

WRAP Modifications Since July 2001

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The Water Rights Analysis Package (WRAP) model is documented by:

Reference and Users Manual for the Water Rights Analysis Package (WRAP), TWRI TR-180, 1st Edition August 1999, 2nd Edition October 2000, 3rd Edition July 2001.

Modifications made to WRAP since the July 2001 version of the model and manual are described as follows. The manual will soon be updated to reflect these modifications as well as other improvements currently being developed.

Subsequent to the July 2001 WRAP, several versions of the computer programs with additional revisions were distributed, including but not limited to those dated December 2001, April 2002, October 2002, and January 2003. The following description of modifications since the July 2001 WRAP is organized based on dividing the modifications between those made between the July 2001 and April 2002 versions, between the April 2002 and October 2002 versions, and since the October 2002 version.

The July 2001 WRAP included the programs *SIM*, *TABLES*, and *HYD*. The Windows interface program *WinWRAP* was added with the October 2002 version. Conditional reliability modeling versions of *SIM* and *TABLES*, with short-term reliabilities conditioned on initial storage, are presently being tested and refined, are not included in the January 2003 WRAP, but will be incorporated soon. WRAP uses a monthly computational time step, but daily time step features are currently being developed for incorporation in future versions of the model.

Modifications Since October 2002

The January 2003 versions of *SIM*, *TABLES*, and *HYD* have several new features described by this document. *WinWRAP* has been reorganized slightly since the October 2002 version.

Modifications to SIM Since the October 2002 Version

Yield Versus Reliability Table with Firm Yield

The 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*. The firm yield, defined as the maximum value of *AMT* that has a computed reliability of 100.0 percent, also may be of interest. A table of annual yield, represented by the variable *AMT*, versus reliability, that includes firm yield (100% reliability), may be developed simply by running *SIM* multiple times, manually changing the *AMT* entry in *WR* record field 3 for each run. The January 2003 version has a new feature that automates this procedure. The model user runs *SIM* one time. The model internally repeats the simulation multiple times with the annual target amount (*AMT*) being systematically changed for each simulation.

The routine to automatically develop a yield versus reliability table is activated with the new firm yield *FY* record. The *FY* record is placed in the *DAT* file between the *JD* and *UC* records. The output table is written to the *YRO* file (filename *root.YRO*). Thus, a file options *FO* record with the *YRO* file (field 8) activated must be included in the *DAT* file any time a *FY* record is used. *WRAP-SIM* repeats the simulation multiple times with the output files (*root.OUT* and *root.MSS*) 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.

FO Record - File Options

field	columns	variable	format	value	description
1	1-2	CD	A2	FO	Record identifier
7	47-48	F6	I8	blank,0,+ -1	root.MSS (message) file is created (default) root.MSS file is not created
8	55-56	F7	I8	blank,0,- 1 2,+	additional output file is not created (default) root.HRR (hydropower & reservoir release) file created root.YRO yield-reliability output file is created.

FY Record - Firm Yield and Yield-Reliability Table

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

The firm yield is the last entry in the yield-reliability table written to an *YRO* file. The following yield-reliability table is provided to illustrate the automated yield-reliability/firm yield option. This example table is created with the following entries on a *FY* record:

FYIN(1) = 0.92
 FYIN(2) = 200,000 acre-feet/year
 FYIN(3) = 10,000 acre-feet/year
 FYIN(4) = 1,000 acre-feet/year
 FYIN(5) = 100 acre-feet/year
 Either FYWRID = Jones Reservoir and/or FYGROUP = yield

Yield Versus Reliability Table for the Following Water Right(s):

38.782 percent: Jones Reservoir municipa yield
 52.148 percent: Jones Reservoir industri yield
 9.070 percent: Jones Reservoir irrigati yield

If more than one right, the target amount is distributed using the percentages shown above. The total number of periods is 696. The period reliability is the percentage of the periods for which at least 92.0 percent (FY record field 2; default=100%) of the target is supplied. The table below ends with the maximum target that results in a mean annual shortage of less than 0.05 units.

Iteration	Level	Annual Target	Mean Shortage	Mean Actual	Volume Reliability (%)	Periods Without Shortage	Period Reliability (%)
1	0	200000.0	16025.7	183974.3	91.99	630	90.52
2	1	190000.0	13327.9	176672.1	92.99	639	91.81
3	1	180000.0	10741.8	169258.2	94.03	646	92.82
4	1	170000.0	8321.3	161678.7	95.11	656	94.25
5	1	160000.0	6077.6	153922.4	96.20	664	95.40
6	1	150000.0	4533.4	145466.6	96.98	672	96.55
7	1	140000.0	3274.3	136725.7	97.66	677	97.27
8	1	130000.0	1828.7	128171.3	98.59	683	98.13
9	1	120000.0	432.1	119567.9	99.64	692	99.43
10	1	110000.0	0.00	110000.0	100.00	696	100.00

11	2	119000.0	284.9	118715.1	99.76	694	99.71
12	2	118000.0	162.5	117837.5	99.86	695	99.86
13	2	117000.0	40.5	116959.5	99.97	695	99.86
14	2	116000.0	0.00	116000.0	100.00	696	100.00

15	3	116900.0	25.6	116874.4	99.98	695	99.86
16	3	116800.0	10.7	116789.3	99.99	696	100.00
17	3	116700.0	0.00	116700.0	100.00	696	100.00

18	4	116790.0	9.24	116780.8	99.99	696	100.00
19	4	116780.0	7.76	116772.2	99.99	696	100.00
20	4	116770.0	6.27	116763.7	99.99	696	100.00
21	4	116760.0	4.78	116755.2	100.00	696	100.00
22	4	116750.0	3.29	116746.7	100.00	696	100.00
23	4	116740.0	1.80	116738.2	100.00	696	100.00
24	4	116730.0	0.32	116729.7	100.00	696	100.00
25	4	116720.0	0.00	116720.0	100.00	696	100.00

The table begins with a list of the water rights for which the target amounts are adjusted. *FYWRID* and *FYGROUP* from *FY* record fields 7 and 8 connect with the water right identifiers in *WR* record field 11 and group identifiers in *WR* record fields 12 and 13. The program is dimensioned to include up to 100 *WR*-record water rights. The water right identifier and two group identifiers are listed for each right on the top of the yield-reliability table. The annual target is divided between the rights by the percentages shown, which are computed based on directly proportioning the *AMT* from their *WR* records. Thus, the first right in the example, which represents a municipal diversion from Jones Reservoir, accounts for 38.78% of the annual target shown in the table.

The iterative simulations are organized as follows.

1. The total annual target amount *AMT* equals *FYIN(2)* (=200,000 ac-ft/yr) from the *FY* record for the first simulation. *AMT* for the initial and all subsequent iterations is distributed to multiple water rights in proportion to *WR* record field 3 *AMTs*, with resulting percentages listed at the top of the table, to determine the initial individual *AMT* for each of the rights.
2. The total annual target amount *AMT* is decreased by *FYIN(3)* from the *FY* record for each subsequent level 1 iteration until either no shortages occur or the target is finally decreased to zero or less.
3. If both *FYIN(4)* and *FYIN(5)* are zero, the computations stop. If *FYIN(4)* is not zero, the computations proceed to level 2. In the example, since *FYIN(4)* of 1,000 ac-ft has been entered on the *FY* record, the computations proceed to level 2.
4. For level 2, the initial target amount *AMT* is set equal to the next-to-last target amount from the level 1 iterations (120,000 ac-ft). *AMT* is decreased by *FYIN(4)* (1,000 ac-ft) for each level 2 iteration until either no shortages occur or the target *AMT* reaches zero.
5. If *FYIN(5)* is zero, the computations stop without proceeding to levels 3 and 4. Otherwise, level 3 iterations are performed using *FYIN(5)* as the incremental decrease in *AMT*. For the example, *FYIN(5)* is 100 ac-ft.
6. If *FYIN(5)* is not zero, upon completion of the level 3 iterations, an extra level 4 set of iterations is performed with the incremental decrease set at 10 percent of *FYIN(5)*.

Each line in the table represents the results of a simulation. The annual target amount *AMT* is the only input variable that changes between simulations. No other features of *WRAP-SIM* are affected. All other features remain in effect.

FYIN(1) entered in field 2 of the *FY* record (0.92 in example) is the fraction of the monthly target that must be met in order for the routine to not declare that month a failure in the computation of period reliability. *FYIN(5)* might be set at 0.92 for an analysis based on the premise that a 8% reduction in water use through emergency demand management measures is acceptable during dry periods. The *FYIN(5)* default is 1.0, meaning the entire target must be met in order to not declare a failure in meeting the target that month. *FYIN(1)* affects only the period reliability (last two columns of table). It is not used in the volume reliability computations (columns 3, 4, 5). The firm yield criterion for stopping the iterative routine is based on reaching a total shortage of

essentially zero, defined as less than 0.05 units (typically acre-feet/year). If *FYIN(1)* is non-zero, the 100% period reliability yield may be larger than the 100% volume reliability yield. Both are shown in the yield-reliability table. In the example with *FYIN(5)*=0.92, the volume reliability firm yield is 116,720 ac-ft/yr and the period reliability firm yield is 116,800 ac-ft/yr.

The *FY* record computations are performed for only one annual diversion or hydropower amount. A single annual target amount is adjusted during the iterative routine. However, this amount may be shared by two or more water rights (*WR* records). The *FY* record routine is dimensioned for up to 100 water rights. The water right identifier in *FY* record field 7 is matched with the identifiers entered in water right *WR* record field 11. The water right group identifier in *FY* record field 8 is matched with the identifiers entered in water right *WR* record fields 12 and 13. The annual amount is divided between multiple rights in proportion to the amounts *AMT* entered in field 3 of the *WR* records. For those rights designated by *FYWRID* and *FYGROUP* on the *WR* record, this is the only use made of the amounts entered in field 3 of their *WR* records. If only one right is designated by the *FY* record, an amount entered in field 3 of its *WR* record is not used for anything in the computations.

New Type 7 Water Right for Return Flows

The water right type entered in field 6 of the water right *WR* record now includes a type 7 as shown below. The *BACKUP* variable entered in field 6 of the supplemental options *SO* record now includes a *RETURN* option shown on the next page.

WR Record - Water Right

field	columns	variable	format	value	description
6	36	WRNUM (wr,5)	I4	blank,0,1 2 3 4 5,-1 6,-3 7	Type 1 water right Type 2 water right (no refilling storage) Type 3 water right (no streamflow depletions) Type 4 water right (storage-diversion relationship) Type 5 water right (hydroelectric power) Type 6 water right (hydroelectric power) Type 7 water right (inflow to stream)

The primary reason for these new features is to allow return flows to be assigned priorities that are different than the corresponding diversions. Adding a *WR* record with a type 7 right and a *SO* record with the *RETURN* option along with the *WR* record and other supporting records for a diversion right will reproduce exactly the same simulation results obtained handling return flows in a conventional manner if the priorities are the same. However, the new approach allows the return flows to be placed elsewhere in the priority loop. This allows control over which rights get first access to the return flows.

With a type 7 right, the annual amount *AMT* entered in *WR* record field 3 is discharged into the stream. The stream inflow amounts resulting from type 7 rights are found in the simulation results as return flows. A type 7 right may model a return flow or other situations involving discharge of water into the stream system within the water rights priority computation loop. The

target amount is computed for a type 7 right just like any other type of right. The annual amount entered in *WR* record field 3 is converted to monthly values by factors on *UC* records and may be adjusted by options specified on *SO*, *TO*, *TS*, and *DI* records. The difference is that a type 7 right is not a diversion from the stream, but rather an inflow to the stream. After the monthly amount is determined just like a diversion target, it is then multiplied by the return flow factor *RFAC* from *WR* field 8 and treated computationally as a return flow. *RFAC* is assigned a default of 1.0 if the *RFAC* field is blank. All return flow options are valid, except monthly return factors (*RF* records) can not be used. Water availability computations are not relevant and are not performed for a type 7 right. The flow is simply entered into the stream system; it is not taken from streamflow, reservoir storage, or any other source.

SO Record - Supplemental Water Rights Options

field	columns	variable	format	value	description
6	35-40	BACKUP	2x,A6	BACKUP	Diversion shortages for preceding right will be added to diversion target at the end of the target building process.
				BFIRST	Diversion shortages for preceding right will be added to diversion target at the beginning of the target building process.
				RETURN	Diversion shortages for preceding right multiplied by <i>RFAC</i> (default=1.0) to be subtracted from target for type 7 right. Used only for type 7 right.
				blank	Backup option is not used.
9	64	ISHT(wr)	I8	blank,0	<u>Targets and Shortages Written to Output File</u> Last target and shortage computed is in output file.
				1	Target and shortage in output file based on <i>AMT</i> from <i>WR</i> record field 3 after step 1 on page 206.
				2	After applying drought index (step 2 on page 206).
				3	After applying options on <i>TO</i> record (step 3).
				4	After <i>TS</i> records (step 4 on page 206).
				5	After applying drought index (step 5 on page 206).
				6	After applying options on <i>TO</i> record (step 6).
				7	After applying BACKUP option (step 7).
10	65-72	ADL(wr)	F8.0	+	Annual diversion limit
				blank	Limit not applied.

The backup option with *RETURN* entered in *SO* field 6 may be used in combination with a type 7 right. A *WR* record for a type 7 right along with its *SO* record may be placed behind the *WR* and supporting records for a more senior diversion right. The diversion shortage for the first right will be applied in computing the amount *AMTRF* that the second right (type 7 right) returns to the stream as follows:

$$AMTRF_{type\ 7\ right} = T_{type\ 7\ right} - (S_{previous\ right}) (RFAC_{type\ 7\ right})$$

where the target amount *T* for the type 7 right is computed as normal and then adjusted for the shortage *S* from the previous right.

Annual Limit on Diversions

An option has been added that allows an annual diversion limit to be entered in the new field 10 of the supplemental options *SO* record. Starting with the first month of each year, the cumulative amount diverted by a right that year is recorded. Further diversions are curtailed upon reaching the limit specified in *SO* record field 10.

Limits on Withdrawals from Reservoir Storage

Monthly and annual limits on releases from reservoir storage are entered in fields 7 and 8 of the *SO* record. In the past, these limits were applicable only for water right types 1 and 2. A new modification allows the limits to also be applied to type 3 rights.

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 two alternative ways in the October 2002 version with a third option added in the January 2003 version.

1. 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.
2. 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.
3. 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.

New Multiplier Factors and Parameter Limits Record

The variables *STX*, *INX*, *EVX*, *CIX*, *SAX*, and *DEPTHX* in fields 3, 4, 5, 6, and 8 of the new *XL* record were added with the January 2003 version of *SIM*. The other variables on the *XL* record (*POWFCT*, *CNLB*, *CNUB*, *MPLB*, *CNUB*, and *EPWL*) are moved from the *JD* record. Thus, the *JD* record now has fewer fields. The fields moved from the old *JD* record to the new *XL* record have typically been blank in most data sets, activating defaults.

The primary reason for adding the multiplication factors *STX*, *INX*, *EVX*, *CIX*, *SAX*, and *DEPTHX* is to facilitate unit conversions. Prior to the January 2003 version, the only WRAP feature limited to one set of units was the NRCS curve number (CN) method option for distributing flows from gaged to ungaged control points. Otherwise, the model had flexibility for using different alternative set of units. The new multiplication factor *DEPTHX* entered in *XL*

record field 8 allows the NRCS CN method option to be applied with any set of units. The multiplication factors *STX*, *INX*, *EVX*, *CIX*, and *SAX* provide additional flexibility to allow easier use of any set of units. The multiplier *DAF* entered in field 6 of the watershed parameter *WP* record was previously designed solely to convert units for drainage areas entered in *WP* record field 3 to square miles. In the new January 2003 version, the old input variable *DAF* may be used as a conversion factor to convert *WP* record drainage areas from any units to any other units.

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 rates for all control points for which the *CPDT(cp,1)* and *CPDT(cp,2)* fields on 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 multiplication factor *STX* (default=1.0) is applied to the reservoir storage amounts entered on *WS*, *OR*, *SV*, *PV*, *MS*, *IS*, and *SD* records. The model user must adopt a consistent unit (acre-foot, million cubic meters, ect.) for entering storage capacities in the *WRAP-SIM* input records. However, *STX* allows easy conversion to another consistent unit.

The multiplication factor *DEPTHX* entered in *XL* record field 8 is used in the NRCS CN method for distributing flows from gaged to ungaged sites. The CN method uses runoff depth (streamflow volume) in inches computed as follows.

$$\text{Runoff depth in inches} = \left(\frac{\text{streamflow}}{\text{drainage area}} \right) \text{DEPTHX}$$

The default of *DEPTHX* = 0.01875 is defined as follows based on streamflow units of acre-foot/month and watershed drainage area units of square miles.

$$\begin{aligned} \text{Runoff depth in inches} &= \left(\frac{\text{acre-foot}}{\text{square mile}} \right) \left(\frac{43,560 \text{ ft}^3}{\text{acre-foot}} \right) \left(\frac{\text{mile}}{5,280 \text{ ft}} \right)^2 \left(\frac{12 \text{ inches}}{\text{foot}} \right) \\ \text{Runoff depth in inches} &= \left(\frac{\text{streamflow in acre-foot}}{\text{drainage area in square miles}} \right) 0.01875 \end{aligned}$$

If units for streamflow other than acre-feet/month and/or drainage area units other than square miles are used, an appropriate *DEPTHX* is entered on the *XL* record to convert the monthly runoff depth to inches.

The multiplication factor *POWFCT* used in the hydroelectric power computations is described on page 162 of the July 2001 manual. *POWFCT* has not changed from earlier versions of *WRAP-SIM* except for the move from the *JD* record to the *XL* record.

XL Record - Multiplication Factors and Parameter Limits

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

Dimension Limit Increase

The maximum number of *TO* records plus *SO* record backup rights has been increased from 400 to 650.

Reading Alphanumeric Identifiers in WRAP-SIM, TABLES, and HYD

In reading alphanumeric input variables, fortran read statements read any trailing blanks to the right of the alphanumeric characters and include them in the variable. Thus, alphanumeric variables are normally right justified in their input fields. However, the *WRAP* code previously allowed water right identifiers to be entered any place in the specified field with the program automatically right justifying the entry. The January 2003 *WRAP-SIM*, *TABLES*, and *HYD* have been modified to automatically right justify essentially all entries of alphanumeric identifiers including water right, control point, reservoir, and use type identifiers. The alphanumeric identifiers can now be entered any place in their fields with the program automatically removing the trailing blanks. The entries must still be contained in their correct field, which for many variables has a field width of six characters. Right justification is still fine and will always work with any of the alphanumeric variables.

Data Statements and Disk Storage Size of SIM.exe and HYD.exe

Fortran data statements were previously used to assign initial values to most of the variables in *SIM* and *HYD* prior to execution of the programs. The programs have been restructured to initialize variables with arithmetic statements during execution. The data statements have been removed. This results in a dramatic decrease in the disk storage size of the executable programs *sim.exe* and *hyd.exe*.

TABLES Modifications Since the October 2002 Version

2TAR and 2IFT Records – Diversion Targets and Instream Flow Targets

The new *2TAR* and *2IFT* records have the same format as the *2NAT*, *2REG*, *2UNA*, *2DEP*, *2DIV*, *2SHT*, *2IFS*, *2STO*, *2CLO*, and *2CLC* records. The *2TAR* record creates tables of diversion targets. The *2IFT* record creates tables of instream flow targets. The *2IFS* record has been corrected to tabulate instream flow shortages rather than instream flow targets. In the October 2002 version of *TABLES*, the identifier *2TAR* was adopted for the new summary table attachment to the *2REL* record reliability table but changed in the January 2003 version to *2RET*.

Units

Several table headings include volume and/or energy units. In the past, the units in table headings were AC-FT for volume and MW/GW-HRS for energy generated by hydropower. These terms have been replaced with the character variables *UNIT* and *UNHP*. The user may enter values on the new optional *UNIT* record. If a *UNIT* record is not used, the defaults are:

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

If a *UNIT* record is included in the data set with blank entries for *UNIT* and/or *UNHP*, their values are blanks. The units entered on the *UNIT* record are printed in the table headings but do not affect the data in the tables. Program *TABLES* organizes and manipulates data from *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.

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 <i>UNIT</i> record, the default is AC-FT.
3	11-15	UNHP	A5	AN blank	Hydropower units printed in table headings. Without a <i>UNIT</i> record, the default is MW-HR.

Other Modifications to TABLES

The *ISUM* and *ISRT* records summarize and sort water rights data from a *WRAP-SIM* input file. A water right group summary (*KK=4*) option was added to the *ISUM* table. Modifications were made to the *ISUM* and *ISRT* routines to reflect recent previous modifications to *WRAP-SIM*. Dimension limits were increased from 3,000 to 5,000 water rights and control points and from 1,200 to 1,500 reservoirs. The *ISUM* and *ISRT* routines were also updated to recognize the new *SIM FY* and *XL* records.

Problems were corrected related to situations in which an instream flow *IF* right at the beginning of the *SIM* output file could prevent building of diversion reliability tables with the *2REL* record.

Several new error checks/messages were added to *TABLES*. A few headings were refined.

HYD Modifications Since the October 2002 Version

Dimension Limit Increase

The maximum number of control points has been increased from 250 to 300. The maximum number of years has been increased from 100 to 125.

Multiplication Factors

A *XL* record has been added to *HYD*. 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*.

XL Record - Multiplication Factors

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

WinWRAP Added with the October 2002 WRAP

WinWRAP is a major new addition incorporated into the October 2002 WRAP. *WinWRAP* is a new program that facilitates application of the WRAP programs within the Microsoft Windows environment. Prior to development of *WinWRAP*, the WRAP programs were normally executed within the Microsoft Disk Operating System (MS-DOS). *WinWRAP* is placed in the same folder (directory) as the other WRAP programs. A mouse click of the *WinWRAP* icon activates the program. Instructions for using *WinWRAP* are provided within its *Information* menu. *WinWRAP* allows execution of the WRAP programs (*SIM*, *TABLES*, *HYD*) within the windows operating system in combination with use of Microsoft programs (*DOS Editor*, *NotePad*, *WordPad*, *Word*, *Excel*, *Access*) to access and edit WRAP input and output files.

WinWRAP facilitates application of WRAP within *MS Windows* but does not change the WRAP programs. Their input and output files are still the same. The executables can still be executed in *MS DOS* if the user chooses. *WRAP-SIM*, *TABLES*, and *HYD* are still intact.

SIM Modifications During April-October 2002

Target Setting Routines

Several refinements have been made to the various *WRAP-SIM* routines that set diversion, instream flow, and hydropower targets.

WRAP-SIM has been modified such that a *WR/SO* record backup right refers to the next preceding *WR* record, while ignoring any intervening *IF* records. Backup right applications may occur in which it is useful to place an *IF* record between an *WR* record and its *WR/SO* record backup right. Previously, a water right *WR* record with a backup right (*SO* record field 6) immediately following an instream flow *IF* record could cause problems. A backup right allows the diversion shortage from the preceding right to be added to its diversion target. Previously, a *WR/SO* record backup right following an *IF* record would do nothing and be meaningless unless the instream flow (*IF* record) right specified releases from reservoir storage. A *WR/SO* record backup right following an *IF* record with storage (*IF* field 7) could cause problems. With the modification, all intervening *IF* records are now ignored.

An *IF* record must be followed by at least one *WS* record if releases from reservoir storage are used to meet the instream flow requirement (*IFFLAG* of 3 or 4 in *IF* field 7). An error message has been added that terminates execution if an *IF* record with *IFFLAG* of 3 or 4 does not have at least one reservoir designated (*WS* record). Previously, the error of specifying releases from storage without designating a reservoir could have somewhat unpredictable results, which could possibly vary with different versions of the model.

Unless releases from reservoir storage are specified, water right types other than type 1 are meaningless for an instream flow right and should not be specified on an *IF* record. Violations probably will not cause problems but possibly could. A warning message has been added for this situation.

Diversion and hydropower targets are established through a series of optional steps activated by *SO*, *DI*, *TO*, and *TS* records. Targets and shortages at intermediate steps in the computations may be written to the output file as specified in *SO* record field 9. The system for selecting the intermediate targets to output has been clarified and expanded a little. More choices are provided in *SO* record field 9. As discussed later, the *BFIRST* option was previously added to *SO* record field 6.

Another revision was made to assure that target limits specified in *TO* record fields 5 and 6 are not inappropriately applied under certain conditions.

Dimension Limit Increases and Additional Error Messages

The maximum number of water use types with sets of water use coefficients (*UC* records) has been increased from 100 to 300. The maximum number of *TO* records plus *SO* record backup rights was increased from 200 to 400 (and later increased to 650 with the January 2003 version). The manual indicates a dimension limit for *TO* records, but this limit actually applies to the sum

of the number of *TO* records plus the number of *SO* records with the backup right option activated.

Several new error messages were added at various places in *WRAP-SIM*.

Filename Extension for Naturalized Flows

The October 2002 and later versions of *WRAP-SIM* include the option of using the filename extension of *FLO* (*root.FLO*) for the file containing the *IN* records instead of *INF* (*root.INF*). The program checks for *root.FLO* first and then, if *root.FLO* is not found, it looks for *root.INF*. Either the new *FLO* or old *INF* extensions are fine. However, the modification is motivated by *MS Windows* use of the *INF* extension to signify setup information.

TABLES Modifications During April-October 2002

Frequency Table

A routine has been added for performing a frequency analysis for the total monthly storage in any selected group of reservoirs, which could include all the reservoirs in the model or any subset thereof. A bottom summary line has been added to the *2FRE* frequency table for reservoir storage. The monthly storages for each month for all control points or reservoirs included in the table are summed. A frequency analysis is then performed on the monthly totals. The frequency statistics for the totals are automatically included as the last line in the table for an *ID* of 4 or 5 (*2FRE* field 2). An *ID* of -4 or -5 results in the totals line being the only entry in the table.

Reliability Table

Several water right *WR* records with associated *SO*, *TO*, *DI*, *WS*, and other supporting records may be combined to represent a particular water use requirement. A *2REL* record will create a table containing a line for each component *WR* record. However, model users may be interested in the combined reliability of the total water use requirement rather than the individual reliabilities associated with its component *WR* records. The complexity of interpreting the overall reliability from the component rights in the reliability table depends upon the options applied in building the targets in *WRAP-SIM*. The totals line at the bottom of *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. A new *2REL* table feature is designed for this type of situation.

A new optional diversion or hydropower summary has been added to the end of the reliability table. The new *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 the new *2TAR* record (changed to *2RET* in January 2003 version) follow the *2REL* record. The only entry on the *2TAR* (*2RET*) record is the diversion target to be adopted for the add-on summary.

2REL Record - Water Supply Diversion or Hydropower Reliability Summary

field	columns	variable	format	value	description
1	1-4	CD	A4	2REL	record identifier
2	6	TFLAG	I2	0, blank 1,+	not used Diversion summary table is added at the end of the reliability table. A 2TAR record must follow.
3	8	RFLAG	I2	0, blank	N = number of months with non-zero targets $N = NYRS * 12$ for $R_p = (n/N) * 100\%$

2RET Record – Target for 2REL Summary Table

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

Other Modifications to TABLES

Several new error messages have been added at various places in *TABLES*. The program no longer reads past the *ENDF* in the initial check of record identifiers, allowing the user to enter anything after *ENDF*. This is useful for storing records.

HYD Modifications During April-October 2002

CP Record Factors

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. A new feature 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.

IN/EV Record Error Checks

An error was corrected that prevented certain *IN/EV* record error checks from being performed correctly.

Filename Extension for Naturalized Flows

The filename extension *INF* (*root.INF*) has been changed to *FLO* (*root.FLO*) for the input and output files containing the *IN* records. The change to *FLO* was motivated by the MS Windows designation of the extension *INF* to mean setup information.

WRAP-SIM Modifications During November 2001 – April 2002

There were no WRAP modifications during August-October 2001. The following modifications occurred during November 2001 to April 2002.

Additional Fields on April 2002 Version WRAP-SIM JD Record

The fields 15-19 added to the *JD* record in the April 2002 *WRAP-SIM* discussed here were moved to the previously discussed new *XL* record in the January 2003 version. These new fields allow bounds to be specified on curve numbers (CN) and mean precipitation (MP) used in the CN method for distributing flows from gaged to ungaged control points. If these fields are left blank, the default bounds are zero and 100 for CN's and zero and 100 inches for MP's. The new field 19 allows specification of the evaporation-precipitation depth adjustment limit that activates a warning message. If this field is blank, the default is 2.0 feet.

JD Record - (new in April 2002 version; moved to *XL* record in January 2003 version)

field	columns	variable	format	value	description
<u>Limits on CN and Mean Precipitation</u>					
15	105-112	CNLB	F8.0	+ blank	Lower limit on CN Default = 0.0
16	113-120	CNUB	F8.0	+ blank	Upper limit on CN Default = 100.0
17	121-128	MPLB	F8.0	+ blank	Lower limit on MP Default = 0.0
18	129-136	MPUB	F8.0	+ blank	Upper limit on MP Default = 100.0 inches
<u>Warning Limit on Runoff EP-Adjustment</u>					
19	137-144	EPWL	F8.0	+ blank	Limit for warning message Default = 2.0 feet

Curve Number (CN) and Mean Precipitation (MP) Bounds

Curve numbers (CN) and mean precipitation (MP) are used in the CN method for distributing flows from gaged to ungaged control points, incorporated in *INMETHOD* (CP record field 6) options 4, 5, and 8. Subroutine *FLDIST* distributes flows from gaged to ungaged locations. Subroutine *IACNP* reads the *FD* and *WP* records from the root.DIS file and computes incremental drainage areas (A), curve numbers (CN), and mean precipitation (MP) for use in subroutine *FLDIST*. The CN and MP for an incremental watershed is computed from the CN's and MP's read from the *WP* records for total watersheds. The basic premise in computing the CN and MP for an incremental watershed is that the CN or MP for a total watershed equals the area-weighted average of the values for all its subwatersheds.

Situations may occur in which the CN or MP input for total watersheds are unrealistically low or high. Unrealistic values may also result for the computed CN's or MP's for small incremental subwatersheds. Problems may be related to preciseness of the CN's and MP's relative to the size of incremental subwatersheds that are a very small portion of the total watershed. The CN may be negative or exceed 100, violating the definition of CN and resulting in negative flows from the CN method algorithm.

A new feature has been added to the *WRAP-SIM* routines for applying the CN method for synthesizing flows. If in determining flows for any particular ungaged control point, the CN or MP for either the gaged or ungaged incremental or total watershed falls outside the specified lower and upper bounds, the drainage area ratio method is used instead of the NRCS CN method. Under these conditions, *INMETHOD* options 4 and 5 revert to option 7 (drainage area ratio method without channel losses), and option 8 reverts to option 6 (with channel losses). Only flows at ungaged control points with watershed parameters violating the bounds are affected by the new feature. This will likely affect only a very small portion, if any, of the control points in any particular river basin.

Warning messages are written to the message file for each control point total or incremental watershed for which either the CN or MP violates either the lower or upper bounds. Negative watershed areas continue to be treated as errors that result in an error message and termination of program execution.

The default lower and upper bounds are zero and 100 for CN's. The default bounds are zero and 100 inches for MP's. Optionally, the bounds may be specified in the *JD* record fields 15-18 (moved to *XL* record in January 2003 version).

Handling of Negative Flows in Distributing Flows

Incremental flows at a gaged control point are computed in subroutine *FLDIST* by subtracting flows at upstream control points specified on a *FD* record. Incremental flows are used in distributing flows from gaged to ungaged control points. The incremental flows may be computed as negative numbers. Previously, negative incremental flows were converted to zeros for all flow distribution options except *INMETHOD* option 6. Also, after the flow distribution computations, any negative total flows computed for ungaged control points are

converted to zero, except for option 6. Option 6 incorporates channel losses in the drainage area ratio method. Two modifications were made in November 2001 in regard to handling negative flows.

1. In distributing flows to headwater control points with no other upstream control points, using option 6, negative total flows are converted to zero. Thus, negative synthesized flows at ungaged locations are not allowed for any of the flow distribution methods.
2. With *INMETHOD* option 8, negative incremental flows were previously set to zero. Now, negative incremental flows trigger reverting to option 6. Thus, for option 8, a negative incremental flow has the same effect as a CN or MP violating lower or upper bounds.

Warning Message for Evaporation-Precipitation Adjustment for Reservoir Site Runoff

WRAP-SIM includes an option to account for the portion of the precipitation falling on a reservoir water surface that is also reflected in the naturalized streamflows. Adjustments to the evaporation-precipitation depths from the *EV* records are computed as naturalized streamflow expressed as a depth per unit of watershed area. This represents runoff occurring without the reservoir from the land area covered by the reservoir. Variables *EPADJ* in *JD* record field 10 and *EWA* in *CP* record field 9 allow specification of the runoff EP-adjustment as an incremental flow per incremental watershed area.

Previously, *WRAP-SIM* printed a warning message any time the adjustment exceeded 2.0 feet. The warning limit may now be specified in the new field 19 of the *JD* record. The warning limit defaults to 2.0 feet. The warning message has been reworded. Also, after the message is printed 2,000 times, it is no longer repeated, and a final message to that effect is printed. The warning limit affects only the warning message. Computations are not affected.

Evaporation-Precipitation Adjustment for Zero Evaporation-Precipitation

EPADJ in *JD* record field 10 may specify adjustments for all control points except those flagged by *EWA* in *CP* record field 9. *FD* records are required for all specified control points. *WRAP-SIM* has been modified slightly to allow control points with zero evaporation specified by *CPEV* in *CP* field 8 as well as those flagged by *EWA* in field 9 to be exempt from requirements for *FD* records associated with pertinent *EPADJ* options in *JD* record field 10.

RF and TS Record Dimension Limit

The dimension limit has been increased from 20 to 50 for the number of sets of return flow factors (*RF* records) that may be used in *WRAP-SIM*. The number of water rights to which target series *TS* records may be assigned has been increased from 20 to 30.

Error Correction for *IFFLAG* = 2 or 4 Combined with *RFMETH* = 2 or 4

Next month return flows are specified by *RFMETH* of 2 or 4 on a *WR* record. *IFFLAG* of 2 or 4 on a *IF* record specifies a second pass through the water rights loop if an instream flow

requirement is shorted during the first pass. An error has been corrected that resulted in next month return flows being double counted in the regulated and unappropriated flows in months in which instream flow shortages trigger a second pass through the water rights loop.

Correction of Hydropower Double-Counting Error

In determining the amount of water to release for hydroelectric power, *WRAP-SIM* considers the amount of water passing through the turbines for diversions or other requirements at downstream locations associated with other more senior rights. The hydropower release amount is the amount, in addition to the water already passed through the turbines anyway for downstream water right requirements, required to meet the energy target. Accountings are maintained of flows through the turbines for two types of senior rights: (1) rights that release from the same reservoir as the hydropower right and (2) rights not directly associated with the hydropower reservoir but for which water flows through the hydropower reservoir to meet a senior downstream water right requirement. These cumulative turbine flow amounts are computed as variables *PREREL* and *PREPASS* in subroutine *POWER*. The error was associated with a senior type 3 right with a diversion at a location downstream of the multiple-purpose reservoir met by releases from the same reservoir as the more junior hydropower right. The releases for the type 3 diversion right were erroneously included in both variables *PREREL* and *PREPASS*; thus double counting the credit for releases through the turbines. The error has been corrected.

Sequencing of BACKUP Right

The backup right feature of *WRAP-SIM* activated by the variable *BACKUP* entered in field 6 of the *SO* record refers to diversion shortages incurred by a water right being added to the diversion target to be met by another more junior right. The backup feature has been expanded to allow another option for sequencing of the backup. Previously, the shortage was added to the backup-right's diversion target after completion of all the other optional target-building adjustments associated with the drought index (*DI* record), supplemental options (*SO* record), target options (*TO* record), and target series (*TS* record) options. The new option allows the shortage to be added to the backup right's diversion target at the beginning of the target-building process, such that it is subject to all of the other optional adjustments. The new option is activated by entering *BFIRST* for the variable *BACKUP* in field 6 of the *SO* record.

Warning Message for Multiple-Reservoir System Operations

OR records properly sequenced behind *WR* and *WS* records specify operating rules for secondary reservoirs. A type 2 or 3 (*WR* field 6) water right combined with one to 20 *WS/OR* records allow a diversion target to be met by 1 to 20 secondary reservoirs. Types 2 and 3 water rights have no primary reservoir (no refilling storage). Other water rights (*WR* records) refill storage in these reservoirs. A type 1 or 5 right allows storage to be refilled in the first reservoir (called the primary reservoir) listed with its *WS* record immediately following the *WR* record.

An operating rules *OR* record is not required for the primary reservoir associated with a type 1 or 5 right. The July 2001 version of *WRAP-SIM* includes an error message preventing inclusion of an *OR* record for a primary reservoir. The error message has been replaced in the current version

with a warning message. The primary (first reservoir listed) for a type 1 or 5 water right optionally may or may not include an *OR* record. However, if an *OR* record is included, a warning message reminds the user that the reservoir is subject to being refilled and thus operated differently than the secondary reservoirs.

If multiple reservoirs are operated to meet a common diversion target, the recommended approach is to treat the diversion as a type 2 or 3 right with all of the reservoirs being operated as secondary reservoirs. Storage is refilled with separate type 1 rights for each reservoir. However, a type 1 right may also be used to refill storage in a primary reservoir using releases from one to 19 secondary reservoirs.

Correction of Error Messages Related to Return Flows

Two error messages have been corrected. If *WR* record field 8 refers to a *RF* record that does not exist, an error message is activated. This message is correctly activated now, but not previously. Another error message is activated if the return flow control point identifier is not found on any *CP* record. The wording of that message has been corrected to refer to the return flow control point rather than water right control point.

Corrections of Evaporation Allocation Option

The *EA* record activates a feature for allocating net evaporation-precipitation among water rights that share a common reservoir. Two errors have been corrected.

1. A problem in the code with the reservoir indexing scheme caused program execution to be terminated for most but not all sequencing of *EA* records.
2. The other problem corrected was related to incorrect handling of the situation of zero total reservoir storage content for evaporation allocation method 2.

TABLES Modifications During November 2001 – April 2002

The reliability tables include an 8-character wide column for the identifiers of the control points, water rights, hydropower projects, or water right groups included in the table. Although water right identifiers may be up to 16-characters long, only the first 8 characters were printed in the table. The reliability table has been modified to print all 16-characters of the water right identifiers.

Several tables including the reliability table can include either all of the control points, water rights, hydropower projects, or water right groups included in the simulation results or alternatively only a specified selection of up to 30 entries. The manual indicates that up to 30 identifiers may be listed, with up to eight per record. With more than eight identifiers, the data in the first few fields that are common to all the multiple records should not be required on the second and subsequent records. However, previously, the table would not be built unless these data were repeated on all of the records. This error has been corrected. A problem occurring when the *PAGE* record is used with more than one *TITL* record was also corrected.