5, 6, and 7 of the *JD* record 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 up to 30 water rights, water right groups, control points, and/or reservoirs listed on *WO*, *GO*, *CO*, and *RO* records, respectively.

Control Point Output Records

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

- The *JD* record field 5 allows selection of either the *none* or *all* options. If a -1 is entered in field 5, all control points will be output. If field 5 is blank or zero and there is no *CO* record, no control point is output.
- The *JD* record field 5 also allows output of just those control points for which *INMETHOD* in field 6 of the *CP* record is 0, 1, or 2 to be output. These are primary control points for which naturalized streamflows are entered on *IN* records rather than being synthesized. A -2 in field 5 activates this option.
- The *JD* record field 5 also allows the first any number of control points in the input file to be selected. For example, entering the integer 125 in field 5 of the *JD* record results in output records for the first 125 control points in the order that the *CP* records are found in the *WRAP-SIM* input file.
- Control points listed on the *CO* record are included in the output along with those that may be specified by the *JD* record. *CO* records may be used alone (blank field 5 on *JD* record) or in combination with the two *JD* field 5 options noted above.

Reservoir/Hydropower Output Records

The *RO* record provides the only means to specify reservoir/hydropower output records. The options are (1) all, (2) none, or (3) those reservoirs listed on *RO* records.

Reservoir/hydropower output records are used to obtain information regarding hydroelectric power generation and reservoir inflows and releases. Reservoir storage and net evaporation-precipitation are included on the control point and water rights records as well as on the reservoir/hydropower records. Reservoir/hydropower records are typically included in the output only if the other information listed in Table 15 is of interest or if tables are to be created with program *TABLES* that require reservoir/hydropower records rather than the other output.

Water Right Output Records

As indicated in Tables 13 and 14, both the water right and control point output records include the following variables in common: diversion shortage, diversion target, evaporation-precipitation volume, storage, and streamflow depletion. The values for these variables on the control point output record reflect the summation for all rights at that control point. If only one water right is assigned to a particular control point, the values for these variables will be the same on the water right versus control point output records. Other variables listed in Tables 3-9 and 3-10 pertain to either a water right or a control point but not both.

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

- The *JD* record field 6 allows selection of either the *none* or *all* options.
- The *JD* record field 6 also allows the first any number of water rights in the input file to be selected. For example, entering the integer 125 in field 6 of the *JD* record results in output records for the first 125 water rights in the order that the *WR* records are entered in the *WRAP-SIM* input file.
- *WO* records are used to list the 16-character water right identifiers found in field 11 or alternate field 14 of the *WR* records or field 9 of the *IF* records. All rights with the identifiers listed on the *WO* records are output in addition to any that may be specified by the *JD* record as noted above.
- Group output *GO* records are used to list the 8-character water right group identifier found in fields 12 and 13 or alternate fields 15 and 16 of the *WR* record. All rights with the identifiers listed on *GO* records are output as well as those listed on *WO* records or specified by the *JD* record.

Water Right Identifiers

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

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

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

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

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

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

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

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

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

TABLES

The computer program *TABLES* reads *WRAP-SIM* input and output files, performs various computations and data manipulations, and develops tables which are written to an output file. *WRAP-SIM* output files are designed for storing large quantities of data in a concise format. *TABLES* provides convenient and flexible capabilities for 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 wordprocessor program for graphics or report preparation.

Program Organization

The Fortran program *TABLES* consists of a main program and several subroutines. The main program opens the required files, checks the identifier on each record of the *TABLES* input file in turn, and calls the appropriate subroutines. The *WRAP-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 a specific type of table or data listing and is activated by one or more types of input records. The types of *TABLES* input records are listed in Table 16 and described in this section. Headings for the tables created by several of these records are shown as Tables 17 through 22.

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

Input and Output Files

An execution of *TABLES* begins with an interactive routine in which the user provides roots of the filenames for the *TABLES* input (root1.dat) and output (root2.out) files and *WRAP-SIM* files (root3). The *TABLES* input and ouput filenames may have either the same (default) or different roots (root1 and root2). *WRAP-SIM* input and output files have the same root (root3).

root1.DAT	*TABLES* input file specifying tables to be developed
root2.OUT	*TABLES* output file with the resulting tables
root3.DAT	*WRAP-SIM* input file
root3.OUT	*WRAP-SIM* output file
root3.HRR	*WRAP-SIM* hydropower and reservoir release file

The *TABLES* input file specifies the tables and/or other types of information to be developed and stored in the *TABLES* output file. The data from which the tables and data listings are compiled are read from *WRAP-SIM* input and/or output files. One, two, or three *WRAP-SIM* files are required depending on the types of tables or data sets specified in the *TABLES* input file (filename root1.dat).

Table 16
Program TABLES Input Records and Associated Tables

Miscellaneous Records

TITL - titles or headings
COMM - comments
PAGE - title page
UNIT units for table headings
ENDF - end of input data file

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

1REC - listing of specified input records
1SUM - water rights summary by control point or type of use
1SRT - listing of water rights sorted by priority, type of use, control point, or water right type

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

2REL - reliability summary by control point, water right, water right group, or reservoir
2RET - composite volume reliability supplement to 2REL summary table
2FRE - frequency table for streamflow, storage, or instream flow shortage
2FRQ - frequencies for specified streamflow, storage, or instream flow shortage
2PER - percentage of storage capacity and storage-duration tables for selected reservoirs
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
2NAT - tables of monthly and annual naturalized streamflows
2REG - tables of monthly and annual regulated streamflows
2UNA - tables of monthly and annual unappropriated streamflows
2DEP - tables of monthly and annual streamflow depletions
2DIV - tables of monthly and annual diversions
2TAR - tables of monthly and annual diversion targets
2SHT - tables of monthly and annual diversion shortages
2IFS - tables of monthly and annual instream flow shortages
2IFT - tables of monthly and annual instream flow targets
2CLO - tables of monthly and annual channel losses
2CLC - tables of monthly and annual channel loss credits
2STO - tables of monthly and annual reservoir storages

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

3REG - records of regulated streamflows
3NAT - records of naturalized streamflows
3UNA - records of unappropriated streamflows
3DEP - records of streamflow depletions
3U+D - records of unappropriated flows plus streamflow depletions

Job Type 4 Record - Develop Tables from *WRAP-SIM* System Release/Hydropower File

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

Table 17

Headings for Water Rights Summary Specified by 1SUM Record

(Heading for first column may be either use, control point, water right type, or group.)

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

Table 18

Headings for Annual Summary Specified by 2SCP and 2SBA Records

(Headings are similar for 2SWR, 2SRE, and 2SGP records.)

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

Table 19

Headings for Monthly Summary Specified by 2SWR Record

(Headings are similar for 2SCP, 2SBA, 2SRE, and 2SGP records.)

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

Table 20

Annual Rows with Monthly Columns Format Headings for Tables Specified by 2NAT, 2REG, 2UNA, 2DEP, 2DIV, 2SHT, 2IFS, 2CLO, 2CLC, 2STO, and 2PER Records

(An alternative columnar format places all data in a single column.)

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

Table 21

Headings for Reliability Summary Specified by 2REL Record

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

Table 22

Headings for Frequency Tables Specified by 2FRE Record

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

Input Records and Associated Tables

The tables or data sets to be developed are specified by records in an input file with the filename root1.DAT. Each type of table is associated with an input record that begins with a four-character record identifier, followed by parameters providing instructions associated with that particular type of table or data listing. All records are optional; there are no required records. No limits are placed on the number or order of the records, with the exception of title TITL records that are limited to a maximum of five records and must be located at the beginning of the input file. Any number of each type of record, except the TITL records, can be placed in any order in the input file.

TABLES reads one record of the input file (root1.DAT); develops the table or multiple tables specified; stores the tables in the output file (root2.OUT); and then goes on to the next record of the input file. The input records are handled in sequential order. Thus, erroneous *TABLES* root1.DAT file records are easy to locate. If the program is terminated by the operating system due to illegal operations, the erroneous record in the root1.DAT file is located simply by observing the last table correctly written to the root2.OUT file. *TABLES* also writes various error and warning messages to the monitor to help in detecting and correcting blunders in the table-specification input file.

TABLES input records are listed by their four-character identifiers in Table 16 and discussed as follows. Examples of headings for several of the types of tables are provided as Tables 17 through 22. Examples in the *Reference Manual* illustrate the format and content of various types of tables. This section ends with a set of tables that provide detailed instructions for developing each record of a *TABLES* input file.

Miscellaneous Records

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

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

UNIT records specify unit labels to include in table headings other than the default *AC-FT* for volume and *MW-HR* for hydroelectric energy. The unit headings entered on a UNIT record are adopted for all records following the UNIT record. Without a *UNIT* record, the defaults of *AC-FT* and *MW-HR* are adopted. In TABLES, the units pertain only to tables headings, not actual computations. *TABLES* computations are manipulations of the *WRAP-SIM* simulation results perfomed without reference to units.

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 terminal 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*.

Job Type 1 Records (Tables are developed from data from a WRAP-SIM input file.)

1REC, 1SUM, and 1SRT records specify listings and tabulations of data which are read from a *WRAP-SIM* input file, which is the only *WRAP-SIM* file required. The four-character identifiers for type 1 records begin with the numeral one (1REC, 1SUM, 1SRT).

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

A 1SUM record results in a summary table of water rights data by control point, type of use, water right type, or water right group. This table includes number of rights, diversion amounts, number of reservoirs, storage capacity, and range of priorities. The heading for a 1SUM record by type of use is shown as Table 17. The types of water use listed in the first column may be replaced with control points, water right types, or water right groups.

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

Job Type 2 Records (Tables are developed from data from a WRAP-SIM output file.)

Job type 2 records result in tables being developed from the data contained in the water right, control point, and reservoir/hydropower records of a *WRAP-SIM* output file. These types simulation results data are tabulated in Tables 13, 14, and 15. A *WRAP-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.

2SCP, 2SWR, 2SGP, and 2SRE records result in summary tables for specified control points, water rights, water right groups, or reservoirs, respectively. These tables consist of either a monthly or annual tabulation of the data items contained on the *WRAP-SIM* control point, water right, or reservoir/hydropower output records. The heading for an annual summary table created by a 2SCP record is shown as Table 19. Each row of data in the table corresponds to a year in the hydrologic period-of-analysis. A monthly table has an additional column for the month and 12 times as many rows as an annual table. Each row of data is for a particular month. The headings for a monthly water right summary table associated with a 2SWR record are shown in Table 18.

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

A 2SBA record results in a basin summary table, with the same headings and data as the 2SCP record shown in Table 19. The naturalized, regulated, and unappropriated streamflows in the 2SBA table are the maximum of the values found at any of the control points. The other tabulated data are the summation of values for all of the control points.

2NAT, 2REG, 2UNA, 2DEP, 2DIV, 2TAR, 2SHT, 2IFT, 2IFS, 2CLO, 2CLC, and 2STO records all have the same format. The tables created by these records also all have the same format. 2NAT, 2REG, 2UNA, 2CLO, and 2CLC records are relevant only for control points. These records create tables of naturalized flows, regulated flows, unappropriated flows, streamflow depletions, diversions, diversion targets, diversion shortages, instream flow targets, instream flow shortages, channel losses, channel loss credits, and end-of-period reservoir storages, respectively. The tables may be developed in two optional formats: (1) annual rows and monthly columns with headings shown in Table 20 and (2) columnar format to facilitate graphing the data with programs such as *Microsoft Excel*. Both formats are illustrated by Table 2-9 of the *Reference Manual*. The format illustrated by Table 20 and includes one line for each year of the simulation, with each line containing the year, 12 monthly (January through December) values of the variable, and the total or mean for the year. The other option illustrated by Table 2-9 of the *Reference Manual* consists of individual columns with monthly data for all months or annual data for all years of the period-of-analysis or means for the 12 months of the year. Any number of these columnar tables may be created with up to 100 columns in each table. The primary use of this format is to simplify transporting the data into *Microsoft Excel* or other spreadsheet or graphics programs for plotting or other manipulations.

The 2PER record builds two tables for specified reservoirs: (1) tabulations of end-of-period reservoir storage as a percentage of a user-specified storage capacity and (2) draw-down frequency relationships. Percentage storage content tabulations are particularly useful for reviewing simulation results for multiple-reservoir system operations. The *WRAP-SIM* multiple-reservoir system release rules are based on balancing percent depletions of specified storage zones. The drawdown-duration table is developed in terms of the percentage of months for which the storage draw-down equaled or exceeded specified percentages of storage capacity. Sets of 2PER records are used to specify the reservoirs to be included in the tabulation and, for each reservoir, the storage capacities C_1 and C_2 at the top and bottom, respectively, of the conservation pool or zone. The end-of-period storages (S) are read from the reservoir/hydropower record of the *WRAP-SIM* output file. The storage percentages in the 2PER table are computed as follows:

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

A 2REL record calls for a table containing period and volume reliabilities and the percentage of time that certain percentages of demand are met. A 2REL summary may be developed for either selected water rights, water right groups, control points, or hydroelectric power reservoirs. Three separate 2REL records would be used to obtain three separate reliability summary tables for selected water rights, control points, and hydroelectric power reservoirs, respectively. Period reliability is the number of months for which shortages occurred divided by the total number of months in the simulation. Volume reliability is the total volume of shortages (or total energy shortage) divided by the corresponding total permitted diversion volume (or permitted firm energy). The table also expresses reliabilities in terms of the percentage of the months and the percentage of the years during the simulation for which the water right diversion or hydroelectric energy generated equaled or exceeded specified percentages of the permitted diversion or hydroelectric energy target. The format of this table is illustrated by Table 21. Fixed percentages of target amounts are tabulated in the heading, and the computed exceedance frequencies are shown on each row of the table. Reliabilities are further discussed in the last section of this chapter.

The 2FRE record determines the mean, standard deviation, and frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with a specified control point or the reservoir storage or instream flow shortage associated with a specified water right. The flow or storage amount is computed and tabulated for each of the exceedance frequencies shown in Table 22. The frequencies are defined as the percentage of the months in the simulation for which the flow or storage equaled or exceeded the amount shown in the table. For a specified frequency (90% for example), if a particular flow value in the simulation results is equaled or exceeded exactly that percentage of the time, that value is selected. Otherwise, linear interpolation is applied to the two flow values bracketing the specified frequency.

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

The 2FRQ and 2FRE records both provide frequency relationships for the same variables but differ as follows. The 2FRE record determines flows for the set frequencies shown in Table 22. Conversely, the 2FRQ record determines frequencies for flows specified by the user as input on the 2FRQ record. Whereas, a single 2FRE table may include rows of information for multiple control points or water rights, each 2FRQ table is limited to a single specified control point or water right. Of course, any number of 2FRQ records may be included in the input file. Examples of tables created with 2FREQ and 2FRQ records may be found in Table 2-9 of the *Reference Manual*. Frequency computations are discussed later in the present section.

Job Type 3 Records (Streamflow records are developed from data from a WRAP-SIM output file.)

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

- naturalized streamflows (3NAT record)
- regulated streamflows (3REG record)
- unappropriated streamflows (3UNA record)
- streamflow depletions (3DEP record)
- summation of streamflow depletions plus unappropriated flows (3U+D record)

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

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

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

Job Type 4 Records (Data from WRAP-SIM Hydropower and Reservoir Release File)

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

In the *WRAP-SIM HRR* output file, reservoir releases each month of the simulation for a given water right is listed as a row, which may contain releases from up to 20 reservoirs associated with that water right. The 4SWR and 4SGP records create tables with releases from each reservoir listed as columns. The 4SWR record results in a table for a specified water right in which monthly releases from each reservoir for that right are listed in a column. The 4SGP record results in a table for a specified group of water rights in which the total monthly releases for all rights in the group from each reservoir for that group are listed in a column.

Field 8 of the *FO* record in a *WRAP-SIM* input field specifies whether or not a *HRR* file is created. Water right identifiers are written to the *HRR* file by default unless group identifiers are specified in field 13 of the *JD* record. The same water rights are included in both the *OUT* and *HRR* output files. Thus, whichever water rights are selected by *WRAP-SIM* options described in Chapter 3 to output to the basic *OUT* file (filename root.OUT) are also included in the *HRR* file (filename root.HRR).

Unlike the *OUT* file which is a direct access file, the *HRR* file is read sequentially. Thus, 4SWR/4SGP tables may require considerable computer time searching for water right identifiers in the *HRR* file. *TABLES* run times may be reduced significantly by minimizing the number of water rights output by *WRAP-SIM*.

Format and Content of Input Records

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

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

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

Alternative Fixed Field Width and Comma Delimited Formats

Appendices C, D, and E present 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.

Table 23
Quick Reference Chart for TABLES

					columns						
4	8	12	16	20	24	28	32	36	40	44	page
TITL											81
COMM											81
PAGE											81
UNIT											82
ENDF											82

Job Type 1 Records – Tables from WRAP-SIM Input File

1REC	KK	NUM	REC	REC	REC	REC	REC	REC	REC	REC	83
1SUM	KK										83
1SRT	KK										83

Job Type 2 Records – Tables from WRAP-SIM Output File

2REL	RFLAG	ID		NUM		IDEN		IDEN		IDEN	84
2RET	TAR										84
2FRE	ID	NUM		IDEN		IDEN		IDEN		IDEN	86
2FRQ	ID	NM		IDEN		QF(1)		QF(2)		QF(3)	86
2PER	NUM	IDEN		IDEN		IDEN		IDEN		IDEN	87
2SCP	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	88
2SWR	MNAN	NUM				IDEN				IDEN	88
2SGP	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	89
2SRE	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	89
2SBA	MNAN										89
2NAT	TA	PT	NEW	ID	NUM		IDEN		IDEN		90
2REG	TA	PT	NEW	ID	NUM		IDEN		IDEN		90
2UNA	TA	PT	NEW	ID	NUM		IDEN		IDEN		90
2DEP	TA	PT	NEW	ID	NUM				IDEN		90
2DIV	TA	PT	NEW	ID	NUM				IDEN		90
2SHT	TA	PT	NEW	ID	NUM				IDEN		90
2IFS	TA	PT	NEW	ID	NUM				IDEN		90
2CLO	TA	PT	NEW	ID	NUM		IDEN		IDEN		90
2CLC	TA	PT	NEW	ID	NUM		IDEN		IDEN		90
2STO	TA	PT	NEW	ID	NUM		IDEN		IDEN		90

3NAT	CDOUT	HEC	INFAC								91
3REG	CDOUT	HEC	INFAC								91
3UNA	CDOUT	HEC	INFAC								91
3DEP	CDOUT	HEC	INFAC								91
3U+D	CDOUT	HEC	INFAC								91

4SWR	MNAN	NUM		IDEN		IDEN		IDEN		IDEN	92
4SGP	MNAN	NUM	IDEN	IDEN	IDEN	IDEN	IDEN				92
4	8	12	16	20	24	28	32	36	40	44	page

TITL Record - Titles or Headings

field	columns	variable	format	value	Description
1	1-4	CD	A4	TITL	record identifier
2	5-78	TITLE	A76	AN	title or heading

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

COMM Record – Comments

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

Any number of COMM records can be inserted anyplace in the input file to provide notes or comments. The COMM 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	prints title page

Legend for Format Column of Tables

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

UNIT Record – Units for Table Headings

Field	columns	variable	format	value	description
1	1-4	CD	A4	UNIT	record identifier
2	5-10	UNIT	A5	AN blank	Volume units printed in table headings. Without a *UNIT* record, the default is AC-FT.
3	11-15	UNHP	A5	AN blank	Hydropower units printed in table headings. Without a *UNIT* record, the default is MW-HR.

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

UNIT = AC-FT
UNHP = MW-HR

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

ENDF Record - End of Input File

field	columns	Variable	format	value	description
1	1-4	CD	A4	ENDF	record identifier

1REC Record - Listing of Specified WRAP Input Records

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

1SUM Record - Water Rights Summary

field	columns	Variable	format	value	description
1	1-4	CD	A4	1SUM	record identifier
2	8	KK	I4	1 2 3 4	summary by control point summary by type of use summary by water right type summary by groups as defined by GO record

1SRT Record - Listing of Sorted Water Rights

field	columns	Variable	format	value	Description
1	1-4	CD	A4	1SRT	record identifier
2	8	KK	I4	0 1 2 3	listing of rights in priority order listing of rights by control point in priority order listing of rights by type-of-use in priority order listing of rights by water right type in priority order

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	6	TFLAG	I2	0, blank	not used
				1,+	Diversion summary table is added at the end of the reliability table. A 2RET record must follow.
3	8	RFLAG	I2	0,blank	N = number of months with non-zero targets
				1,+	N = NYRS*12 for $R_P = (n/N)*100\%$
4	12	ID	I4	0	table includes selected control points
				1	table includes selected water rights
				2	table includes selected hydropower reservoirs
				3	table includes selected water right groups
5	16	NUM	I4	0	include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) in table
				-	include NUM previously listed rights, reservoirs, water right groups, or control points in table
				+	number of water rights, reservoirs, water right groups, or control points to follow (1 to 30; 8 per record)
6-13	17-80	IDEN	8(2x,A6)	AN	identifiers of control points (ID=0), water rights (ID=1), reservoirs (ID=2), or water right groups (ID=3),
	17-80	IDEN8	8A8		
	17-144	IDEN16	8A16		
					to include in table (IDEN(ID,I),I=1,NUM)
				blank	if NUM is zero or negative

2RET Record – Supplemental 2REL Summary Table

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

Explanation of 2REL/2RET Records

For control points (ID=0), water rights (ID=1), and water right groups (ID=3), reliabilities are computed for water supply diversions. For hydropower reservoirs (ID=2), reliabilities are computed for electric energy generation. *TABLES* reads the data for control points (ID=0) from the control point records (Table 14) in the *WRAP-SIM* output file. The data for water rights (ID=1) and water right groups (ID=3) are from the water right records (Table 13) in the *WRAP-SIM* output file. The data for the hydropower reservoirs (ID=2) are from the reservoir/hydropower records (Table 15) in the *WRAP-SIM* output file.

Control point and reservoir identifiers (IDEN) may contain a maximum of six characters and are entered in 8-character fields in the format 8(2x,A6). Water right group identifiers (IDEN8) may contain a maximum of eight characters and are entered in 8-character fields in the format 8A8.

Water right identifiers (IDEN16) may contain a maximum of 16 characters and are entered in 16-character fields in the format 8A16. Water rights IDEN16 are unique identifiers for individual rights; so diversions and shortages are not aggregated. Only the first right with IDEN16 is used.

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

Up to 30 identifiers (*NUM* = 30 in field 4) on 4 records (8 identifiers per record) may be included in a single table. Any number of tables may be created using multiple 2REL records. A blank or zero field 5 results in all of either the control points (ID=0 in field 3), water rights (ID=1), hydropower rights (ID=2), or water right groups (ID=3) included in the WRAP-SIM output file being included in the reliability table.

TFLAG in *2REL* field 2 flags adding a table showing the diversion target, diversion, shortage, and volume reliability for the total of all the control points, water rights, reservoirs, or groups included in the reliability table, based on a total diversion target specified by the user. This option requires that a *2RET* record follow the *2REL* record. The only entry on the *2RET* record is the diversion target to be adopted for the add-on summary, which if left blank defaults to the summation of the pertinent targets from the *WRAP-SIM* output file.

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

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

field	columns	Variable	format	value	description
1	1-4	CD	A4	2FRE	Record identifier
2	5-8	ID	I4	1	naturalized flows
				2	regulated flows
				3	unappropriated flows
				4	reservoir storage
				-4	reservoir storage with only totals included in table
				5	reservoir storage associated with a water right
				-5	reservoir storage with only totals included in table
				6	instream flow shortage for an *IF* record right
3	12	NUM	I4	0	Include all control points or reservoirs in table
				+	number of control points or reservoirs to follow (30 maximum, eight per record)
4-11	13-76	IDEN	8(2x,A6)	AN	identifiers of control points (ID=1-4) or rights (ID=5,6)
		IDEN16	8A16		to include in table (IDEN(ID,I),I=1,NUM)
				blank	if NUM is zero or negative

2FRQ Record - Frequency for Specified Flow or Storage

field	columns	Variable	format	value	description
1	1-4	CD	A4	2FRQ	Record identifier
2	8	ID	I4	1	naturalized flows
				2	regulated flows
				3	unappropriated flows
				4	reservoir storage
				5	reservoir storage associated with a water right
				6	instream flow shortage associated with an *IF* record right
3	12	NM	I4	+	number of flows or storages entered for *TABLES* to determine frequencies (NM may range from 1 to 7)
4	13-20	IDEN	10x,A6	AN	identifier of control point (ID=1-4) or
	13-28	IDEN16	A16		water right (ID=5,6)
5-11	21-76	QF(I)	7F8.0	+	streamflows (ID=1,2,3), storage (ID=4,5), or instream
	29-84	I=1,NM			flow shortage (ID=6) for which to compute frequency

2PER Record - Percent Storage and Storage Drawdown-Duration Tables

First 2PER Record

field	columns	Variable	format	value	description
1	1-4	CD	A4	2PER	Record identifier
2	5-8	NUM	I4	+ -	number of reservoirs reservoir identifiers previously entered
3-14	9-104	IDEN(res) res=1,12	12(2x,A6)	AN	reservoir identifiers

Second 2PER Record - Total Storage Capacity (required)

field	columns	Variable	format	value	description
1	1-4		A4	2PER	Record identifier
2	4-8		4X		blank or comments (not read by *TABLES*)
3-14	9-104	C1(res) res=1,12	12F8.0	+	total storage capacity in each reservoir

Third 2PER Record - Inactive Storage Capacity (0ptional; defaults to all C2 = 0.0, but required if followed by another set of 2PER records)

field	columns	Variable	format	value	description
1	1-4		A4	2PER	Record identifier
2	4-8		4X		blank or comments (not read by *TABLES*)
3-14	9-104	C2(res) res=1,12	12F8.0	+	total storage capacity in each reservoir

The 2PER record develops two tables. The first is a tabulation end-of-period reservoir storage expressed as a percentage of a user-specified storage capacity.

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

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. 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 second table is a storage drawdown-duration relationship expressed in terms of the percentage of months for which the draw-down equaled or exceeded specified percentages of storage capacity.

Storage contents are read from reservoir records (Table 15) in the *WRAP-SIM* output file. A maximum of 12 reservoirs can be included. The reservoir identifiers are provided on the fist record. The C_1 storage capacities are provided on the required second record. The C_2 storage capacities are provided on the optional third record. C_2 is assumed zero for all reservoirs if the third record is not provided. The third record is required if followed by another set of 2PER records.

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
				-	negative means tables are developed for Abs(NUM) control points listed on a previous record
				+	number of control points to follow
4-11	13-76	IDEN(ID,I) I=1,NUM	8(2x,A6)	AN	identifiers of control points for which to develop tables (IDEN(ID,I),I=1,NUM)

2SWR Record - Summary Tables for Water Rights

field	columns	variable	format	value	Description
1	1-4	CD	A4	2SWR	record identifier
2	5-8	MNAN	I4	0	annual table
				1	monthly table
				2	both annual and monthly tables
3	9-12	NUM	I4	blank,0	develop tables for all water rights
				-	develop tables for NUM water rights listed on a previous record
				+	number of water rights to follow
4-11	13-140	IDEN16	8A16	AN	identifiers of water rights for which to develop tables (IDEN16(ID,I),I=1,NUM)
				blank	if NUM is zero or negative

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

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

TABLES reads the data for 2SCP and 2SBA tables from the control point records (Table 14) in the *WRAP-SIM* output file. The data for the 2SWR and 2SGP tables are from the water right records (Table 13) in the *WRAP-SIM* output file. The data for the 2SRE table are from the reservoir/hydropower records (Table 15) in the *WRAP-SIM* output file.

2SGP Record - Summary Tables for Water Right Groups

field	columns	Variable	format	value	Description
1	1-4	CD	A4	2SGP	record identifier
2	5-8	MNAN	I4	0	annual table
				1	monthly table
				2	both annual and monthly tables
3	9-12	NUM	I4	-	develop tables for NUM water right groups listed on a previous record
				+	number of water right groups to follow
4-11	13-140	IDEN8	8A8	AN	identifiers of water right groups for which to develop tables IDEN8(ID,I),I=1,NUM)
				blank	if NUM is negative

2SRE Record - Summary Tables for Reservoirs

field	columns	variable	format	value	Description
1	1-4	CD	A4	2SRE	record identifier
2	5-8	MNAN	I4	0	annual table
				1	monthly table
				2	both annual and monthly tables
3	9-12	NUM	I4	0	develop tables for all reservoirs
				-	develop tables for NUM reservoirs listed on a previous record
				+	number of reservoirs to follow
4	13-76	IDEN	8(2x,A6)	AN	identifiers of reservoirs for which to develop tables (IDEN(ID,I),I=1,NUM)
				blank	if NUM is zero or negative

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

field	column	variable	format	value	Description
1	1-4	CD	A4	2SBA	record identifier
2	8	MNAN	I4	0	Annual table
				1	monthly table
				2	both annual and monthly tables

2NAT Record - Naturalized Streamflow
2UNA Record - Unappropriated Streamflow
2DIV Record - Diversion
2TAR Record - Diversion Target
2IFS Record - Instream Flow Shortages
2CLO Record - Channel Loss
2REG Record - Regulated Streamflow
2DEP Record - Streamflow Depletion
2SHT Record - Diversion Shortage
2IFT Record - Instream Flow Target
2STO Record - Reservoir Storage
2CLC Record - Channel Loss Credits

field	columns	variable	format	value	description
1	1-4	CD	A4	2NAT	record identifier for naturalized streamflow table
				2REG	record identifier for regulated streamflow table
				2UNA	record identifier for unappropriated streamflow table
				2DEP	record identifier for streamflow depletion table
				2DIV	record identifier for diversion table
				2TAR	record identifier for diversion target table
				2SHT	record identifier for diversion shortage table
				2IFS	record identifier for instream flow shortage table
				2IFT	record identifier for instream flow target table
				2CLO	record identifier for channel loss table
				2CLC	record identifier for channel loss credits table
				2STO	record identifier for reservoir storage table
2	8	TA	I4	blank,0	do not develop annual row/monthly column table
				1	develop table in annual row and monthly column format
3	12	PT	I4	blank,0	do not develop columnar plot table
				1	develop columns of monthly data
				2	columns of annual totals or means
				3	columns of 12 monthly means
4	16	NEW	I4	0	write columns; next record starts a new table
				1	add more columns to existing table or start first table
5	20	ID	I4	0	develop tables for control points
				1	develop tables for water rights
				2	develop tables for reservoirs
				3	develop tables for water right groups
6	24	NUM	I4	0	develop table for all control points (ID=0), rights (ID=1), or reservoirs (ID=2). NUM cannot be zero if ID=3.
				-	develop tables for NUM previously listed control points, water rights, or reservoirs
				+	number of control points, water rights, reservoirs, or water right groups to follow
7-14	25-88	IDEN	8(2x,A6)	AN	identifiers of control points (ID=0), water rights (ID=1),
		IDEN8	8A8		reservoirs (ID=2), water right groups (ID=3) to
		IDEN16	8A16		include in table [IDEN(ID,I),I=1,NUM]
				blank	if NUM is zero or negative

3NAT Record - Naturalized Streamflows
3REG Record - Regulated Streamflows
3UNA Record - Unappropriated Streamflows
3DEP Record - Streamflow Depletions
3U+D Record - Unappropriated Flows plus Streamflow Depletions

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

The 3NAT, 3REG, 3UNA, 3DEP, and 3U+D records have the same format. The specified data are read from control point output records in the *WRAP-SIM* output file. *TABLES* converts the data to the format of *WRAP-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 3NAT, 3REG, 3UNA, 3DEP, and 3U+D records.

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 in the *WRAP-SIM* output file. The records may be ordered with all years grouped together for a control point followed by all years for the next control point (default of *HEC* = 0 in field 3). Alternatively, records for all control points may be grouped together for each year (*HEC* = 1 in field 3).

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

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

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

4SWR Record - Multiple-Reservoir System Release Table for a Water Right

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

4SGP Record - Multiple-Reservoir System Release Table for a Water Right Group

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

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

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

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

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

4SWR/4SGP tables may use considerable computer time searching for identifiers in the *HRR* output file. *TABLES* run times may be reduced by minimizing the number of water rights output by *WRAP-SIM*.

WRAP-HYD

The purpose of *WRAP-HYD* is to facilitate developing hydrology-related input data for *WRAP-SIM*. The *HYD*rology data program provides a set of optional routines to read, modify, and create files of naturalized streamflows (*IN* records) and net evaporation-precipitation depths (*EV* records). *WRAP-HYD* output files are read by *WRAP-SIM* as input files. *WRAP-HYD* provides certain computational routines that are also available in *WRAP-SIM* and others that are not. For the routines incorporated in both programs, the format of the computed output is different. The primary *WRAP-HYD* output is files of *IN* and *EV* records that are read by *WRAP-SIM* as input. *WRAP-HYD* also includes options for reading and writing streamflow and evaporation-precipitation data as columns in a table, which facilitates transferring data from and to spreadsheet programs such as *Microsoft Excel*.

WRAP-HYD is a set of computational options designed to provide assistance in developing sequences of naturalized streamflows and net evaporation-precipitation rates (*IN* and *EV* records). Capabilities are provided for performing the tasks outlined in Table 24 and discussed in the following paragraphs. The tasks are listed in Table 24 generally in the order in which they are performed within *WRAP-HYD*. All tasks are optional. The model-user specifies any number of tasks to be performed in a particular run of *WRAP-HYD* through entries on the *CP*, *FO*, *EP*, *JC*, *AS*, *RS* and *EQ* input records. Table 25 notes the records that are used to choose each of the *WRAP-HYD* capabilities outlined in Table 24. These data manipulation options involve reading *IN* and/or *EV* records and creating revised *IN* and/or *EV* records stored in new files. *WRAP-HYD* options include developing several related tables as well as sets of *IN* and *EV* records. A single execution of *WRAP-HYD* may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. Files may also be transported back and forth between *WRAP-HYD* and spreadsheet programs.

Initial Manipulations of IN and/or EV Records

The following optional tasks are performed as the *IN* and *EV* records are initially read. These options are activated by input entered on *XL*, *CP*, and *MF* records.

- The flows and/or evaporation-precipitation rates from *IN* or *EV* records are multiplied by factors specified on *XL*, *CP,* and *MF* records. The monthly factors on *MF* records may also be added.
- Streamflows and/or evaporation-precipitation rates may be assigned to a control point by either verbatim repeating data from another control point or by multiplying the repeated flows by the factors from the *CP* records.

The *XL* and *CP* record factors in *WRAP-HYD* are similar to the previously discussed factors in *WRAP-SIM*. The factors may be used for unit conversions, such as converting streamflows from second-feet-day ($ft^3/s \times day$) to acre-feet or net evaporation-precipitation depths from inches to feet. Also, the same streamflow or evaporation-precipitation rates may be conveniently assigned to multiple control points as appropriate. Drainage area ratios may be applied to transfer flows from gaged to ungaged sites. These data adjustments occurring immediately after the original data are read are then followed by the other optional tasks listed in Table 24.

Table 24
Capabilities Provided by WRAP-HYD

- *Initial Manipulations of IN and/or EV Records*

  1. Multiplying the streamflows or evaporation-precipitation depths from *IN* or *EV* records by constants specified on *XL* or *CP* records or multiplying or adding monthly-varying factors from *MF* records
  2. Assigning flows or net evaporation-precipitation rates to a control point by either verbatim repeating data from another control point or by multiplying the repeated flows by the factors from the *CP* records

- *Developing Sets of Net Evaporation-Precipitation Depths (EV Records)*

  3. Subtracting precipitation depths from evaporation depths to obtain net evaporation-precipitation depths
  4. Developing rates for a particular control point as a weighted average of values from two, three, or four other data sets
  5. Adjusting evaporation-precipitation depths (E) using the equation: $E_{adjusted} = a\,E^{b} + c$

- *Developing Sets of Naturalized Streamflows (IN Records)*

  6. Adding or subtracting sets of adjustments to streamflows associated with historical water supply diversions and return flows, reservoir storage and evaporation, and other factors that may be pertinent to the flow naturalization computations
  7. Developing adjustments for the historical effects of reservoir storage and net evaporation-precipitation
  8. Applying the equations: $Q_{adjusted} = a\,Q^{b} + c$ or $\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$
  9. Distributing flows from gaged (known flow) to ungaged (unknown flow) locations
  10. Adjusting streamflows to prevent incremental flows from being negative

- *Changing the Organization and Format of IN and EV Record Files*

  11. Converting the format of the files from records grouped by control point to the standard INF and EVA file format with records grouped by year
  12. Converting an HYD file to INF and EVA files in the standard format or vice versa

- *Converting between IN/EV Record and Columnar Spreadsheet Table Formats*

  13. Converting flows and evaporation-precipitation depths to a columnar format, and vice versa, to facilitate manipulating and plotting data with *Microsoft Excel* or other programs

Table 25
Activating WRAP-HYD Capabilities

Optional Capability	Activation Switch
• *Initial Manipulations of IN and/or EV Records*	
1. Multiplying by factors on *XL*, *CP,* or *MF* records or adding factors from *MF* records	*CP* record fields 4 and 5 *MF* and *XL* records
2. Repeating data at multiple control points	*CP* record fields 7 and 8
• *Developing Sets of Net Evaporation-Precipitation Rates (EV Records)*	
3. Subtracting precipitation rates from evaporation rates	*EP* record
4. Averaging data sets	*EP* record
5. Applying the equation: $E_{adjusted} = a\,E^{b} + c$	*EQ* record
• *Developing Sets of Naturalized Streamflows (IN Records)*	
6. Adding adjustments	*AS* record
7. Reservoir adjustments	*AS* followed by RS record
8. Applying the equation: $Q_{adjusted} = a\,Q^{b} + c$	*EQ* record
9. Flow distribution	*FO* field 4 and *CP* field 6
10. Negative incremental flow adjustments	*JC* record fields 11 & 12
• *Changing the Organization and Format of IN and EV Record Files*	
11. Converting from control point group format	*JC* record fields 1, 2, 4
12. Converting *WRAP2/WRAP3* HYD file	*JC* record fields 1, 2, 4
• *Converting between IN/EV Record and Columnar Formats*	
13. Converting between a table in columnar format	*JC* record fields 1, 2, 5

Developing Sets of Net Evaporation-Precipitation Depths

WRAP-HYD includes an option to perform the following arithmetic operations on two, three, or four arrays of numbers.

1. Each array is altered by multiplying each element by a user-specified constant, which may be positive or negative depending on the application. The default multiplier is 1.0.
2. The arrays are combined by adding corresponding elements.

This option is designed to combine sets of reservoir evaporation, precipitation, and/or net evaporation minus precipitation rates (depth/month) to develop sets of *EV* records for input to *WRAP-SIM*. Typical applications of this feature include:

- subtracting precipitation rates from evaporation rates to obtain net evaporation-precipitation rates
- developing rates for a particular control point as a weighted average of values from multiple data sets

The first application consists of simply subtracting a set of precipitation depths from concurrent evaporation depths to obtain net evaporation-precipitation depths. The second application involves determining evaporation-precipitation rates for a control point as a weighted average of values from two to four other data sets. *WRAP-HYD* multiplies the different sets of data by user-specified weighting-factors and sums the products. The Texas Water Development Board maintains precipitation and evaporation databases based on a grid of quadrangles covering the state. This *WRAP-HYD* option is designed to determine values for a control point as a weighed-average of data from two, three, or four adjoining quadrangles.

Developing Sets of Naturalized Streamflows

A *WRAP-SIM* simulation begins with sequences of monthly naturalized streamflows covering the hydrologic period-of-analysis at all control points. The following *WRAP-HYD* capabilities are provided to facilitate developing the naturalized flows which are input to *WRAP-SIM* as *IN* records.

1. adding or subtracting sets of adjustments to streamflows
2. developing streamflow adjustments for the historical effects of reservoirs
3. applying the equations: $Q_{adjusted} = a\,Q^{b} + c$ or $\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$
4. distributing flows from gaged (known flow) to ungaged (unknown flow) locations
5. adjusting streamflows to prevent incremental flows from being negative

Streamflow Naturalization Adjustments

Naturalized streamflows are gaged flows adjusted to remove the effects of human water management and use. *WRAP-HYD* has options for modifying streamflows by adding or subtracting any number of data sets of flow adjustments. Typically, the original unadjusted streamflows will be historical gaged flows. Typical adjustments include historical water supply diversions, return flows from surface and/or groundwater diversions, reservoir storage changes, and reservoir surface evaporation/precipitation. Other types of adjustments may be added or subtracted as well.

The adjustment data sets are simply time series of numbers to be added to the streamflows. The streamflow adjustments may be positive, negative, or zero. An option allows an adjustment data set to be multiplied by a user-specified factor prior to being added to the streamflows. Any number of sets of adjustments may be applied at a particular control point. The data sets are added at a specified control point and optionally at all downstream control points. If the channel loss factor field of the *CP* record is non-zero, channel losses are reflected in cascading the adjustments downstream. Options are provided for setting the final adjusted flows to zero if the computations result in negative values. Particular adjustments may cover all or any portion of the hydrologic period-of-analysis.

The adjustments to be combined with the streamflows may consist of either constant annual sequences of 12 monthly values or longer multiple-year time series. Adjustments for the effects of reservoirs are computed within *WRAP-HYD* and then handled the same as the other adjustments read from input files. The following types of sets of adjustments may be added to the streamflows.

1. A constant may be entered in field 9 of the *AS* record to add to the flows.
2. A set of 12 adjustments for each of the 12 months of the year to be repeated annually during a specified span of years are input on constant inflow *CI* records.
3. Time series of adjustments spanning any number of years are entered on flow adjustment *FA* records.
4. Adjustments for the effects of reservoirs are computed within *WRAP-HYD* as discussed in the next section.

All four types of adjustments are handled the same. An adjustment specification *AS* record provides the following information for each set of adjustments.

- control point identifier
- beginning and ending year of adjustments
- whether adjustments are to be applied to all downstream control points
- factor by which adjustments are multiplied
- selection of negative streamflow option

Adjustments may result in negative streamflows. Options are available to either maintain the negative streamflows as the adjustments accumulate or set them equal to zero. For multiple sets of adjustments, the negative values in the cumulatively adjusted streamflows may be set to zero after any specified adjustment. If negative flows are changed to zero, an option allows flow in the next month to be decreased by the amount of the negative flow. Another option limits the adjustment to the amount of streamflow. For example, if an adjustment of 25 acre-feet/month is to be subtracted from a streamflow of 15 ac-ft/month, the adjustment is changed to 15 ac-ft/month. The 15 ac-ft (not 25 ac-ft) adjustment is applied at each control point as the adjustment cascades downstream.

Streamflow Adjustments for the Effects of Reservoirs

Input data required to compute adjustments for the effects of reservoirs on streamflow include historical end-of-month storage content (*SC* records) and storage-area relationships (*SV/SA* or *RS* records), and net evaporation-precipitation rates (*EV* records). The adjustments include the following user-specified component parts.

- increases in reservoir storage content
  (*RS* record field 3; default: adjustment to be added to streamflows)
- decreases in conservation storage content
  (*RS* record field 4; default: adjustment to be subtracted from streamflows)
- decreases in storage above a specified storage capacity which represent spills or flood releases (*RS* field 5; default: adjustment to be subtracted from streamflows)

- net evaporation minus precipitation volumes
  (*RS* record field 6; default: adjustment to be added to streamflows)
- portion of naturalized streamflow representing runoff from land area covered by reservoir that would have occurred without the reservoir
  (*RS* record field 7; default: adjustment to be added to streamflows)

The model-user specifies on the *RS* record which component parts to include in the total adjustment. *WRAP-HYD* combines the component parts to obtain a total adjustment which is applied just like other *FA/CI* record adjustments to adjust the streamflows at the control point of the reservoir and optionally at each downstream control point. Each component part of the adjustment may be either added to or subtracted from the streamflow, with defaults shown in parentheses in the preceding list. The defaults represent the typical conventional process of naturalizing gaged streamflows. *RS* record field 8 specifies creation of a table showing the component parts of the monthly reservoir adjustments.

WRAP-HYD computes net evaporation-precipitation volumes by applying rates (depth/month) to the average water surface area during the month determined by combining storage contents with the storage-area relationship for the reservoir. Net evaporation-precipitation depths are either read from *EV* records or computed as specified by *EP* records based on data read from *EV* records. The format for entering reservoir storage volume versus water surface area relationships is the same in both *WRAP-HYD* and *WRAP-SIM*. A storage-area relationships may be provided as either a table on *SV* and *SA* records or as equation coefficients entered on a *RS* record (rather than *WRAP-SIM WS* record).

WRAP-HYD also has an option for increasing the naturalized streamflows to account for runoff derived from precipitation falling on dry land, that historically was actually covered by the reservoir. The precipitation falling on the reservoir is removed in the flow naturalization process with the net evaporation less precipitation adjustments. As explained in Chapter 3 of the *Reference Manual*, the adjustment for the portion of the streamflow representing runoff from the land area covered by a reservoir that would have occurred without the reservoir is incorporated in both *WRAP-SIM* and *WRAP-HYD* and is conceptually the same as the drainage area method for transferring flows. The adjustment is computed by multiplying the naturalized streamflow by the ratio of reservoir water surface area to watershed drainage area. Since the current value for naturalized flow at the control point is used, this adjustment should be made after other relevant adjustments.

JC record field 13 (*EPADJ*), *CP* record field 9 (*EWA*), and *RS* record field 7 (*RS(5)*) activate this option. *RS(5)* specifies whether the site runoff is included in a particular reservoir adjustment. The *JC* record field 13 sets the default option applied to all control points for which the *CP* record field 9 is left blank. An entry for *EWA* on a *CP* record overrides the default option set by *EPADJ* on the *JC* record. The precipitation-runoff adjustment requires a drainage area. An effective total watershed area may be input as a positive number in *CP* record field 9 for use with the total naturalized flows at that control point. Alternatively, the incremental or total watershed area and corresponding incremental or total naturalized flows for either the ungaged (*FD* record field 2) or gaged (*FD* record field 3) control points may be used by entering a –1 or –2 in *CP* record field 9 (applicable to that control point) or *JC* record field 13 (default for all control points). Incremental flows and watershed areas determined based on information from

the *FD* and *WP* records are identically the same for the rainfall-runoff adjustments as for distributing streamflows from gaged to ungaged sites.

The increase or decrease in reservoir storage content during each month is computed from the end-of-month storage contents provided on *SC* records. Storage increases, decreases, or both may be included in the adjustment. Storage decreases occurring above and below a specified storage capacity are determined separately. The user-specified storage capacity is typically the full conservation storage. Storage above this capacity represents flood storage, and corresponding storage reductions represent spills or flood releases. Flood control pool spills are shown as a separate column in the table created by *RS* record field 8. With the *RS* record default options, flood spills are handled the same as decreases in conservation pool storage in the final adjustments. However, if water supply diversion data is lacking, conservation pool storage decreases may be omitted to compensate for omissions of diversions in the adjustments.

Regression Equation to Adjust Flows and/or Evaporation-Precipitation Depths

The monthly streamflows (Q) and evaporation-precipitation depths (E) at a control point may be further adjusted by applying the equations:

$$Q_{adjusted} = a\,Q^{b} + c \qquad \text{and/or} \qquad E_{adjusted} = a\,E^{b} + c$$

The *Q* coefficients *a*, *b*, and *c* and *E* coefficients *a*, *b*, and *c* for particular control points or groups of control points are entered on *EQ* records.

The second equation converts the evaporation-precipitation depth *E* at a specified control point to an adjusted value $E_{adjusted}$, without considering other control points. The *Q* equation may also be applied directly to a specified control point without considering flows at downstream locations. However, alternatively, an incremental Q adjustment may be cascaded downstream. The incremental Q adjustment is computed as:

$$\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$$

$\Delta Q_{adjustment}$ is treated like any other adjustment to be added to the streamflows. It may be cascaded downstream with channel losses and with additions to the flows at downstream control points.

The regression equation feature may be used in various ways. One alternative strategy for quantifying the effects of either climate change or watershed land use changes involves modeling a watershed with a precipitation-runoff simulation model such as the *Soil and Water Assessment Tool (SWAT)* developed at the USDA Agricultural Research Service and TAMU Agricultural Experiment Station Research Center in Temple, Texas. *SWAT* computes streamflow given precipitation and other climatic data and watershed characteristics. Changes in climate are reflected in precipitation, temperature, and other climatic variables. Changes in land use are modeled by changing watershed parameter values. *SWAT* is applied to compute streamflows for scenarios with and without climate or watershed changes. Regression analyses are then applied to flows computed with different scenarios to obtain a set of *a*, *b*, *c* coefficients for input to *WRAP-HYD*. The regression equation for evaporation-precipitation depths may likewise be used to reflect climate change.

Distributing Flows from Gaged to Ungaged Locations

Naturalized streamflows are typically developed for locations of gaging stations by adjusting the recorded observed flows. Naturalized flows at numerous ungaged sites of water rights are then estimated based on combining the concurrent naturalized flows at gaging stations with parameters characterizing the watersheds above the gaged and ungaged sites. Alternative methods for transferring naturalized flows from gaged (known flow) to ungaged (unknown flow) locations are outlined in detail in the *Reference Manual*. These techniques include the drainage area ratio method, a modified version of the NRCS curve number methodology, and other related approaches. Watershed parameters are entered on *FD*, *FC*, and *WP* records in a DIS file. *WRAP-HYD* includes an option for developing tables displaying the watershed parameters including both values inputted on WP records and values for incremental watersheds computed within *WRAP-HYD*.

The same flow distribution techniques are incorporated in both *WRAP-HYD* and *WRAP-SIM*, but the computed flows are stored in different formats. *WRAP-HYD* stores the flows computed for the ungaged control points as *IN* records along with the original *IN* records for the known-flow (gaged) control points. *WRAP-SIM* writes synthesized naturalized flows to its output file just like all the other simulation results. In a typical major river basin application, recorded streamflows may be used from perhaps 10 to 25 pertinent gaging stations. Naturalized flows developed at the gage sites may then be distributed to several other key control points (perhaps another 10-25 sites) within *WRAP-HYD* with the results permanently stored as *IN* records in the *WRAP-HYD* output (*WRAP-SIM* input) file. Within *WRAP-SIM*, naturalized streamflows may be distributed to several hundred other water rights sites internally without further enlarging the file of *IN* records.

Negative Incremental Streamflow Adjustments

Total, rather than incremental, naturalized streamflows are provided as *WRAP-SIM* input. All computational and data handling procedures in *WRAP-SIM* and *WRAP-HYD* are based on total flows. Negative incremental streamflows are an indication of complexities that perhaps could cause inaccuracies in the simulation. The incremental local flow at a control point is defined as the total flow at the control point minus the corresponding flow at control point(s) located immediately upstream. Since flows normally increase going downstream, incremental flows are usually positive. However, flows may be greater upstream than downstream for various reasons. As discussed in Chapter 3 of the *Reference Manual*, *WRAP-HYD* and *WRAP-SIM* include options to (1) identify negative incremental flows and (2) adjust the naturalized streamflows to alleviate negative incrementals. The negative incremental flow adjustments may be written to a file for information.

Negative incremental inflow options 1, 2, and 3 specified on the *WRAP-HYD JC* record or *WRAP-SIM JD* record are the same in either program. Option 4 involves computations performed within the *WRAP-SIM* water rights loop and thus is not pertinent to *WRAP-HYD*. *WRAP-HYD* adjusts the actual *IN* records. *WRAP-SIM* adjusts streamflows used in the internal computations but never actual changes the *IN* records in the data file.

Changing the Organization and Format of IN and EV Record Files

In the default set of input files, *IN* and *EV* records are stored in separate files with filenames root.INF and root.EVA. In the standard format, each *IN* and *EV* record has 12 values for the 12

months of the year. Each record corresponds to both a year and a control point location. In the standard format, the records are grouped by year. The group for each year consists of records for all control points. Records for all of the control points grouped together for a year are followed by records for all control points for the next year.

WRAP-HYD reads input files near the beginning of the data handling and computational tasks and writes to output files near the end. The format for the output files may be different than that of the input files. Options allow reading input files in alternative formats and converting to the standard default format noted in the preceding paragraph. These options facilitate:

- changing the format of the files from records grouped by control point to the standard *WRAP* format with records grouped by year
- changing a *WRAP2/WRAP3* hydrology file (filename root.HYD) to the standard *WRAP* format and vice versa

The first capability listed above consists of reading a file with record groups consisting of all years for a control point and creating a corresponding file in the standard format of records for all control points grouped together for a year. Developing files with the records grouped by control point may be more convenient than the standard format. In this alternate format, IN and/or EV records for a control point are grouped together with each group beginning with the record for the first year and continuing in chronological order. *WRAP-HYD* can read a root1.INF and/or root1.EVA file in this alternative format and convert to root2.INF and EVA files in the standard format or to a HYD file.

WRAP-HYD can also read a HYD file of *IN* and *EV* records in the old WRAP2/WRAP3 format and create INF and EVA files or a HYD file in the standard format. Standard format *WRAP* files can also be converted to a HYD file in *WRAP2/WRAP3* format.

Converting between IN/EV Record and Columnar Formats

Spreadsheet programs such as *Microsoft Excel* are useful for plotting, regression analyses, and other manipulations of streamflow and evaporation/precipitation data. For example, naturalized streamflows at multiple control points may be developed by adjusting gaged streamflows at gaging stations with different record lengths and with gaps of missing data. Naturalized flows covering different time periods may be transported from *WRAP-HYD* to *Microsoft Excel* to apply regression analyses to fill in missing months and extend coverage to a common simulation period for all control points and then back to *WRAP-HYD* to convert to standard *IN* record format.

WRAP-HYD will write and read monthly streamflow or evaporation/precipitation data in a text file, with the data sequence for each selected control point being in a single column. Working with monthly time series data in columns, of length 12 months x number of years in hydrologic simulation period, is often more convenient than two dimensional arrays with 12 columns for January-December and a row for each year. With the columnar text file format, each column contains all streamflows (or evaporation/precipitation depths) for a particular control point. For example, 1940-1999 monthly naturalized flows at 125 selected control points may be represented by 125 columns with each containing 600 monthly flows. The columns may have different lengths and gaps with missing data.

WRAP-HYD writes the tables in the following format. The year and month columns are each four-characters wide, and the flow (or evaporation-precipitation) columns are 8-characters wide with the data right-justified.

Year	Mon	CP-1	CP-2	CP-3	CP-4	CP-5	CP-6
1991	1	778.1	239.8	827.5	452.6	49.2	1723.0
1991	2	3215.4	319.5	4513.2	299.2	64.6	6293.8
1991	3	2185.4	399.4	3149.5	354.1	53.8	5298.1

In reading the table, the first eight characters (year and month columns) are not read by *WRAP-HYD* and thus may be blank or contain notes or other information. Lines starting with ** or 40 blank characters are skipped over. Thus, ** may be used to insert notes. The table is written with the control points (columns) in the same order as the *CP* records. However, the columns may be in any order in reading a table. Any number of control points ranging from one to the total number of *CP* records may be included in a table. The control point identifiers in the first row must correspond to the identifiers in field 2 of the *CP* records. Every year of the period-of-analysis (with 12 monthly rows per year) must be included in chronological sequence. Example 8 in Appendix H of the *Reference Manual* further illustrates the table format.

Input and Output Files

WRAP-HYD input filenames (*root.extension*) all have the same root, denoted here as *root1*, and extensions indicating the type of data in each file. The input files are as follows.

basic data *DAT* file	root1.DAT	file with all input not included in following files
inflow *FLO* file	root1.FLO	inflow *IN* records with streamflows
evaporation *EVA* file	root1.EVA	*EV* records with evap-precip depths
distribution *DIS* file	root1.DIS	flow distribution *FD & FC* and watershed parameter *WP* records
hydrology *HYD* file	root1.HYD	*IN* and *EV* records combined in a single file

The basic input file with filename root1.DAT file is always required. The other files are provided as needed depending upon the tasks being performed with *WRAP-HYD*.

The *WRAP-HYD* and *WRAP-SIM* DAT files are similar. The format of the *WRAP-HYD* FLO file is the same as the *WRAP-SIM* FLO file except streamflow adjustments may be included in the *WRAP-HYD* FLO file. EVA, DIS, and HYD files have the same format in either program.

WRAP-HYD output filenames have a common root, denoted here as *root2*, and extensions indicating the type of data in each file. The root (*root2*) of the filenames for the output files will typically be different than the root (*root1*) of the input files to prevent existing files from being overwritten. The output files are as follows:

output *OUT* file	root2.OUT	file with all output not included in the following files
message *MSS* file	root2.MSS	messages used to find errors in the input
inflow *FLO* file	root2.FLO	inflow *IN* records with naturalized streamflows
evap *EVA* file	root2.EVA	evaporation *EV* records with net evaporation-precipitation
hydrology *HYD*	root2.HYD	*IN* and *EV* records combined in a single file

The FLO and EVA output files are created by *WRAP-HYD* to serve as input files for *WRAP-SIM*. The HYD file is an alternative to the FLO and EVA files with the IN and EV records being combined in a single file. The message file (root2.MSS) is similar to the message file created by *WRAP-SIM*. Other optional miscellaneous information that may be stored in a file with filename root2.OUT include tables of (1) flows and evaporation depths, (2) component parts of reservoir adjustments, (3) watershed parameters, and (4) negative incremental flow adjustments. The output files are all optional, depending on the tasks being performed.

Types of Input Records

WRAP-HYD input files contain a set of records controlling various options and supplying the data to be used in the computations. The various types of records and the files in which they are stored are listed in Table 26. The record types are labeled by a two-character identifier placed at the beginning of each record. These record identifiers provide a mechanism for organizing and referencing the input by data type.

Some of the same input record types are used in both *WRAP-HYD* and *WRAP-SIM*. Several *WRAP-HYD* records are not used by *WRAP-SIM*. Likewise, several record types associated with the main *WRAP-SIM* input file are not pertinent to *WRAP-HYD*. However, these records may be included in a *WRAP-HYD* root1.DAT file and will be simply ignored by *WRAP-HYD*.

The following record types are used by *WRAP-HYD* as well as *WRAP-SIM*. The format and content of these records, described in the *SIM* Section, are essentially the same with either program.

***, CP, CI, SV, SA, ED, IN, EV, FD, FC, WP*

A file options *FO* record serves the same purpose in both *HYD* and *SIM*. However, the *FO* record is different in the two programs to accommodate differences in file organization. The *JC*, *EP*, *AD*, *FA*, *RS*, *SC*, and *EQ* records are unique to *HYD*. Descriptions follow for the *WRAP-HYD* records that are different than the common *SIM* and *HYD* records already described in the *SIM* Section.

*File Options **FO** and **JC** Records*.- The files to be opened are specified on the *FO* record. The *JC* record is used to specify the period-of- analysis and select various options.

*Evaporation-Precipitation **EP** Manipulation Record*.- The *EP* record controls the combining of reservoir evaporation-precipitation data sets.

*Adjustment Specifications **AS** Record*.- The *AS* record activates streamflow adjustment computations and controls the selection of adjustment options.

*Flow Adjustments **FA** Record*.- Streamflow adjustment amounts may be input on *FA* records.

*Reservoir Specifications **RS** Record*.- A *RS* record activates routines for computing streamflow adjustments modeling the effects of a reservoir. Information needed for the computations are provided, and the selection of adjustment options is controlled.

*Storage Contents **SC** Record*.- Historical storage contents for a reservoir are input on *SC* records for use in developing the streamflow adjustments specified on a *RS* record.

*Regression Equation **EQ** Record*.- Coefficients for the regression equation are provided on EQ records.

Table 26
Types of WRAP-HYD Input Records

Basic Input File (filename root1.DAT)

Records for organizing the data management and computational tasks

**	comments or notes not read by the computer that may be inserted throughout
FO	*F*ile *O*ptions specifying which types of input and output files are to be used
JC	*J*ob *C*ontrol data with basic data and option switches
XL	multiplier factors designed primarily for use as unit conversions
MF	monthly factors for arithmetic manipulation of flows and net evaporation rates
EP	specification of *E*vaporation-*P*recipitation rate manipulations
ED	*E*nd of *D*ata
EQ	Coefficients for regression *EQ*uations

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

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

Records for describing storage-volume relationship for a reservoir

SV	*S*torage *V*olumes corresponding to areas on *SA* record
SA	*S*urface *A*rea corresponding to volumes on *SV* record
RS	coefficients for storage-area equation may be entered on *R*eservoir *S*pecification record

Hydrology Input Files (root1.FLO, root1.EVA, root1.HYD)

IN	*IN*flows to the system (naturalized streamflows)
EV	*EV*aporation (reservoir net evaporation-precipitation depths)

Flow Distribution File (filename root1.DIS)

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

Either Basic Data File or Flow File (root1.DAT or root1.FLO)

Records for Adjusting Streamflows

AS	*A*djustment *S*pecifications for adjusting streamflows
FA	*F*low *A*djustments
RS	*R*eservoir *S*pecifications for developing streamflow adjustments
SC	*S*torage *C*ontents of a reservoir

Locating Errors in the Input Data

WRAP-HYD contains features similar to those of *WRAP-SIM* to help detect missing records or inconsistencies and locate erroneous records that cause program execution to terminate due to illegal computer operations. These features do not pertain to those situations in which reasonable but incorrect data are input in the right format.

Tracking Program Progress

Tracing the progress of reading input records and performing computations up to program termination may be useful in locating the input record causing the problem. The following *WRAP-HYD* features trace the progress of the simulation.

WRAP-HYD execution begins with an interactive session in which the user supplies the root of the input (*root1*) and output (*root2*) filenames, and the files are opened. The program checks whether the specified files exist, writes a message to the monitor if an input file is missing, and allows the user to confirm overwriting of existing output files. The following messages then appear on the monitor as various tasks are performed.

```
Reading the input data from file_____.DAT
*********************************************
Number of CP, SV/SA, and EV records read from DAT file.
   ___ control points
   ___ control points with IN records
   ___ storage-area table SV/SA records
   ___ evap-precip rate adjustment EP records
*********************************************
Reading the IN/EV records
Developing EV records as specified by EP records
Adjusting flows as specified by AS records
Distributing flows from gaged to ungaged control points (FD records)
Writing IN and/or EV records to output file(s)
***** Normal Completion of Program WRAP-HYD *****
```

Progress is tracked in more detail by notes the program writes to the message file, which has a filename in the format *root2.MSS*. If program execution is terminated prior to completion the specified tasks, the trace messages help locate the input record causing the problem. Optional levels of input data traces are specified by input variable *ICHECK* in field 4 of the *JC* record. The basic trace (*ICHECK* ≥ 0) consists of printing the messages shown in Table 27 to the MSS file. Only those messages associated with options included in the *WRAP-HYD* application will be written to the message file. If model execution is prematurely terminated, the last message provides the approximate location in the input files at which a problem occurred.

Additional information noted in Table 28 may also be written to the message file as specified by *ICHECK* in field 4 of the *JC* record. The *ICHECK* = 1 trace shown in Table 27 is used to find the general location of the problem record based on where the trace stops. The program is then rerun with a different *ICHECK* value to check which records in the groups noted in Table 28 are read and copied correctly. For *ICHECK* options 3 through 7, the records noted in Table 28 are written to the MSS file immediately after each record is read. The records are

copied to the MSS file almost verbatim as read, except most real numbers are written in a F8.0 Fortran format with zero digits to the right of the decimal point. Blank fields read as zeros are output as zeros. If the program reads some but not all records of a particular record type, the problem will typically be associated with either the last record read and copied to the MSS file or more likely the next record in the input file.

Error and Warning Messages

WRAP-HYD contains a variety of error checks. Most are performed as the input files are read. If data are missing or in the wrong format, program execution is stopped and an error message is written. Warning messages identify potential problems, but program execution is not terminated. Error and warning messages are written to the message file (filename root2.MSS). *WRAP-HYD* and *WRAP-SIM* both generate two types of error messages:

1. The Fortran input/output status specifier *IOSTAT* is included in most of the read statements.
2. Many other specific error check algorithms are coded into the various routines. Many of the *WRAP-SIM* error messages listed in Table 10 and other similar messages are incorporated in *WRAP-HYD*.

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

ERROR: Fortran IOSTAT error occurred reading an input record with identifier CD of ___
IOSTAT status variable = ____
The first 80 characters of each of the last two records read are as follows:

The last two records read from the input file prior to termination of the program are written following this message. The message indicates the value for the *IOSTAT* variable as defined within the Fortran language compiler. A negative one (-1) means the end of file was reached without finding the data record. A -2 indicates the end of the record was reached without finding the data. A positive integer refers to Fortran error condition messages provided by the compiler. The most common value for the *IOSTAT* variable is 64, which means input data is in the wrong format, such as a letter in a real or integer numeric field or a decimal in an integer field. A 39 indicates a problem with a read statement, but no information regarding the problem is available.

A value of 2 for *ICHECK* activates an additional *IN/EV* record check along with the other error checks in effect for *ICHECK* of 1 and 3-7. The *WRAP-HYD ICHECK=2* check is not included in *WRAP-SIM*. The *ICHECK=2* routine is applicable to INF and EVA files but not a HYD file. The routine reads the control point identifiers entered in field 2 of the *IN* and *EV* records and matches them against those on the *CP* records. The following warning message is written to the MSS file for each *IN* or *EV* record that does not match a CP record.

WARNING: Control point _____ on (IN or EV) record matches no control point identifier on CP records.

Table 27
WRAP-HYD Trace Messages Written to MSS File

*** Starting to read file ____.DAT.
*** JC record was read.
*** Starting to read CP records.
*** Finished reading CP records.
*** Starting to read CI records.
*** Finished reading CI records.
*** Starting to read SV/SA records.
*** Finished reading SV/SA records.
*** Counting EP records. (They will be reread later.)
*** Finished reading file ____.DAT.
****

Number of CP, SV/SA, and EP records read from DAT file.
___ control point CP records
___ control points with IN records
___ storage-area table SV/SA records
___ evap-precip rate adjustment EP records

****

*** Starting ICHECK=2 check of IN records.
*** Finished ICHECK=2 check of ____ IN records.
*** Starting ICHECK=2 check of EV records.
*** Finished ICHECK=2 check of ____ EV records.
*** Starting to read IN/EV records.
*** Rearranging first year inflows and multiplying by factors on CP records.
*** Reading first year evap-precip rates.
*** Rearranging first year evap and multiplying by factors on CP records.
*** Finished reading IN/EV records.
*** Starting to read IN records from INF file in optional format [JC(1)=2].
*** Reordering IN records and multiplying by factors on CP records.
*** Starting to read EV records from EVA file in optional format [JC(1)=2].
*** Reordering EV records and multiplying by factors on CP records.
*** Finished reading IN/EV records.
*** Starting to read EP records.
*** Finished developing EV records as specified by EP records.
*** Starting to adjust flows as specified by AS and/or EQ records.
*** Finished adjusting flows as specified by AS and/or EQ records.
*** Starting negative incremental flow routine (ADJINC/NEGINC on JC record).
*** Finished negative incremental flow routine.
*** Starting to read flow distribution DIS file.
*** Finished reading flow distribution DIS file.
*** Starting flow distribution computations.
*** Finished flow distribution computations.
*** Starting to write IN and/or EV records to INF/EVA files.

***** Normal Completion of Program WRAP-HYD *****

Table 28
Trace Information Copied to Message File for Various Values of ICHECK

ICHECK = -1	Minimal trace messages; most error detection routines in effect
ICHECK = 0	Messages shown in Table 27; most error detection routines in effect
ICHECK = 1	Messages shown in Table 27; all error detection routines in effect
ICHECK = 2	Messages shown in Table 27; IN and EV record check
ICHECK = 3	Messages shown in Table 27 plus all *CP* records as read
ICHECK = 4	Messages shown in Table 27 plus all *AS* records as read
ICHECK = 5	Messages shown in Table 27 plus all *SV* and *SA* records as read
ICHECK = 6	Messages shown in Table 27 plus all *IN* and *EV* records as read
ICHECK = 7	Messages shown in Table 27 plus all *FD*, *FC*, and *WP* records as read

Table 29
WRAP-HYD Error and Warning Messages

Written to Monitor from Subroutine FILINI before Opening MSS File
ERROR: No FO record found when opening files.
WARNING: No input file is specified in FO record.

Written to MSS File from main program
WARNING: ICHECK=2 option specified on JC record is invalid without INF and EVA files.
WARNING: No output is written since INEV(1)=5 in field 12 of first CP record.

Written to MSS File from Subroutine WRAPIN
ERROR: Missing JC record.
ERROR: Number of years on JC record must be at least one.
ERROR: JC(1,2,3,4,5,6) of __ on JC record is not valid.
ERROR: (Input,Output) file required by JC(1,2,3,4,5,6) of __ on JC record is missing on FO record.
ERROR: ADJINC of ___ and NEGINC of ___ on JC record are not compatible.
ERROR: ADJINC of ___ on JC record is not valid.
ERROR: EPDADJ of ___ in JC field 13 is not valid.
ERROR: Control point ____ has an invalid INEV of ___ (CP record field 12)
ERROR: Missing CP record. Read CD of _____
ERROR: Control point _____ has an invalid INMETHOD of ___
ERROR: Downstream control point identifier [CPID(cp,2)] _____ on CP record for _____ matches no CPID(cp,1).
ERROR: Identifier _____ is assigned to both control points ___ and ___
ERROR: Control point identifier _____ from CI record ___ matches no control point identifier on CP records.
ERROR: Missing SV/SA record. Read CD of _____
ERROR: Missing or duplicate reservoir ID found while reading SV/SA records.
ERROR: Read CD of __ when expecting ED record.

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

Table 29 (Continued)
WRAP-HYD Error and Warning Messages

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

Written to MSS File from Subroutine FLDIST
ERROR: NRCS CN method can not be applied for zero or negative drainage area for CP _____
ERROR: Gaged CP _____ is not downstream of ungaged CP _____ as required by INMETHOD (6,8)
WARNING: The incremental CN and/or mean precipitation MP is negative for gaged ___ or ungaged ___ gaged CN, ungaged CN, gaged MP, ungaged MP = ____ ____ ____ ____
WARNING: Convergence criterion of 0.5% was not met for flow distribution option 8 after 100 iterations at ungaged CP _____ for year ___ , month ____. Last flow computed of _____ was adopted.
WARNING: Evap-precip adjustment at control point ____ for EWA(cp) of ___ for year ___, month ____ Runoff Adjustment (feet) = _____

Written to MSS File from Subroutine BISECT
WARNING: Subroutine BISECT stopped at 100 iterations in solving the NRCS CN equation for P.

Written to MSS File from Subroutine EPADD
ERROR: ID of ___ from EP record matches no identifier on the CP records.
ERROR: Read CD of __ when expecting an EP record.

Written to MSS File from Subroutine FLOWADJ
ERROR: JC(3) of __ on JC record is not valid.
ERROR: AS(3,4,5) of __ on AS record is not valid.
ERROR: ID of ___ on AS record matches no identifier on the CP records.
ERROR: CD of __ found when expecting (FA,SC) record.
ERROR: In reading (FA,SC) record for CP _____, read year of ____ when expecting _____
ERROR: RS(1,2,3,4,5,6) of __ on RS record is not valid.
ERROR: The identifier ____ on RS record matches no reservoir identifier on SV records.
ERROR: Interpolation of SV/SA records is out of range for reservoir _____
ERROR: In performing flow adjustments, reached end of input file (unit=__) without reading ED record.
WARNING: Read a FA record when AS(3) is greater than 1.
WARNING: Read a RS record when AS(3) is not 2.

If *IN* records are provided, the variable *INMETHOD* in field 6 of the *CP* record should be zero or one. If this is not the case, the following message is written.

WARNING: INMETHOD is ___ on CP record for control point _____ on IN record.

If *EV* records are provided, field 8 of the CP record (*CPEV*) should be blank. If this is not the case, the following message is written.

WARNING: CPEV is _____ on CP record for control point _____ on EV record.

The *ICHECK=2* routine also counts the total number of *IN* and *EV* records and includes these counts in the trace messages shown in Table 27. The total number of control points with *IN* records (also shown in the trace of Table 27) multiplied by the number of years in the simulation period should equal the total number of *IN* records.

Other error and warning messages are listed in Table 29. Subroutines *INFEVA*, *IACNP*, and *FLDIST* are similar in *WRAP-HYD* and *WRAP-SIM* and have the same error messages. *WRAP-HYD* includes a number of other error and warning messages associated with those features not included in *WRAP-SIM*.

Dimension Limits

The arrays in the Fortran code are dimensioned to reserve memory space. The dimension limits may be changed by revising and recompiling the Fortran code. Table 30 notes the maximum limits currently placed on various features. There are no limits on the number of streamflow adjustments specified on *AS*, *FA*, *RS*, *RC*, *CI*, and *EQ* records.

Table 30
WRAP-HYD Dimension Limits

control points	300
reservoir storage-area tables	50
number of upstream gages on *FD* records	15
number of years in period-of-analysis	125

Sequential Organization of WRAP-HYD Operations

WRAP-HYD is designed for flexibility for use is a myriad of ways. A single execution of the program may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. Files may also be transported back and forth between *WRAP-HYD* and spreadsheet or other programs.

WRAP-HYD operations are organized around creating, adjusting, and writing streamflow *FLOW(cp,year,month)* and evaporation-precipitation *EP(cp,year,month)* arrays with values for all control points on the *CP* records covering the hydrologic period of analysis specified in *JC* record fields 2 and 3. As currently dimensioned, the maximum size of the two 3-dimensional arrays is as follows: *FLOW(250,100,12)* and *EP(250,100,12)*. All elements are set equal to zero at the beginning of a *WRAP-HYD* execution. The following sequence of operations on the *FLOW* and *EP* arrays are performed in the order listed. All operations are optional.

1. Files are opened, the DAT file is read, and initial error checks are performed.

2. The original flow and evaporation-precipitation data are read from either *IN/EV* records or as columns in a table as specified by *JC(1)* and *JC(2)* on the *JC* record. These are assigned to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays. Any elements not read in are still zeros.

3. Combining of sets of evaporation-precipitation depths are performed as specified by *EP* records to obtain new sets of values stored in the *EP(cp,year,month)* array.

4. Streamflow adjustments are performed as specified by adjustment specification *AS* and/or regression equation *EQ* records. Each *AS* or *EQ* record results in revised values in the *FLOW(cp,year,month)* array for the specified control point and optionally downstream control points. The *AS* and/or *EQ* record adjustments are performed in sequential order as each *AS* or *EQ* record is read from the input file. Thus, the order of the *AS* and *EQ* records set the order of the adjustment computations. Any number of *AS* and *EQ* records and resulting adjustments, in any order, may be included in a *WRAP-HYD* run.

   Information required to perform *AS* record adjustments is provided by associated *FA*, *CI*, *RS*, and *SC* records. A reservoir specification *RS* record defines the component parts computed within *WRAP-HYD* of an adjustment for the effects of a reservoir. The computed component parts may be written to the OUT file as a table for information. The total reservoir adjustment is treated just like any other adjustment of the *FLOW(cp,year,month)* array. Any number of reservoirs (*RS* records) may be included in a *WRAP-HYD* run. All adjustments are performed sequentially in the order that the *AS* records are entered in the input file.

   The regression equations:

$$Q_{adjusted} = a\,Q^{b} + c$$
$$\Delta Q_{adjustment} = (a\,Q^{b} + c) - Q$$
$$E_{adjusted} = a\,E^{b} + c$$

   are applied to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays as specified by *EQ* records with the coefficients *a*, *b*, and *c* read from the *EQ* records. Again, any number of *EQ* records may be included in the data set, with the adjustments being performed in the order that the EQ records are read. If both *EQ* and *AS* records are included, they may be intermixed in any order.

5. Streamflows are distributed from gaged (known flow) to ungaged (unknown flow) control points as specified by *FD*, *FC*, and *WP* records from the DIS file. Watershed parameter tables may be written to the OUT file for information. The synthesized flows are stored in the *FLOW(cp,year,month)* array.

6. Negative incremental flow adjustments are performed as specified by *ADJINC* on the *JC* record. The *FLOW(cp,year,month)* array is modified. The adjustments may also be written to the OUT file as specified by *NEGINC* on the *JC* record.

7. The *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays are written to output files as *IN* and *EV* records and/or as tables, as specified by *JC(4)*, *JC(5)*, and *JC(6)* on the *JC* record.

Alternative Formats for IN and EV Records

WRAP-HYD will read inflow *IN* and evaporation-precipitation *EV* records in the file and record formats described in Table 31. *WRAP-HYD* options allow writing *IN* and *EV* records to output files in these same alternative formats, except option 2 is limited to input only. Input and output options are controlled by the files specified on the files options *FO* record and the job

control variables on the *JC* record. The options for reading the streamflow and evaporation-precipitation data are selected by entries for JC(1) and JC(2) on the *JC* record. For options 1, 2, 3, and 4, the monthly naturalized streamflows and evaporation, precipitation, or net evaporation-precipitation depths are read as sets of *IN* and *EV* records. For option 5, these data are read as a table with each column containing the data for a particular control point.

Table 31
Options for Organizing Streamflow and Evaporation-Precipitation Input Data

Option	Filename Extension	JC Record JC(1)-JC(2)	Format Description
1	FLO & EVA	1	Records are grouped by year. Records for all control points for a year are followed by a complete set of records for the next year. Each record contains 12 values for the 12 months of the year.
2	FLO & EVA	2	Records are grouped by control point. Records for all years for a control point are followed by a complete set of records for the next control point. Otherwise, option 2 is the same as option 1.
3	HYD	3	IN records for all control points for a year are followed by EV records for all control points for the year in WRAP2/WRAP3 format with pairs of records with each covering six months.
4	HYD	4	Same record sequencing as option 3 but each record covers 12 months
5	FLO&EVA	5	The data are in columns of a table rather than IN/EV records.

In the standard format (option 1), records for all control points are grouped together for each year as required by *WRAP-SIM*. The set of all records for a year is followed by the set of all records for the next year. However, compiling data by control point is usually more convenient. The second option noted above allows the records for all years for a particular control point to be grouped together. *WRAP-HYD* converts the records to the required *WRAP-SIM* sequencing.

The *IN* and *EV* record format and file organization have been restructured in the current *WRAP* compared to its 1996 predecessor *WRAP2/WRAP3* versions. However, *WRAP-HYD* and *WRAP-SIM* include options for reading *IN* and *EV* records in either the old or new record and file formats. With the current standard approach, the *IN* and *EV* records are in a 12-months-per-record format and are separated into two files, with filenames root.INF and root.EVA. In the old *WRAP2/WRAP3* method (option 3 in the table above), each record covers six-months (two records per year), and the *IN* and *EV* records are combined and stored as a hydrology root.HYD file. *WRAP-HYD* has an option that reads an old-format root1.HYD file and converts to the new format root2.INF and root2.EVA files and vice versa.

WRAP-SIM will also read *IN/EV* records from a DAT file. The fourth option allows flows to be read and written to a HYD file in the format required for a *WRAP-SIM* DAT file. The *IN/EV* records can be transferred between a *WRAP-SIM* DAT file and *WRAP-HYD* HYD file.

The fifth option facilitates transporting data between a spreadsheet program such as *Microsoft Excel* and *WRAP-HYD*. With the fifth option, the data are read as columns from a spreadsheet table rather than as rows of *IN/EV* records. *WRAP-HYD* writes streamflow and evaporation-precipitation data in this same format if specified by JC(5) on the *JC* record.

Sequential Order of Input Records

The input records are organized in the files in the sequential order outlined in Table 32. Other records from a *WRAP-SIM* DAT file may be included in their normal sequence even though they are not used by *WRAP-HYD*. The unused records will simply be passed over.

Format of Input Records

The section entitled *Format of Input Records* in the SIM Section is applicable to *WRAP-HYD* and well as *WRAP-SIM*. The record identifier is entered as the first two characters of each record. Comment records are not read by the program, except for the ** identifier. The other records begin with a two-character identifier, followed by a 6-character wide field and several eight-character fields. This manual describes input format in terms of fixed-width fields. However, optionally, fields with integer *I* and real *F* numerical data formats may be delimited with commas.

The Fortran format specifications found in the fourth column of the following tables describing each record type are defined as follows.

A6	alphanumeric (AN) label right justified in a field that is 6 characters wide
2X	two blank spaces (Fields with the spacing descriptor X are skipped over and not read.)
F8.0	real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)
12F8.0	twelve real numbers with each in a field with a width of 8 characters
I8	integer number right justified in field of 8 characters (Decimal is not allowed.)
3I8	three integer numbers with each right justified in field of 8 characters

In the fixed-width-fields format, variables with integer *I* format and character *A* specifications are right-justified in the appropriate field with no decimal. Real variables (F format) should either be right justified or include the decimal.

Examples 8 and 9 in the *Reference Manual* Appendix H illustrate the differences between the fixed-width field and comma-delimited formats. These two examples are the same, except the input files for Example 8 are totally in fixed-width-fields format, while much of the input in Example 9 comma-delimited. Commas may be used to truncate numeric (integer *I* and real *F* format) data. However, comma-delimited data entry is not applicable to character variables and spacing (*A* and *X* formats). A comma may be used to shorten the width of a field, but the number of characters in a field can not exceed that specified in this manual.

Table 32
Sequential Order of Input Records

Basic Input File (filename root1.DAT)

**	Comments	Comments may be inserted throughout.
FO	File Options	FO record is preceded only by optional comment ** records.
JC	Job Control Data	The JC record follows the FO record.
CP	Control Point	All CP records are grouped together following the JC record.
CI	Constant Inflows	Set of optional CI records follows set of all CP records.
SV	Storage Volumes	Set of all SV-SA tables grouped together in any order, with
SA	Surface Area	each SA immediately following corresponding SV.
EP	Evaporation-Precipitation Specifications	All EP records are grouped together.
AS, FA, RS, SC,EQ		Set of streamflow adjustment records listed below.

Streamflow adjustment records (EQ,AS,FA,RS,SC) are placed at the end of either the: Basic Input File (filename root1.DAT) or Streamflow File (filename root1.INF)

AS	Adjustment Specifications	An AS record precedes each set of FA records and each
FA	Flow Adjustments	set of RS/SC records. FA records for CP are grouped.
RS	Reservoir Specifications	A RS record precedes each group of SC records.
SC	Storage Content	SC records for a control point are grouped together.
EQ	Regression Equation	EQ records may be before, after, or between AS records.
ED	End of Data	ED is last record in files containing AS/FA/RS/RC records.

Streamflow File (filename root1.INF)

**	Comments	Comments may be inserted before each group of records.
IN	Inflows	IN records are grouped together by year and control point. Control points may be in any order. Years should be in sequential chronological order. IN records precede flow adjustment record sets.

Evaporation-Precipitation Depth File (filename root1.EVA)

**	Comments	Comments may be inserted before each group of records.
EV	Evaporation	EV records are organized the same as IN records.

Flow Distribution File (root.DIS)

**	Comments	Comments may be inserted before each group of records.
FD	Flow Distribution	Each FC record follows the corresponding FD
FC	Flow Distribution Coefficients	record. The set of all WP records follows the set
WP	Watershed Parameters	of all FD/FC records.
ED	End of Data	

Hydrology File (filename root2.HYD) [alternative to standard INF and EVA files]

IN	Inflows	IN/EV records are grouped by year. Set of EV records for all control
EV	Evaporation	points for year follow set of all IN records for the preceding year.

Table 33
Quick Reference Chart for WRAP-HYD

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

Basic Input Data File (filename root.DAT)

**											
FO	INF	EVA	DIS	HYD	MSS	OUT	INF	EVA	HYD		117
JC	NYRS	YRST	ICHECK	JC(1)	JC(2)	JC(3)	JC(4)	ADJINC	NEGINC		118
CP	CPID1	CPID2	CPDT1	CPDT2	INMETH	CPIN	CPEV	EWA	CL	INWS	120
CI	CIID	Jan	Feb	Mar	Apr	May	Jun				121
CI		Jul	Aug	Sep	Oct	Nov	Dec				121
SV	RES	TARA	TARA								122
SA		TARB	TARB								122
EP	ID	EPID(1)	EPM(1)	EPID(2)	EPM(2)	EPID(3)	EPM(3)	EPID(4)	EPM(4)		122
ED											116

Inflow File (filename root.INF)

IN	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	123

Net Evaporation-Precipitation File (filename root.EVA)

EV	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	123

Flow Distribution File (filename root.DIS)

FD	ID	IDDS	NGAGE	UGID(1)	UGID(2)	UGID(3)	UGID(4)	UGID(5)	UGID(6)	UGID(7)	125
FC	COEF1	COEF2	COEF3								125
WP	ID	DA	CN	MP	DAF						125
ED											

Flow Adjustment Records in Basic Input (root.DAT) or Inflow (root.INF) Files

AS	ID	AS(1)	AS(2)	AS(3)	AS(4)	AS(5)	AS(6)				126
FA	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	127
FA	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	127
RS	ID	RS(1)	RS(2)	RS(3)	RS(4)	RS(5)	CAP	EVCFA	EVCFB	EVCFC	128
SC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	129
SC	ID	PYR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	129
EQ	ID	A	B	C	AS(1)	AS(2)	QE	AS(4)	AS(5)		130
ED											116

2	8	16	24	32	40	48	56	64	72	80	page

Format and Content of Each Type of Input Record

The remainder of this manual consists of a set of tables outlining the information to be entered in each field of each type of *WRAP-HYD* input record.

**** Record** - Comments

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

Comment (**) records are not read by the program, except for the ** identifier. They are used to insert notes in the input data set. Any number of comment records may be placed at the following locations.

- almost any place in the DAT file
- before the first *IN* and *EV* records for each year in the INF and EVA files
- before each set of flow adjustment (*AS* record) in the DAT and INF files
- before each set of reservoir adjustment (*RS* and *SC* records) in the DAT and INF files
- before the *FD* records and between the *FD* and *WP* records in the DIS file

ED Record - End of Data

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

A *ED* record is required at the end of a file containing *AS*, *FA*, *RS*, *SC* and records (DAT or INF) and also at the end of a flow distribution (DIS) file.

FO Record - File Options (Required)

field	columns	variable	format	value	description
1	1-2	CD	A2	FO	Record identifier
2	8	F(2)	I6	blank,0,- +	root1.INF inflow file is not read root1.INF inflow file is read
3	16	F(3)	I8	blank,0,- +	root1.EVA evaporation file is not read root1.EVA evaporation file is read
4	24	F(4)	I8	blank,0,- +	root1.DIS flow distribution file is not read root1.DIS flow distribution file is read
5	32	F(5)	I8	blank,0,- +	root1.HYD hydrology file is not read root1.HYD hydrology file is read
6	40	F(6)	I8	- blank,0,+	root2.MSS error message file is not created root2.MSS error message file is created
7	48	F(7)	I8	blank,0,- +	root2.OUT output file is not created root2.OUT output file is created
8	56	F(8)	I8	blank,0,- +	root2.INF inflow file is not created root2.INF inflow file is created
9	64	F(9)	I8	blank,0,- +	root2.EVA evaporation file not created root2.EVA evaporation file is created
10	72	F(10)	I8	blank,0,- +	root2.HYD hydrology file not created root2.HYD hydrology file is created

The *FO* record specifies the files to be used. Entering a positive integer indicates that the file will be used. A negative integer results in the file not being used. With the exception of the message (MSS) file which defaults to the file being opened (created), leaving the field corresponding to a file blank or entering a zero results in the file not being opened. The MSS file should essentially always be used. Selection of the other files depends on the operations specified on the JC record. Also, the RS(6) reservoir adjustment table is activated from the *RS* record. The program writes error messages and terminates execution if the files required for the operations specified by the *JC* and *RS* records are not opened by the *FO* record.

JC(1) = 1, 2, or 5	root1.INF file is required, F(2) = 1
JC(1) = 3 or 4	root1.HYD file is required, F(5) = 1
JC(2) = 1, 2, or 5	root1.EVA file is required, F(3) = 1
JC(2) = 3 or 4	root1.HYD file is required, F(5) = 1
JC(3) = 2, 3, or 4	root1.INF file is required, F(2) = 1
JC(3) = 0, 1, or 2	root2.INF and/or EVA files are required, F(8) = 1 and/or F(9) = 1
JC(4) = 3, or 4	root2.HYD file is required, F(10) = 1
JC(5) = non-zero	root2.OUT file is used if F(7) = 1, otherwise INF and/or EVA files used.
JC(6) = non-zero	root2.OUT file is required, F(7) = 1
NEGINC = 2 or 3	root2.OUT file is used if F(7) = 1, otherwise MSS file is used.
RS(6) = 1	root2.OUT file is required, F(7) = 1

JC Record - Job Control (required)

field	columns	variable	format	value	description
1	1-2	CD	A2	JC	Record identifier
2	3-8	NYRS	I6	AN	Number of years in simulation
3	9-16	YRST	I8	+	First year of hydrologic period-of-analysis
					Level of Error Checks
4	24	ICHECK	I8	-1	minimal trace messages and reduced error checks
				blank,0	normal trace and reduced error checks
				1	normal error checks and input trace
				2	*IN/EV* record check
				3	copy *CP* records to MSS file
				4	copy *AS* and *EQ* records to MSS file
				5	copy *SV/SA* records to MSS file
				6	copy *IN/EV* records to MSS file
				7	copy *FD/FC/WP* records to MSS file
					Input Options
5	32	JC(1)	I8	blank,0	Streamflows are not read as input.
				1	*IN* records read from INF file in standard format
				2	*IN* records read from INF file in optional format
				3	*IN* records read from HYD file in WRAP3 format
				4	*IN* records read from HYD file with 12 flows/record
				5	Streamflows read from INF file in columnar format
6	40	JC(2)	I8	blank,0	Evaporation-precipitation depths are not read.
				1	*EV* records from EVA file in standard format
				2	*EV* records read from EVA file in optional format
				3	*EV* records read from HYD file in WRAP3 format
				4	*EV* records read from HYD file with 12 values/record
				5	Evap-precip read from INF file in columnar format
7	48	JC(3)	I8	blank,0	No flow adjustments
				1	Flow adjustment data read from DAT file
				2	Flow adjustment data read from INF file
				3	Flow adjustment data from DAT(1^{st}) and INF (2^{nd}) files
				4	Flow adjustment data from INF (1^{st}) and DAT (2^{nd}) files
					Output Options
8	56	JC(4)	I8	blank,0,1,2	Standard INF and/or EVA output files as needed
				3	*WRAP3* format HYD output file is used instead
				4	HYD file with 12 values/record is used instead
9	64	JC(5)	I8	blank,0	Option with output in columns is not used.
				1	Streamflows written as columns in a table
				2	Evap-precip depths written as columns in a table
				3	Both streamflows and evap-precip tables created
10	72	JC(6)	I8	blank,0	Watershed parameter tables are not created.
				1	Incremental watershed parameter table in OUT file
				2	Table of parameters from WP records in OUT file
				3	Both watershed parameter tables created

JC Record - Job Control (continued)

field	columns	variable	format	value	description
					Negative Incremental Flow Options
11	80	ADJINC	I8	blank,0,1	Negative incremental flows are not considered
				2	Downstream flow adjustments are performed
				3	Upstream flow adjustments are performed
				-3	Option 3 with secondary control points excluded
12	88	NEGINC	I8	blank,0,1	No incremental flow adjustments written
				2	Downstream flow adjustments written
				3	Upstream flow adjustments written
					Set Default for Evap-Precip Adjustment
13	96	EPADJ	I8	blank,0	No adjustment unless specified on *CP* record
				-1	Adjustments based on ungaged CP (*FD* record field 2)
				-2	Adjustments based on gaged CP (*FD* record field 3)

XL Record - Multiplication Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	XL	Record identifier
2	3-8	STX	F6.0	+	Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, *IS*, and *SD* records.
				blank, 0	Default = 1.0
3	9-16	INX	F8.0	+	Multiplier of flows on *IN* records, subject to being superceded by non-blank *CP* record field 4.
				blank, 0	Default = 1.0
4	17-24	EVX	F8.0	+	Multiplier of E-P rates on *EV* records, subject to being superceded by non-blank *CP* record field 5.
				blank, 0	Default = 1.0
5	25-32	CIX	F8.0	+	Multiplier of flows on *CI* records.
				blank, 0	Default = 1.0
6	33-40	SAX	F8.0	+	Multiplier of reservoir surface areas on *SA* records.
				blank, 0	Default = 1.0
7	49-56	DEPTHX	F8.0	+	Multiplier factor for runoff depth in NRCS CN method flow distribution computations.
				blank, 0	Default = 0.01875

The *XL* record in *HYD* contains fewer variables than the similar *XL* record in *SIM*. The factors common to *HYD* and *SIM* are used in the same manner in both programs. The factors are previously discussed in conjunction with their use in *SIM*.

CP Record - Control Point Information (A *CP* record is required for each control point.)

field	columns	variable	format	value	description
1	1-2	CD	A2	CP	Record identifier
2	3-8	CPID(cp,1)	A6	AN	Control point identifier [cp = 1,NCPTS]
3	11-16	CPID(cp,2)	2x,A6	AN	Identifier of next downstream control point.
				blank,OUT	Basin outlet. There is no control point downstream.
					Multiplier Factors
4	17-24	CPDT(cp,1)	F8.0	+	Factor by which inflows on IN records are multiplied
				blank,0	Default factor = 1.0
5	25-32	CPDT(cp,2)	F8.0	+	Factor by which evaporation rates are multiplied
				blank,0	Default factor = 1.0
					Method for Obtaining Naturalized Flows
6	40	INMETHOD (cp)	I8	0,1	IN records are input for this control point.
				2	Specifications are provided by *CPIN(cp)* in field 7.
				3	Flow distribution equation is used.
				4	NRCS CN method with synthesized flows limited to not exceed source control point flows
				5	NRCS CN method without above noted flow limit
				6	channel loss coefficient incorporated in DAR method
				7	drainage area ratio method (areas from WP records)
				8	NRCS method with channel losses
7	43-48	CPIN(cp)	2x,A6	blank	INMETHOD in field 6 is not 2.
				AN	Another CP from which *IN* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* indicate zero streamflows at this control point.
					Method for Obtaining Net Evaporation-Precipitation
8	51-56	CPEV(cp)	2x,A6	blank	*EV* records are read as input
				AN	Another CP from which *EV* records are repeated
				NONE ZERO	The words *none, zero, NONE, or ZERO* in this field indicate zero net evaporation at this control point.
					Adjustment for Runoff from Reservoir Site
9	57-64	EWA(cp)	F8.0	+	Watershed area in acres for runoff adjustment.
				-1	Negative number flags use of *FD* and *WP* records.
				blank,0	Net evaporation-precipitation option is not used.
					Channel Loss Factor
10	65-72	CL(cp)	F8.0	+	Channel loss factor for stream reach below CP.
				blank	The default channel loss factor value is 0.0.
					Watershed Areas on WP Records
11	73-80	INWS(cp)	I8	blank,0	Parameters on WP record are for the total watershed.
				+	Parameters on WP record are for incremental watersheds. (any positive integer)
					Do Not Include IN/EV Records in Output
12	88	INEV(cp)	I8	1	omit the *IN* records for this CP in the output file
				2	omit the *EV* records for this CP in the output file
				3	omit both the *IN* and *EV* records in the output file
				4	omit both for this CP and all previous control points
				5	omit for this CP and all subsequent control points

MF Record - Monthly Factors

field	columns	variable	format	value	description
1	1-2	CD	A2	MF	Record identifier
2	3-8	MF	F6.0		Factors for each of 12 months
3-13	9-96	MF	F8.0		

Control point *CP* record fields 4 and 5 are multiplier factors for all streamflows on the *IN* records and all evaporation-precipitation depths on the *EV* records for that control point. The MF record expands this capability. A negative number for *CPDT(cp,1)* or *CPDT(cp,2)* indicates that the *CP* record will be followed by a *MF* record with a set of 12 numbers. The 12 monthly factors on the *MF* record are applied as specified in *CP* record fields 4 and 5 as follows.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -2.0, flows or evaporation depths from the *IN* or *EV* records are multiplied by the *MF* record factors.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -3.0, *MF* record factors are added to flows or evaporation depths from the *IN* or *EV* records.

For *CPDT(cp,1)* or *CPDT(cp,2)* of -4.0, the operation and factors specified for the preceding control point are repeated for this control point.

CI Record - Constant Inflows and/or Outflows

field	columns	variable	format	value	description
1	1-2	CD	A2	CI	Record identifier
2	3-8	CIID	A6	AN	Control point identifier
3-8	9-56	CI(M=1,6) CI(M=7,12)	6F8.0	+,-	Flow added to streamflow at control point CIID for month M. Six entered on first CI record, six on second. Field 2 on the second CI record is not read.

The set of *CI* records follows the *CP* records in *WRAP-HYD* just like in *WRAP-SIM*. *CI* records are in pairs with each record containing streamflow adjustments for six months of the year. Any number of pairs of *CI* records may be entered for any control point.

SV Record - Storage Volumes for Reservoir Storage versus Area Table

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

SA Record - Surface Areas for Reservoir Storage versus Area Table

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

The *SV* and *SA* records have the same format. Storage volume (*SV* record) versus surface area (*SA* record) tables are used in the reservoir net evaporation-precipitation computations. A storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *AS* record. The *SV-SA* tables are allowed a maximum of 12 pairs of values. A *SV* record must be followed by the corresponding *SA* record. A complete set of all *SV-SA* records are grouped together.

EP Record - Evaporation-Precipitation Combining Specifications

field	columns	variable	format	value	description
1	1-2	CD	A2	EP	record identifier
2	3-8	ID	A6	AN	control point identifier
3	11-16	EPID(1)	2x,A6	AN	control point identifier
4	17-24	EPM(1)	F8.0	+	multiplier
5	27-32	EPID(2)	2x,A6	AN	control point identifier
6	33-40	EPM(2)	F8.0	+	multiplier
7	43-48	EPID(3)	2x,A6	AN	control point identifier
8	49-56	EPM(3)	F8.0	+	multiplier
9	59-64	EPID(4)	2x,A6	AN	control point identifier
10	75-72	EPM(4)	F8.0	+	multiplier

All *EP* records are grouped together in the DAT file. The monthly evaporation-precipitation depths for the control point identified in field 2 are computed as a weighted average of the values read for the control points identified in fields 3, 5, 7, and 9 using the multipliers from fields 4, 6, 8, and 10.

IN and EV Records in the Standard Default Format

Records for all control points are grouped together by year. All the records for a year are followed by the complete set of records for the next year.

IN Record - Inflows - Naturalized Streamflows at a Control Point

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

EV Record – Evaporation, Precipitation , or Net Reservoir Evaporation-Precipitation Depths

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

IN and EV Records in the Old *WRAP2/WRAP3* Format

IN records for all control points for a year are followed by a corresponding set of *EV* records for all control points for the year. *IN/EV* records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year. The records are stored in file root.HYD.

First IN Record for Each Year - Inflows

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

Second IN Record for Each Year - Inflows

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

First EV Record for Each Year - Reservoir Evaporation Rates

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

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

FD Record – Flow Distribution

field	columns	variable	format	value	description
1	1-2	CD	A2	FD	record identifier
2	3-8	ID	A6	AN	control point identifier for ungaged CP
3	11-16	IDDS	2x,A6	AN	source gaged control point
4	17-24	NGAGE	I8	+	number of gaged cp's above ungaged site (blank = 0)
				-1	ungaged CP is downstream of source CP
5-19	25-144	UGID(I)	15(2x,A6)	AN	identifiers of upstream gaged control points [I=1,MAXGAG=15]

The *FD*, *FC*, and *WP* records are stored in a DIS file, that ends with an *ED* record. A *FD* record is required for each ungaged control point for which flows are to be synthesized. Flows are transferred from the source control point (field 3) to the ungaged control point (field 2). Upstream control points define incremental watersheds. The *FD* and *WP* records also define incremental watersheds for use in the reservoir site runoff adjustments specified by *EPADJ* on the *JC* record, *EWA(cp)* on the *CP* record, and *RS(5)* on the *RS* record.

FC Record - Coefficients for Flow Distribution Equation

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

A *FC* record follows the *FD* record if the flow distribution method option 3 (field 6 of *CP* record) is applied for this control point requiring coefficients for the equation: $Q_{ungaged} = a\, Q_{gaged}^{\ b} + c$

WP Record – Watershed Parameters

field	column	variable	format	value	description
1	1-2	CD	A2	WP	record identifier
2	3-8	ID	A6	AN	control point identifier
3	9-16	DA	F8.0	+	drainage area
4	17-24	CN	F8.0	+	curve number
5	25-32	MP	F8.0	+	mean precipitation
6	33-40	DAF	F8.0	+	multiplier to convert drainage area to square miles

A *WP* record is provided for each gaged and ungaged control point involved in applying flow distribution methods 4, 5, 6, 7, or 8 specified in field 6 of the *CP* records or determining runoff adjustments specified by JC/CP/RS records. The set of all *WP* records follow the set of all *FD/FC* records in the root.DIS file. The unit conversion multiplier *DAF* in field 6 applies to this and all subsequent *WP* records until a new *DAF* is entered on another *WP* record. The default *DAF* is 1.0.

AS Record - Streamflow Adjustment Specifications

field	columns	variable	format	value	description
1	1-2	CD	A2	AS	record identifier
2	3-8	ID	A6	AN	control point identifier
					Beginning and Ending Years of Adjustments
3	13-16	AS(1)	I8	blank,0	first year of adjustments = first year of analysis period
				+	first year of adjustments
4	21-24	AS(2)	I8	blank,0	last year of adjustments = last year of analysis period
				+	last year of adjustments
					Source of Adjustments
5	32	AS(3)	I8	blank,0,1	following *FA* records
				-1	following *FA* records in format that includes the year and control point
				2	following *RS* and *SC* records
				-2	following *RS* and *SC* records with *SC* records in format that includes year and control point
				3	*CI* records previously read from root1.DAT file
				4	constant adjustment from field 9
					Cascade Downstream? Yes or No?
6	40	AS(4)	I8	0	adjustments apply to all downstream control points
				1	adjustments apply to only this control point
					Negative Flow Options
7	48	AS(5)	I8	0	allow negative streamflows
				1	change negative streamflows to zero
				2	change to zero and subtract next month
				3	modify adjustments to prevent negative streamflows
				4	modify adjustments and subtract negative next month
					Multiplier Factor
8	49-56	AS6	F8.0	+	factor to multiply flow adjustments (default=1.0)
					Constant Flow Adjustment
9	57-64	AS7	F8.0	+	constant streamflow adjustment applied in all months

EQ, AS, *FA*, *RS*, and *SC* records may be placed as the last records in either the DAT and/or INF files as specified by *JC(3)* entered in field 7 of the *JC* record.

The format of the *FA* and *SC* records vary depending on *AS(3)* in field 5 of *AS* record.

Negative flow options (field 7) may be applied with each individual *AS* record set of adjustments. Alternatively, the negative flow options may be applied to the final streamflows after all cumulative adjustments by inserting a final *AS* record with *AS(3)*=4 and *AS7*=0.0.

FA Record - Streamflow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	FA	record identifier (optional after first record)
2	3-8	FA(1)	F6.0	+	streamflow adjustment for Month 1
3	9-16	FA(2)	F8.0	+	streamflow adjustment for Month 2
4	17-24	FA(3)	F8.0	+	streamflow adjustment for Month 3
5	25-32	FA(4)	F8.0	+	streamflow adjustment for Month 4
6	33-40	FA(5)	F8.0	+	streamflow adjustment for Month 5
7	41-48	FA(6)	F8.0	+	streamflow adjustment for Month 6
8	49-56	FA(7)	F8.0	+	streamflow adjustment for Month 7
9	57-64	FA(8)	F8.0	+	streamflow adjustment for Month 8
10	65-72	FA(9)	F8.0	+	streamflow adjustment for Month 9
11	73-80	FA(10)	F8.0	+	streamflow adjustment for Month 10
12	81-88	FA(11)	F8.0	+	streamflow adjustment for Month 11
13	89-96	FA(12)	F8.0	+	streamflow adjustment for Month 12

FA Record - Streamflow Adjustments (Alternative format with control point ID and year)

field	columns	variable	format	value	description
1	1-2	CD	A2	FA	record identifier (optional)
2	3-8	ID	A6	AN	control point identifier (optional)
3	13-16	PYR	I8	+	year (optional)
4	17-24	FA(1)	F8.0	+	streamflow adjustment for Month 1
5	25-32	FA(2)	F8.0	+	streamflow adjustment for Month 2
6	33-40	FA(3)	F8.0	+	streamflow adjustment for Month 3
7	41-48	FA(4)	F8.0	+	streamflow adjustment for Month 4
8	49-56	FA(5)	F8.0	+	streamflow adjustment for Month 5
9	57-64	FA(6)	F8.0	+	streamflow adjustment for Month 6
10	65-72	FA(7)	F8.0	+	streamflow adjustment for Month 7
11	73-80	FA(8)	F8.0	+	streamflow adjustment for Month 8
12	81-88	FA(9)	F8.0	+	streamflow adjustment for Month 9
13	89-96	FA(10)	F8.0	+	streamflow adjustment for Month 10
14	97-104	FA(11)	F8.0	+	streamflow adjustment for Month 11
15	105-112	FA(12)	F8.0	+	streamflow adjustment for Month 12

The choice of format for the *FA* and *SC* records is specified by *AS(3)* in field 5 of *AS* record. The only difference between the two options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3. These records, like all others, may also be in comma delimited format.

RS RECORD - Reservoir Specifications for Streamflow Adjustments

field	columns	variable	format	value	description
1	1-2	CD	A2	RS	record identifier
2	3-8	ID	A6	AN	reservoir identifier
					Adjustment Components
3	16	RS(1)	I8	blank,0	add storage increase (default)
				1	add storage increase
				-1	subtract storage increase
				-9	do not consider storage increase
4	24	RS(2)	I8	blank,0	subtract conservation storage decrease (default)
				1	add conservation storage decrease
				-1	subtract conservation storage decrease
				-9	do not consider conservation storage decrease
5	32	RS(3)	I8	blank,0	subtract flood storage decrease (spill) (default)
				1	add flood storage decrease (spill)
				-1	subtract flood storage decrease (spill)
				-9	do not consider flood storage decrease (spill)
6	48	RS(4)	I8	blank,0	add net evaporation-precipitation (default)
				1	add net evaporation-precipitation
				-1	subtract net evaporation-precipitation
				-9	do not consider net evaporation-precipitation
7	48	RS(5)	I8	blank,0	add watershed runoff from reservoir site (default)
				1	add watershed runoff from reservoir site
				-1	subtract watershed runoff from reservoir site
				-9	do not consider runoff from reservoir site
					Reservoir Adjustments Table
8	56	RS(6)	I8	blank,0	Option not used
				1	Adjustments table written to OUT file
					Reservoir Information
9	57-64	CAP	F8.0	+	Reservoir storage capacity
10	65-72	EVCFA	F8.0	+	Multiplier *A* for storage-area equation shown below.
11	73-80	EVCFB	F8.0	+	Exponent *B* for storage-area equation shown below.
12	81-88	EVCFC	F8.0	+	Constant *C* for storage-area equation shown below. surface area $= A\,(\text{storage})^B + C$
13	88-96	RS7	F8.0	+	beginning storage (beginning of first month)
				blank,0	beginning storage content is zero
14	97-104	RS8	F8.0	+	factor to multiply storage contents
				blank, 0	default: RS7 = 1.0

A *RS* record must be preceded by an *AS* record and followed by a *SC* record.

SC Record - Storage Contents

field	columns	variable	format	value	description
1	1-2	CD	A2	SC	record identifier (optional)
2	3-8	SC(1)	F6.0	+	storage contents for Month 1
3	9-16	SC(2)	F8.0	+	storage contents for Month 2
4	17-24	SC(3)	F8.0	+	storage contents for Month 3
5	25-32	SC(4)	F8.0	+	storage contents for Month 4
6	33-40	SC(5)	F8.0	+	storage contents for Month 5
7	41-48	SC(6)	F8.0	+	storage contents for Month 6
8	49-56	SC(7)	F8.0	+	storage contents for Month 7
9	57-64	SC(8)	F8.0	+	storage contents for Month 8
10	65-72	SC(9)	F8.0	+	storage contents for Month 9
11	73-80	SC(10)	F8.0	+	storage contents for Month 10
12	81-88	SC(11)	F8.0	+	storage contents for Month 11
13	89-96	SC(12)	F8.0	+	storage contents for Month 12

SC Record - Storage Contents (Alternative format with control point ID and year PYR)

field	columns	variable	format	value	description
1	1-2	CD	A2	SC	record identifier (optional after first record)
2	3-8	ID	A6	AN	reservoir (optional)
3	13-16	PYR	I8	+	year (optional)
4	17-24	SC(1)	F8.0	+	storage contents for Month 1
5	25-32	SC(2)	F8.0	+	storage contents for Month 2
6	33-40	SC(3)	F8.0	+	storage contents for Month 3
7	41-48	SC(4)	F8.0	+	storage contents for Month 4
8	49-56	SC(5)	F8.0	+	storage contents for Month 5
9	57-64	SC(6)	F8.0	+	storage contents for Month 6
10	65-72	SC(7)	F8.0	+	storage contents for Month 7
11	73-80	SC(8)	F8.0	+	storage contents for Month 8
12	81-88	SC(9)	F8.0	+	storage contents for Month 9
13	89-96	SC(10)	F8.0	+	storage contents for Month 10
14	97-104	SC(11)	F8.0	+	storage contents for Month 11
15	105-112	SC(12)	F8.0	+	storage contents for Month 12

The choice of format for the *FA* and *SC* records is specified by *AS(3)* in field 3 of *AS* record. The only difference between the two options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3. These records, like all others, may also be in comma delimited format.

EQ Record - Regression Equation

field	columns	variable	format	value	description
1	1-2	CD	A2	AS	record identifier
2	3-8	ID	A6	AN	control point identifier
					Regression Equation Coefficients
3	9-16	A			coefficient A
4	17-24	B			coefficient B
5	25-32	C			coefficient C
					Beginning and Ending Years of Adjustments
6	37-40	AS(1)	I8	blank,0	first year of adjustments = first year of analysis period
				+	first year of adjustments
7	45-48	AS(2)	I8	blank,0	last year of adjustments = last year of analysis period
				+	last year of adjustments
					Type of Adjustments
8	56	QE	I8	blank,0,1	Flow $Q_{adjusted} = A\ Q^B + C$
				2	Flow Change $\Delta Q_{adjustment} = (A\ Q^B + C) - Q$
				3	Evap-Precip $E_{adjusted} = A\ E^B + C$
					Cascade Downstream if QE=2 (Yes or No?)
9	64	AS(4)	I8	0	QE=2 adjustments apply to all downstream cp's
				1	*QE=2* adjustments apply to only this control point
					Negative Flow Options
10	72	AS(5)	I8	0	allow negative streamflows
				1	change negative streamflows to zero
				2	change to zero and subtract next month
				3	modify adjustments to prevent negative streamflows
				4	modify adjustments and subtract negative next month

EQ records are grouped with *AS*/*FA*/*RS*/*SC* records and may be placed before, after, or interdispersed with the *AS*/*FA*/*RS*/*SC* records. These records are the last records in either the DAT and/or INF files as specified by *JC(3)* entered in field 7 of the *JC* record.

Fields 6, 7, 9, and 10 of the *EQ* record are identical to fields 3, 4, 6, and 7 of the *AS* record.

Only $\Delta Q_{adjustment}$ may be applied to downstream control points. Therefore, field 9 is blank unless option 2 is selected for *QE* in field 8.

Field 8 specifies the manner in which a regression equation is applied. Streamflows (*QE=1*) or evaporation-precipitation depths (*QE=3*) may be adjusted by direct substitution into the equation.

$$Q_{adjusted} = A\ Q^B + C \quad \text{or} \quad E_{adjusted} = A\ E^B + C$$

Alternatively, for streamflows (*QE=2*), a change in flow $\Delta Q_{adjustment}$ may be computed that is then handled identically as adjustments read from *FA* records or computed in accordance with *RS* records.

$$\Delta Q_{adjustment} = (A\ Q^B + C) - Q$$

INDEX OF INPUT RECORDS