WRAP Additions and Revisions

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Introduction

The Water Rights Analysis Package (WRAP) has evolved since the late 1980's with continual additions and improvements to the software package. The modifications are described by this report as information for model-users whose applications may have spanned over timeframes involving multiple versions of the model. Maintaining a record of modifications is also useful in the continuing efforts to improve and expand the modeling system. More recent modifications are described here in greater detail than those occurring earlier.

Model Development Background

The development of WRAP is described in the *Acknowledgements* and *Chapter 1* of the *Reference Manual*. The model dates back to a 1986–1988 research project at Texas A&M University sponsored by a cooperative federal-state research program administered by the U.S. Department of the Interior and the Texas Water Resources Institute. In 1997, the Texas Commission on Environmental Quality (TCEQ) incorporated WRAP in the Water Availability Modeling (WAM) System implemented pursuant to the 1997 Senate Bill 1. WRAP was greatly expanded and improved during 1997-2003 under the auspices of the TCEQ in conjunction with development of the Texas WAM System. The TCEQ contracted with Texas A&M University again in 2005 to further expand the model during 2005-2008. The Fort Worth District of the U.S. Army Corps of Engineers also supported model expansion efforts during 2001–2005. The Texas Water Development Board sponsored addition of a new feature to WRAP in 2007-2008. Other sponsors have also contributed to the research and development effort at various times.

WRAP Documentation

WRAP is documented by the following set of manuals.

Reference Manual for the Water Rights Analysis Package (WRAP) Modeling System, by R. Wurbs, TWRI TR-255, First Edition August 2003, Second Edition April 2005, Third Edition September 2006, Fourth Edition March 2008. *(Reference Manual)*

Users Manual for the Water Rights Analysis Package (WRAP) Modeling System, by R. Wurbs, TWRI TR-256, First Edition August 2003, Second Edition April 2005, Third Edition September 2006, Fourth Edition March 2008. *(Users Manual)*

Fundamentals of Water Availability Modeling with WRAP, by R. Wurbs, TWRI Technical Report 283, First Edition April 2005, Second Edition September 2006, Third Edition May 2007, Fourth Edition March 2008. *(Fundamentals Manual)*

Conditional Reliability, Sub-Monthly Time Step, Flood Control, and Salinity Features of WRAP, by R. Wurbs, R. Hoffpauir, H. Olmos, and A. Salazar, TWRI TR−284, First Edition September 2006. *(Supplemental Manual)*

Programming Manual for the Water Rights Analysis Package (WRAP) Modeling System, in preparation. *(Programming Manual)*

Prior to being replaced by the set of manuals listed above, WRAP was documented by a single manual that transitioned through the following versions.

Water Rights Analysis Program (TAMUWRAP), Model Description and Users Manual, R.A. Wurbs and W.B. Walls, Texas Water Resources Institute, June 1988.

Water Rights Analysis Package (TAMUWRAP), Model Description and Users Manual, R. Wurbs, D.D. Dunn, and W.B. Walls, TWRI TR−146, March 1993, Revised October 1996.

Water Rights Analysis Package (WRAP), Model Description and Users Manual, R.A. Wurbs, TWRI TR−180, First Edition August 1999, Second Edition October 2000, Third Edition July 2001.

Several manual supplements covering specific modifications were prepared between the April 2005, August 2003, July 2001, October 2000, August 1999, October 1996, March 1993, and June 1988 reference/users manuals for use until the modifications could be incorporated into the next version of the complete documentation. Modifications performed early in the project to implement the TCEQ WAM System were documented by the following report.

Documentation of New Features in the February 1999 Version of the Water Rights Analysis Package (WRAP), by R.A. Wurbs for the Texas Natural Resource Conservation Commission, Texas Water Resources Institute, February 1999.

Other manual supplements covering specific modifications and various drafts of the complete manuals were also prepared during the process of expanding and improving the model.

WRAP Computer Programs

The model documented by the June 1988 manual was a single Fortran program called *TAMUWRAP*. The 1993 and 1996 TR-146 describes a package of three Fortran programs called *WRAP2*, *WRAP3*, and *TABLES*. *WRAP2* and *TABLES* replaced *TAMUWRAP*. *WRAP3* is an expanded version of *WRAP2*. A network flow programming version called *WRAPNET* was also developed during the early 1990's. *WRAPNET* reads the same input files and creates the same simulation results as *WRAP2* but performs computations with a network flow linear programming algorithm that had been adopted for other river/reservoir system models developed by the Texas Water Development Board and other model developers. Although *WRAPNET* worked fine, the model-specific *WRAP2* algorithms were concluded to be advantageous for various reasons.

The WRAP software package developed in conjunction with implementation of the TCEQ WAM System consists of the following Fortran programs. The additions and revisions to WRAP described by this report deal specifically with these four computer programs.

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

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

HYD assists in developing monthly naturalized stream flow volume and monthly reservoir net evaporation-precipitation depth data for the *SIM* hydrology input files.

WinWRAP is an interface that facilitates execution of the *WRAP* programs within *Microsoft Windows* along with Microsoft programs and *HEC-DSSVue*.

The program *SIM* was developed by building upon and expanding *WRAP3*. The name *SIM* replaced the name *WRAP3* in 1998. *SIM* has been greatly expanded since that time. *TABLES* has also grown continuously since its initial creation in 1991-1992. *HYD* has been used little to date because development of the TCEQ WAM System hydrology datasets was essentially completed when *HYD* became available in 2000. The first major modifications to *HYD* since 2001 occurred during 2007−2008. *WinWRAP* was first added to the package with the October 2002 version of *WRAP* and has continued to be refined periodically.

The following Fortran programs described by the September 2006 *Supplemental Manual* cited on page 1 were under development for several years prior to public release of an initial test version in September 2006.

SIMD (*D* for daily) is an expanded version of *SIM* that includes sub-monthly time step and flood control features along with all of the simulation capabilities of *SIM*.

DAY assists in developing sub-monthly (daily) time step hydrology input for *SIMD*.

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

The expanded *SIMD* contains all the capabilities of the monthly time step *SIM*, plus options related to flood control, flow forecasting and routing, sub-monthly targets, and disaggregation of naturalized flows. At some future time, *SIMD* may be declared to replace *SIM*. However, *SIM* is currently maintained as a separate program. *SIM* is complex, and addition of expanded modeling capabilities to *SIMD* adds significantly more complexity. *SIM* has been applied extensively as a component of the TCEQ WAM System. As a safeguard, maintenance of *SIM* allows ongoing applications of the WAM System that do not need the expanded modeling capabilities to continue with the basic *SIM* software. All modifications to *SIM* are also incorporated in *SIMD*.

SIMD, *DAY*, and *SALT* are new programs developed specifically for the major new modeling capabilities described by the September 2006 *Supplemental Manual*. These enhancements also entailed significant modifications to *SIM*, *TABLES*, and *WinWRAP*. Any of the programs may be executed from *WinWRAP*.

Conditional reliability modeling algorithms are incorporated in April 2005 and later versions of *SIM*. Although the modifications to *SIM* are significant, most of the new computational routines required for conditional reliability modeling are contained in *TABLES*.

TABLES contains major new features dealing with *SIM* or *SIMD* conditional reliability modeling results, *SIMD* sub-monthly time and step flood control simulation results, and *SALT* salinity simulation results. The *TABLES* Fortran program is modular with separate modules or subroutines for developing tables and data listing associated with organizing the various types of *SIM*, *SIMD*, and *SALT* simulation results. The modular organization of the program greatly facilitates adding new features.

Program *SALT* reads a *SIM* or *SIMD* simulation results output file and salinity input file and tracks salt loads and concentrations through the river/reservoir system. Addition of salinity simulation capabilities to WRAP required essentially no modifications to *SIM* or *SIMD*.

WRAP Modifications

This report documents additions and revisions to the WRAP programs *SIM*, *TABLES*, *HYD*, and *WinWRAP* that have occurred during various time periods since the 1996 WRAP documented by the October 1996 revised TR−146 *Reference/User Manual*. At least one or two and in some years several improved/expanded versions of the WRAP software were distributed for use during each year since beginning implementation of the TCEQ WAM System in 1997.

Modifications Between the October 1996 and August 1999 Versions

Several revised versions of WRAP with interim documentation were distributed in conjunction with the TCEQ WAM System implementation project between the revised TR−146 dated October 1996 and the first edition of TR−180 dated August 1999. *SIM* replaced *WRAP3* and then continued to be expanded. *TABLES* was expanded. The new *HYD* was added. Major new features in the August 1999 WRAP that were not in the 1996 version include the following.

- a set of routines for adjusting gaged streamflows to determine naturalized flows

- methods for distributing naturalized streamflows from gaged (known-flow) to ungaged (unknown-flow) control points

- options to facilitate compilation of sequences of net evaporation-precipitation rates

- an adjusted net evaporation-precipitation option to account for the previous precipitation runoff from the land area now covered by a reservoir

- capabilities for modeling channel losses

- a set of optional capabilities for modeling instream flow requirements

- a drought index feature allowing instream flow, diversion, and hydropower targets to be expressed as a function of reservoir storage content

- expanded options for modeling return flows

- capabilities for developing streamflow and storage frequency relationships

- improved techniques for dealing with negative incremental naturalized streamflows

- options for adding sets of inflows and/or outflows to the naturalized streamflows

- an optional routine for assigning water right priorities by type of use

- water rights options associated primarily with off-channel reservoirs involving diversions from multiple locations and annual and monthly limits on streamflow depletions

- a backup right feature with diversion shortages for a water right supplied by other rights

- an option for modeling seasonal rule curve reservoir operations

- features for finding errors in the input data

- improvements in input data format, file organization, and input/output data management

- refinements in the structure and organization of the Fortran code

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Modifications Between the August 1999 and July 2001 Versions

Additions and revisions to WRAP between the versions documented by the August 1999 first edition and July 2001 third edition of the TR−180 manual were as follows. Input data records used to activate new features are shown in parenthesis. The changes between October 2000 and July 2001 were relatively minimal compared to the changes between the August 1999 and October 2000 versions. Most of the following additions were included in the October 2000 as well as July 2001 versions. The July 2001 version also reflects addition of negative incremental flow option 5, expansion of *TO* record options, further increases in dimension limits, and other relatively small refinements made after the October 2000 version.

Modifications Applicable to both SIM and HYD (August 1999 – July 2001)

- The system for detecting errors in the input data was improved and expanded. Significantly more error checks were added.

- A new naturalized streamflow distribution option allows channel loss computations to be combined with the NRCS curve number method. (*CP* record field 6, new option 8)

- The adjustment of evaporation-precipitation depths for runoff from reservoir land was restructured for greater flexibility. (*JD* record field 10, *JC* record field 13, *CP* record field 9)

- A new negative incremental flow adjustment feature allows control points with synthesized flows to be optionally included or excluded in the negative incremental flow adjustments. (*JD* record field 8, *JC* record field 11)

- Various computational algorithms and the organization of the Fortran code were refined. Inconsistencies and errors were corrected. Improvements in certain routines reduce run times. Modifications facilitate compiling the code with different Fortran compilers. Restructuring in some cases makes the code easier to understand.

- Dimension limits were increased to allow more control points, water rights, reservoirs, and drought indices.

- Input data optionally may be in a comma-delimited format as an alternative to fixed field widths for most input records for all three programs.

SIM Modifications (August 1999 – July 2001)

- New features were added to provide greater flexibility for specifying water right requirements. A new option allows diversion, instream flow, and hydropower targets to be entered as a time series covering the entire hydrologic period-of-analysis, with monthly targets varying from year to year or repeated for any number of years. (new *TS* record)

- Another new set of options allow diversion and instream flow targets to be defined as a function of: naturalized, regulated, and/or unappropriated streamflow at multiple locations; reservoir storage and/or drawdown; and/or streamflow depletions incurred by other water rights. A new drought index feature further facilities use of a drought index in combination with these options for defining water use targets. With the target building features, an option allows selection of the stage of the target for which the target and shortages are recorded in the output. (new target options *TO* record, *DI* record field 3, *SO* record field 9)

- Monthly and/or annual limits may be placed on the amount of water a right may withdraw from reservoir storage. (*SO* fields 7-8)

- Several water districts, cities, and other water supply entities may each control certain portions of the storage capacity of a reservoir. A reservoir evaporation-precipitation allocation routine was developed to facilitate modeling of storage capacity shared by multiple water right holders. This feature was later restructured and expanded. (new *EA/EF* records)

- New hydropower features were added to provide greater modeling flexibility. Power generation may be limited to releases from reservoir storage and by turbine elevation and discharge capacity. A tailwater rating curve may be entered as an option to a constant tailwater elevation. Releases may increase downstream flows either the next month or same month. Computational algorithms were refined. (*WS* fields 9, 12, 13; new *TQ/TE* records)

- A natural priority option was added that overrides the water rights priorities with rights being considered in upstream to downstream order. (*JD* record field 11 and later *JO* record 8)

- Negative incremental flow option 5 previously developed by HDR, Inc. for *WRAP* applications in specific river basins was added to the generic model. (*JD* record field 8)

HYD Modifications (August 1999 – July 2001)

- A new optional columnar table format was added to facilitate transfer of streamflows and evaporation-precipitation depths to and from spreadsheet programs such as *Microsoft Excel*. (restructured *JC* record)

- Tables displaying intermediate computational results were added for reservoir adjustments, incremental watershed parameters, and negative incremental flows. (*JC* and *RS* records)

- Regression equations were added to facilitate adjusting streamflows by combining the results of a precipitation-runoff model with *HYD*. (new *EQ* record)

- Tables displaying intermediate computational results were added for reservoir adjustments, incremental watershed parameters, and negative incremental flows.

TABLES Modifications (August 1999 – July 2001)

- A new option allows tables of naturalized flows, regulated flows, unappropriated flows, streamflow depletions, diversions, diversion shortages, instream flow shortages, channel losses, and/or reservoir storage to be developed in a columnar format. This facilitates data manipulation and plotting in spreadsheet or graphics software such as *Microsoft Excel*. (*2NAT*, *2REG*, *2UNA*, *2DEP*, *2DIV*, *2SHT*, *2IFS*, *2CLO*, *2CLC*, *2STO* records)

- A new *2DIV* record was added to develop tables for diversions in the same optional formats as the other variables noted above. (new *2DIV* record)

- A new option allows the computation of period reliabilities to either include or exclude months with zero demand. (*2REL* record)

- The format of the reliability table was changed to replace the shortage summary with the corresponding percentage-of-time demand targets are met. Messages are also printed in the reliability table whenever demand targets are zero. (*2REL* record)

- Job Type 3 routines were restructured for better clarity and flexibility. A new option allows regulated streamflows to be converted to input records to be read by *SIM* as *TS* record instream flow target series. (*3NAT*, *3REG*, *3UNA*, *3DEP*, *3U+D* records)

- The input format was restructured for the percentage storage and drawdown-duration tables and multiple-reservoir system release tables. (*2PER, 4SWR, 4SGP* records)

- File management changes included allowing the *TABLES* output filename to have a different root than the input filename. More input error checks/messages were added. The format of various output tables was revised.

- Other modifications in *TABLES* were made to deal with improvements in *SIM* including new input records, changes in format of water rights identifiers, and changes in dimension limits.

Modifications Between the July 2001 and January 2003 Versions

Improvements to *SIM*, *TABLES*, and *HYD* made between July 2001 and January 2003 are listed as follows. The user interface program *WinWRAP* was first introduced with the October 2002 release of WRAP.

SIM Modifications (July 2001 – January 2003)

- The *FY* record routine for computing a yield-reliability and firm yield table was added.

- The *WR* record field 6 type 7 right and *SO* record *RETURN* options were added to allow prioritization of return flows. The type 7 right was later changed to type 4.

- The *WR/SO* record backup right routine was modified to ignore intervening *IF* record rights.

- An annual limit on diversions was added to the *SO* record.

- The *SO* record monthly and annual diversions limits were extended to include type 3 rights.

- The *TO* record lower and upper limits on targets were restructured.

- The multiplier factor and parameter limit *XL* record and associated options were added primarily to provide improved flexibility for conversion factors.

- An *XL* record option was added for placing upper and lower bounds on the CN and MP used in applying the curve number method to distribute flows from gaged to ungaged sites.

- The system (*SO* field 9) for selecting targets and shortages to output was improved.

- Flexibility was added to sequencing of backup right. This feature was later restructured.

- The flow input filename (root.INF) extension INF was changed to FLO because Windows uses the extension INF for a designated type of file. Several new error messages were added.

- Read statements were modified to automatically remove trailing blanks so that alphanumeric identifiers do not have to be right justified.

- Programs were restructured to initialize variables without Fortran data statements, which were removed, greatly reducing storage size.

<u>*TABLES Modifications*</u> *(July 2001 – January 2003)*

- The diversion and instream flow target tables (2TAR and 2IFT records) were added.

- A routine was added for performing a frequency analysis for the total monthly storage in any selected group of reservoirs, with the output provided at the bottom of a 2FRE record table for reservoir storage.

- The supplemental 2RET table was added to the 2REL table for use particularly when target building options complicate the interpretation of reliabilities. Later in the August 2006 version, this feature was integrated into the 2REL record, with the 2RET record deleted.

- The UNIT record was added for specifying units in table headings.

- A water right group summary was added to the 1SUM record table.

- Modifications were made to the 1SUM and 1SRT tables to reflect revisions to *SIM*.

- Read statements were modified to automatically remove trailing blanks so that alphanumeric identifiers do not have to be right justified.

- Several new error checks were added. A few headings were refined. Several dimension limits were increased. The program no longer reads past the ENDF record.

<u>*HYD Modifications*</u> *(July 2001 – January 2003)*

- The multiplier factor and parameter limit *XL* record and associated options were added.

- The monthly factor *MF* record was added.

Modifications Between the January 2003 and August 2003 Versions

The August 2003 *SIM*, *TABLES*, *HYD*, and *WinWRAP* are documented by the August 2003 first edition of the TR−255 *Reference Manual* and TR−256 *Users Manual*. Features in the August 2003 WRAP that were added or revised after the January 2003 version are noted as follows.

<u>*SIM Modifications*</u> *(January 2003 – August 2003)*

- Major restructuring of the code included adoption of dynamic dimensioning. The size of the datasets are no longer limited, and memory requirements are set dynamically by the actual size of the data sets. Array types are declared and the dimension shapes set at the beginning of the program or subroutines, with array sizes being allocated later after an initial pass reading the input file to count the number of various types of records. The dimension limit *DL* record was also created but was later removed.

- Other major restructuring of the code included revising several key arrays and creating new arrays. Data handling for multiple-reservoir system and hydropower rights was reorganized. All scratch files and data statements and most common blocks were removed. New error and warning messages were added.

- The *WR* record type 7 right feature was expanded to include use with *RF* records and to output inflows as negative diversions. Right type 7 was later revised and replaced as type 4.

- Errors were corrected that caused the *IFMETH* = 2 option on the *IF* record to result in second pass computations that were essentially a repeat of first pass computations. With the errors, the *IFFLAG* = 2 option results were basically the same as with the default option 1.

- Additional optional features were added to the instream flow computation options selected on the *IF* record. New options include those activated by *IFMETH* = –2 or –4 and the new *IFFLAG2* on the *IF* record and the new *PASS2* on *JD* record field 14 that was later moved to *JO* record field 10.

- The multiple-reservoir system operation rules were expanded to include new factors entered as input in *OR* record fields 7 and 8. The monthly release limit in *OR* record field 9 was also added.

- The new input parameters *LM(wr,1)* and *LM(wr,2)* entered in *SO* record fields 11 and 12 allow seasonal limits to be placed on streamflow depletions, diversions, and withdrawals from reservoir storage. An option was also added allowing seasonal or annual limits on regulated flows to be placed on instream flow requirements.

- The new input parameter *NOTFLAG* in *SO* record field 13 activates new options to flag a water right such that (1) channel losses are not applied to its return flows or (2) the right is not constrained by instream flow requirements.

- The new *FY* record entry *MFY* activates a new option for distributing yield between water rights based on priorities along with the old alternative method based on fixed proportions.

- The set of beginning-ending storage (BES) options activated by *JD* record field 15 (later moved to *JO* record field 5) was added. The addition was motivated by allowing storage content of all reservoirs at the beginning of the simulation to be conveniently set equal to the storage content at the end of the simulation but may be applied in other ways as well.

- The variables included in the simulation results OUT file are listed in tables in the *Reference* and *Users Manuals*. Return flows were added to the water right output record. Reservoir releases at a control point from upstream reservoirs released to meet requirements further downstream were added to the control point output record.

TABLES Modifications (January 2003 – August 2003)

- The new *1CPT* record activates a set of options for developing listings of control point information in upstream-to-downstream sequencing.

- The new *2RFR*, *2RRE*, *2EVA*, *2RET*, *2ASF*, *2ROR*, *2HPS*, *2HPE*, *2RID*, *2RIR*, *2RAH*, and *2RNA* records along with previously available records result in a standard set of tables for all data included in the *SIM* simulation results output file. These time series records were again expanded in the later August 2006 version.

WinWRAP Modifications (January 2003 – August 2003)

- The new tables added to *TABLES* were also added to the *WinWRAP* feature for building *TABLES* input files. The instructions menu was refined and expanded. Refinements were made to the menus and features for specifying file names.

Modifications Between the August 2003 and May 2004 Versions

The first and second editions of the TR-255/TR-256 *Reference/Users Manuals* are dated August 2003 and April 2005, respectively. Modifications to *SIM* and *TABLES* between their August 2003 and May 2004 versions are listed below. Modifications during May 2004 through April 2005 are covered in the next section.

- Dynamic dimensioning was expanded to include all major array dimensions in *SIM*. The dimension limit *DL* record was removed. The methodologies for dimensioning arrays and transmitting data between modules in *TABLES* were likewise revised.

- A number of new error and warning messages were added to *SIM*.

- The *SIM* dual simulation options activated by *SO* record field 14 were added.

- The streamflow depletion limit option was added to the *TS* record.

- ADD, SUB, and DIV options were added to *TO* record field 4.

- The NOTFLAG options in *SO* record field 13 were expanded.

- Adjusted evaporation depth was added to the *SIM* output file and *TABLES* tables.

- The number of digits to right of decimal point was revised for several variables in the *SIM* output file and *TABLES* tables.

- The limit options activated by *TABLES 1CPT* record fields 4 and 5 were revised.

- The options activated by *UNIT* record fields 4 and 5 were added.

- Additional corrections were made related to the *SIM* second pass instream flow options.

- An error that precluded use of *SIM TO* record field 2 target options 11 and 12 was corrected.

- An error related to *SIM* beginning-ending storage option 4 was corrected.

- New *JD* record beginning-simulation-storage table was later replaced *JO* record BRS table.

- *SIM* options associated with the target series repeat *TSR* record were added.

- Problems were addressed related to *SIM* and *TABLES* precision in defining shortages in computing reliabilities.

- Precision for recording net evaporation depths was increased.

- Warning messages were added citing any simulation results amount that exceeds format limits for *SIM* output file.

Modifications Between the May 2004 and April 2005 Versions

The following significant modifications are also reflected in the April 2005 second edition of the TR−255/TR−256 *Reference and Users Manuals*. An array of other minor improvements to better organize the *SIM* and *TABLES* Fortran code, error/warning checks, monitor messages, and message file messages are not listed.

SIM Modifications *(May 2004 – April 2005)*

- The file options record is obsolete in the April 2005 and later versions of *SIM*. *SIM* performs an initial pass through the DAT file to obtain record counts allowing the setting of dimension limits and determination of files to be opened. The HRR and BES file parameters from the old *FO* record are also now included on the new *JO* record.

- Additional warning messages were added. *JD* record ICHECK option 9 was added allowing many of the warning checks to be deactivated.

- Additional *JD* record field 4 options were added providing greater flexibility in selection of water rights to be included in the simulation results output file.

- The new job options *JO* record was added for new features and some old *JD* record features.

- New options activated by *JO* record field 2 allow greater flexibility in sequencing of *IN* and *EV* records. In prior versions of *SIM*, the *IN* and *EV* records for all control points were read for a given year, and the simulation was performed for that year. The *IN* and *EV* records had to be grouped by year in the input files. New options allow the *IN* and *EV* records to be grouped by control point. All records for the entire simulation are read at the beginning of the simulation.

- The beginning reservoir storage (BRS) file activated by *JO* field 6 was added. The *BRS* file addition was motivated by the need to have beginning-of-simulation storage volumes as input for *SALT*. However, the new *SIM* BRS table may be useful for other purposes as well.

- The input data format has been restructured for the feature for setting water right priorities based on type of use. The use priority *UP* record was added and *UC* record revised with priority input moved from the *UC* to the new *UP* record.

- The *UC*, *RF*, and *CI* records were revised to allow either 12 or 6 entries per record formats. Flexibility is added for format of the input data, but simulation computations are not affected.

- The transient water right feature was added along with a new dual simulation options and transient water right options *DT* record. The transient right option represents significant new simulation computation capabilities. The *DT* record is deleted in the August 2006 *SIM* with features moved to a new *PX* record with new features in addition to old *DT* record options.

- Reservoir storage and hydroelectric power input data were restructured with addition of the new hydroelectric power *HP* record and revisions to the *WS* record. Defaults are set internally by the program such that the *HP* record is not required if all defaults are adopted.

- A new parameter in *HP* record field 6 sets a maximum limit on secondary hydroelectric energy production.

- Defaults are set internally for all variables on the operating rules *OR* record. *OR* records are no longer required if all the defaults are adopted.

- The *SD* record defining an old type 4 water right and all related computational routines were removed from *SIM*. The *SD* record type 4 water right record dates back to *WRAP3* in the early 1990's. However, the *SD* record option was superseded by the drought index *DI* record option in 1999 and has never been used in actual WAM System applications.

- In defining water right types in *WR* record field 6, the type 7 stream inflow right added in the January 2003 version was renamed in the April 2005 version as a type 4 water right.

- An error was corrected related to use of *TO* record field 2 target options 6 and 7 in combination with the second-pass instream flow option. In setting the target, the previously accumulated streamflow depletion at the beginning of the second pass was erroneously assumed to be zero in previous versions of *SIM*.

- A problem was corrected related to the second pass when the iterative *FY* record firm yield computations were applied in combination with the second-pass instream flow option.

- A problem was corrected that prevented use of a flow adjustment FAD file. The problem had been introduced by previous revisions related to new array size allocation and deallocation features in the Fortran code.

- The maximum length of filenames was increased from 30 to 50 characters.

- Conditional reliability modeling options activated by the *CR* record were first introduced in the April 2005 *SIM* and are further refined in the August 2006 *SIM*.

TABLES Modifications (May 2004 – April 2005)

- Beginning with the April 2005 *TABLES*, the time series records include an option for creating Hydrologic Engineering Center Data Storage System (HEC-DSS) files.

- *TABLES* now writes a message file with filename extension TMS. The error and warning messages are restructured and expanded.

- The new parameter *MONTH* added to the 2REL, 2FRE, 2FRQ, and 2RES records allow reliability and frequency tables to be developed for a specified month of the year.

- The old 2PER record was replaced with the new 2RES record which activates a new reservoir reliability table as well as the old percent storage and storage drawdown tables.

- A new 3EPD record was added for adjusted net evaporation-precipitation depths.

- Comment records may now begin with **** or ** as well as COMM.

- The format of the cover page created with the PAGE record was revised.

- The new 1LEN record revises a DAT file with all records limited to 128 characters. This removes comments to facilitate printing.

- The 1REC record routines were updated to reflect new *SIM* input record types.

- The new TEST record activates a series of error checks of the *SIM* output file for use in rare cases in which *TABLES* can not read a *SIM* output file for some unknown reason.

WinWRAP Modifications (May 2004 – April 2005)

- Addition of the *WRAP Files* menu allows activation of an editor such as WordPad by browsing and clicking the filename of the data file.

- A feature was added allowing activation of *HEC-DSSVue* directly from *WinWRAP*.

Modifications Between the April 2005 and September 2006 Versions

The TCEQ is sponsoring continuing improvements and additions to WRAP during 2005−2008. *SIMD*, *DAY*, *SALT* and associated *TABLES* features described in the September 2006 First Edition of *Supplemental Manual* are introduced in the September 2006 WRAP. The Display software tool developed for use with ArcGIS to display WRAP simulation results is also described in the September 2006 *Supplemental Manual*.

The September 2006 *WinWRAP*, *SIM*, *SIM*-related features of *TABLES*, and *HYD* are documented by:

Reference Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR−255, Third Edition, September 2006.

Users Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR−256, Third Edition, September 2006.

The September 2006 Third Edition of the *Reference* and *Users Manuals* reflects thorough editing to improve clarity and detail in documenting old modeling capabilities as well as to incorporate the new features addressed below. Modifications to *SIM*, *SIM*-related *TABLES* features, and *WinWRAP* since completion of the April 2005 version of the software and accompanying April 2005 Second Edition of the *Reference* and *Users Manuals* are noted as follows.

WinWRAP Modifications (April 2005 – September 2006)

- *SIMD*, *SALT*, and *DAY* activation buttons were added. A new monitor message was added.

- The TIN file editor was updated to reflect the revisions to *TABLES* input records. The *HEC-DSSVue* activation menu was updated to access the August 2005 version of *HEC-DSSVue*.

- A problem was corrected which caused *WinWRAP* to occasionally hang-up when extremely large datasets were run on older relatively slow computers.

Modifications Common to Multiple Programs (April 2005 – September 2006)

- A feature has been incorporated in *SIM*, *TABLES*, *HYD*, *SIMD*, and *SALT* to facilitate their execution independently of *WinWRAP*. *WinWRAP* should still be routinely used, but model-users may occasionally prefer to save a mouse click by activating a program directly. Without the new feature, the programs exit upon completion of execution, losing the messages written to the monitor. Now the programs are not exited until the user presses enter or any other key, thus allowing messages on the monitor to be read before exiting.

- All error checks resulting in error messages and program termination now call a common subroutine that prints a new common message to the monitor as well as the error-specific message printed in the message file and then stops the program. This feature is incorporated in all of the programs. Error and warning checks and messages have also been revised for consistency in all programs. A number of new checks have been added along with the restructuring of the overall system for checking input data as it is read and other checks.

The following new input records have been added to _SIM_.

BU Record ⁻ Backup Right
FS Record ⁻ Flow Switch for Adjusting Targets
PX Record ⁻ Priority Sequence Circumvention Options
AX Record ⁻ Monthly Streamflow Availability Multiplier Factors
AF Record ⁻ Streamflow Availability Allocation Factors

The _DT_ record is deleted, and its features are incorporated in the new _PX_ record along with other new capabilities. _SIM_ writes an error message and terminates if a _DT_ record is read.

Most of the modifications reflected in the September 2006 _SIM_ are new additions. Additional input may be required to activate new capabilities, but old datasets generally still run fine with the April 2005 and September 2006 versions providing essentially identical results. However, the following modifications may affect simulation results from existing input datasets.

1. As explained later, the restructuring of the _EA_ record evaporation allocation routine included both error corrections and changing certain aspects of the general modeling strategy and input parameters. Simulation results will change in most situations.

2. The _TO_ record field 2 revision described below could affect simulation results unless the appropriate option is selected. Selection of a different option may be required.

3. Corrections to _UP_ and _TSR_ record options corrected problems that previously caused termination of model execution.

4. As noted above, the _DT_ record has been deleted, with its features incorporated in the new expanded _PX_ record.

The September 2006 _SIM_ also includes various Fortran code refinements to better organize the program that are not necessarily associated with an individual new or revised modeling feature. Some of the code refinements were made to prevent potential problems that could materialize in certain uncommon situations but may or may not have actually occurred in the past.

Significant modifications to _SIM_ between the April 2005 and September 2006 versions include the following revisions and additions.

• Conditional reliability modeling options activated by the _CR_ record were first introduced in the April 2005 _SIM_ and are further refined in the September 2006 _SIM_.

• An error message is activated if a _SIMD_ input record is read that is not relevant to _SIM_.

Evaporation Allocation Features for Multiple-Owner Reservoirs

• The _SIM_ evaporation allocation routines activated by _EA_ and _EF_ records were restructured, corrected, and expanded. Simulation results from the September 2006 _SIM_ may be different

in many cases than the April 2005 and earlier versions. The code was rewritten to be easier to follow. Errors were corrected. New features were added. Revisions are as follows.

1. NEAF option *4* in *EA* record field 3 and EAO options 3 and 4 in *EF* record field 2 have been added.

2. Errors in the code related to use of beginning-of-month versus latest end-of-month storage in various situations were corrected.

3. The feature was corrected in which allocation method 3 automatically switches the computations to the method 2 algorithm if one or more reservoirs are empty.

4. The following change was made to assure that the total sum of evaporation in all component reservoirs is precisely correct for the actual reservoir they represent. In previous versions of *SIM*, the evaporation allocated to the component reservoirs did not precisely sum to the correct total. The evaporation computations are necessarily approximate since the end-of-month storage is the latest value computed in the water rights priority loop. NEAF options 2 and 3 are based on factors computed from beginning-of-period storage and the *EF* record, respectively. In previous versions of *SIM*, the factors were applied to all component reservoirs. In the September 2006 version, the factors are applied to all but the last component reservoir. The evaporation allocated to the last reservoir is the actual total evaporation minus the evaporation allocated to the other reservoirs. This ensures that the total evaporation is correct each month even if the allocation is not exactly in proportion to the factors.

5. With addition of NEAF option 4, the factors on the *EF* record are now applied directly. Previously, each factor was divided by the total to obtain fractions summing to 1.0.

6. The streamflow availability allocation feature activated by the new *AF* record was added for use with the *EA* record. The similar new *AX* record is connected to the *PX* record discussed on the next page.

Expanded Backup Right BU Record Feature

- An expanded backup right feature is activated by the new *BU* record. Previously, the backup right activated by *SO* record field 6 could be applied only to diversion targets. The expanded backup right may be applied to diversion, instream flow, or hydropower targets. Previously, the backup was applied to the preceding *WR* record in the DAT file. The new *BU* record field 4 allows specification of any other water right, with the default (blank field 4) being the preceding *WR* record. The new *BU* record field 5 allows specification of a water right group identifier. The summation of shortages for all rights with that group identifier is added to the diversion, instream flow, or hydropower target of the backup right. The backup rights can also still be stacked allowing backup rights to backup other backup rights. Though superseded by the *BU* record, the old *SO* record field 6 option still works.

Expanded Target Setting Capabilities

- A flow switch feature used in setting targets has been added, which is activated by the new *FS* record. Instream flow, diversion, and hydropower targets can be switched on/off or

otherwise adjusted depending on whether accumulated regulated flow, naturalized flow, unappropriated flow, streamflow depletions, diversions, or control point inflows in the current and/or any number of preceding periods at a specified control point fall within a specified range. A primary motivation for this new feature is flexibility in modeling instream flow requirements that are expressed as a function of whether current and/or accumulated past flows fall within a specified range. Other applications are likely as well.

- A revision related to *TOTARGET* entered in *TO* record field 2 may affect simulation results for existing datasets that base targets on other junior rights. The revisions have no effect on targets based on other senior rights. Options 7, 8, 9, 11, and 12 activated by *TO* record field 2 allow targets to be adjusted as a function of streamflow depletions, reservoir withdrawals, or diversions. Options −7, −9, and −12 have been added to *TO* record field 2 primarily to deal with problems related to setting targets based on junior rights with or without second pass options in effect. Monthly depletions, withdrawals, or diversions are now the latest computed in the priority sequence which will be same-month for senior rights, preceding-month for junior rights, and preceding-pass for second pass simulations. The new −7, −9, and −12 options allow the user to decide whether or not the current month is included in the annual accumulation.

- A problem with using multiple sequential *TO* records to set a target was corrected.

- The new water right type 7 added to *WR* record field 6 allows target setting options to be applied to set reservoir storage targets in the same manner as a diversion target. Additional flexibility is provided for modeling reservoir operating rules.

- Entering a 4 in *WR* record field 6 now selects a type 4 right which is an inflow to the stream. The old type 7 inflow right has been reassigned as type 4. In the past, type 4 was associated with the now obsolete *SD* record.

- The new *XMONTH* option added to *WR* record field 4 allows the target entered in *WR* field 3 to be a monthly rather than an annual amount.

Priority Circumvention Features

- The new priority sequence circumvention options *PX* record and accompanying streamflow availability factors *AX* record replace the *DT* record and add two new modeling features. The *DT* record is deleted with its two features being incorporated by the *PX* record along with addition of the following two other new features.

  1. The *PX* record downstream control point water availability limit feature is designed for modeling subordination agreements but may be applied for other purposes as well.

  2. The *PX/AX* record streamflow availability allocation options provide a scheme for the model-user to define rules for allocating available streamflow between two or more rights that share the same priority. An alternative to the priority system is provided. The new *AF* record serves the same purpose but is connected to the *EA* record for use specifically in modeling multiple-owner reservoirs where the owners share the same priority.

- An error was corrected in the *DT* record transient priority option computations introduced in the April 2005 version of *SIM*. The *DT* record was subsequently deleted with the transient priority options being transferred to the new *PX* record.

New Variables

- A new feature allows reservoir water surface elevations to be computed. The water surface elevations are automatically written to *SIM* reservoir/hydropower output records for all reservoirs that have *PE/PV* input records and are tabulated by a *TABLES* 2WSE record. If a reservoir is selected for output on the *RO* record, the water surface elevation will automatically be included in the output if the reservoir has a storage-elevation table defined by *PE/PV* records.

- A new variable called control point inflows was created. Control point inflow was added as one of the six options that may be selected in *FS* record field 2. A new option activated by *TO* record fields 5 and 6 allows control point inflows to be used as upper limits on targets. Control point inflows are tabulated by the new *TABLES* 2CPI record.

- Net evaporation-precipitation depths reflecting adjustments controlled by *JD* record field 10 and CP record fields 8 and 9 were previously included in the simulation results recorded on reservoir output records. Net evaporation-precipitation depths from *EV* records prior to adjustments have been added to the output.

- The new priority sequence circumvention options *PX* input record activates an option which results in a new variable called "*increase in available flow*" being written to the OUT file.

Other SIM Modifications

- In previous versions of *SIM*, the drought index was always based on beginning-of-month storage. Options activated by *JO* record field 8 were added to base the drought index on either beginning-of-month storage, end-of-month storage, or an average of the two.

- An option has been added allowing a maximum reservoir release rate to be set on the monthly storage limit *MS* record.

- A parameter added in the new field 10 of the *JO* record allows the user to increase the maximum limit on the number of entries in *SV/SA*, *PV/PE*, and *TQ/TE* record tables to any number. Previously, the tables were limited to a maximum of 12 pairs of values.

- Linear interpolation is applied to the *SV/SA*, *PV/PE*, and *TQ/TE* record tables. In previous versions of *SIM*, an error message was printed and the program terminated if a storage volume exceeded the range covered by the input tables. The error routine has been replaced with a warning message with the program execution not being terminated.

- A blunder had been introduced into an earlier version of *SIM* that prevented the optional HRR file from being created. The error in the code has been corrected.

- A problem was corrected that had prevented use of the *USEADD* option in *UP* record field 4.

- A problem was corrected that had prevented use of other than defaults on the *TRS* record.

- The *SIM* output OUT file record length has been lengthened from 100 to 136 characters to allow an 11-character field width with more digits to the right of the decimal. All read format statements in *TABLES* have been revised for the new OUT file format. This allows greater precision in transferring simulation results from *SIM* to *TABLES*. The potential for other problems with extremely large or extremely small numbers is also reduced.

TABLES Modifications (April 2005 – September 2006)

Since the *SIM* output OUT file and associated *TABLES* read format statements have been changed, the September 2006 version of *TABLES* reads a *SIM* OUT file only if it is created with the September 2006 version of *SIM*. Most of the type 2 *TABLES* input records have been changed and, depending on options selected, old versions of the input records likely will not work with the new *TABLES*. The 2CPI, 2XAV, 2EVR, 2WSE, 2BUD, and IDEN records are new. The old 2RET record has been deleted.

A number of new subroutines have been added to *TABLES* to support the expanded modeling capabilities associated with *SIM* and *SIMD* conditional reliability modeling results, *SIMD* sub-monthly time step and flood control simulation results, and *SALT* salinity simulation results. These routines are covered in the *Supplemental Manual* but are not addressed here.

Modifications reflected in the September 2006 *TABLES* of features covered in the basic *Reference* and *Users Manuals* made since the April 2005 version are listed as follows.

General Revisions throughout TABLES

- The *SIM* output OUT file was revised to express *SIM* simulation results with greater precision. All *TABLES* format statements for reading data from the *SIM* OUT file were revised accordingly. The increased precision may affect the results slightly.

- A refined scheme for consistently organizing error and warning checks and messages in all of the WRAP programs has been adopted that included adding a message file to *TABLES*. New error and warning checks and messages in *TABLES* have been added and old data checking routines have been refined.

- The new IDEN record associated with the time series, reliability, and frequency tables was added in conjunction with a refined system for specifying identifiers for control points, water rights, reservoirs, and water right groups that may be used in common by multiple records.

- The *TABLES* Fortran code has been revised in several other respects to improve its organization and facilitate continued additions.

New Features Added to the Time Series Tables

- New features of the *TABLES* time series records include the new parameter *DECIMAL* in field 7 which allows the model-user to set the number of digits to the right of the decimal.

- Moving average, moving total, and multiplier/addition factor features have been added to the time series tables and the 2FRE frequency table. These arithmetic operations allow the *SIM* simulation results variables to be either adjusted or transformed to other related variables.

- The 2CPI (control point inflow), 2EVR (unadjusted evaporation-precipitation depth), 2XAV (increase in available flow due to *PX* record option), and 2WSE (reservoir water surface elevation) time series records are new. These are new variables added to the *SIM* simulation results.

New Features Added to the Frequency Tables

- Moving average, moving total, and multiplier/addition factor features have been added to the 2FRE frequency tables as well as to the time series tables.

- Options have been added to the 2FRE record to assign frequencies based on the normal and log-normal probability distributions. Previously, only the relative frequency option was provided for assigning frequencies.

- The 2FRE and 2FRQ frequency record variable options have been expanded to include reservoir water surface elevation (option 6) and storage (option 7). Instream flow shortage is now option 8.

New Water Budget Tables

- A major new computational routine is activated by the new 2BUD record. Detailed monthly water budgets are developed for individual control points. A period-of-analysis budget is developed for the entire river basin. The 2BUD routine provides a complete tabulation of all inflows and outflows previously unavailable that may be useful for various purposes.

Other TABLES Modifications

- An error associated with KK options 5 and 6 activated by 1CPT record field 2 was corrected.

- The columns of the 2SBA record table have been rearranged slightly.

- The 2REL reliability as well as the 2FRE frequency and time series records have been restructured using the new IDEN record. This allowed the 2RET record to be deleted with the supplemental reliability table now being specified directly on the 2REL record.

- As previously noted, the major new *TABLES* features associated with conditional reliability modeling, daily time step simulation results, flood control, and salinity are described in Appendix E of the *Supplemental Manual* but are not further addressed here.

<u>**Modifications Between the September 2006 and May 2007 Versions**</u>

The May 2007 version of *WinWRAP*, *SIM*, *HYD*, and *SIM*-related features of *TABLES* are documented by:

Reference Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR−255, Revised Third Edition, May 2007.

Users Manual for the Water Rights Analysis Package (WRAP) Modeling System, TWRI TR−256, Revised Third Edition, May 2007.

Modifications to *SIM*, *SIM*-related *TABLES* features, and *WinWRAP* since completion of the September 2006 version of the software and accompanying September 2006 Third Edition of the *Reference* and *Users Manuals* are noted as follows. Most of the modifications described here are to *SIM*. They were developed in conjunction with intermediate December 2006, February 2007, and March 2007 versions as well as with the May 2007 *SIM*. The program *HYD* has not been revised since 2002. Modifications to the programs documented in the *Supplemental Manual* are not addressed here. *SIMD* has also been updated with the *SIM* revisions. Other modifications to *SIMD* and *SALT* are not included in the following descriptions of modifications.

<u>***WinWRAP Modifications***</u> *(September 2006 – May 2007)*

The *WRAP Files* menu of *WinWRAP* was revised to reflect the addition of the new *SIM* SOU and DSS output files and the change in the *TABLES* output filename extension from the fixed TAB to a user-specified extension with a default of TOU. The *All Files* and *DSS Files* menu selections were added and other menu items were revised.

<u>***TABLES Modifications***</u> *(September 2006 − May 2007)*

- The user now has the option of specifying any filename extension for the main *TABLES* output file, with TOU being the default. The *TABLES* output file is the only WRAP file for which the user can assign a filename extension along with entering the filename root. TOU is used for the default filename extension rather than the previous standard extension TAB because Microsoft Visual Studio 2005 uses TAB as one of its defined filename extensions.

- The tables of sorted water rights created by the 1SRT record were expanded to include additional information regarding reservoirs, and an option was added allowing inclusion of instream flow rights. The format of the 1SUM record summary tables was also reorganized slightly. The KK=4 listings by water right group is now applicable to 1SRT as well as 1SUM tables.

<u>***Minor Improvements Common to SIM and TABLES***</u> *(September 2006 − May 2007)*

- A feature was added to write the date and time in the *SIM* and *TABLES* message files.

- A carriage control feature for the direct access OUT file was added that is transparent to the model-user but simplifies the compilation of *SIM* and *TABLES* a little.

SIM Modifications *(September 2006 − May 2007)*

Modifications Made in Conjunction with Updating to the New Intel Compiler

A compiler converts a Fortran program, with a filename extension FOR or variation thereof, to an executable program with filename extension EXE, static library with filename extension LIB, or dynamic library with extension DLL, and also links the program with library routines. Compilers are typically applied within an Integrated Development Environment (IDE) which provides editing, file management, and other utility functions. Many different Fortran compiler/IDE packages are sold by various companies. The compiler, linker, and development environment used with WRAP over the past ten years is a popular Fortran software development package that has evolved through various versions as ownership passed from Microsoft to Digital to Compaq to Intel as follows.

- Digital Visual Fortran combined with a version of the Microsoft Visual Studio IDE replaced Microsoft Power Station in the early 1990's.

- Compaq Visual Fortran replaced Digital Visual Fortran in the late 1990's. The software package was similar under ownership of the two different companies and continued to combine the compiler/linker with its own version of the Microsoft IDE.

- Intel acquired Compaq Visual Fortran in the early 2000's. Intel marketed its Intel version of the 2000 Compaq Visual Fortran Version 6.5 which still continued to be combined with the Microsoft Visual Studio IDE.

- The 2006 Intel Visual Fortran 9.1 replaced Compaq Visual Fortran. Intel Visual Fortran 9.1 is used with the Microsoft Visual Studio 2005 IDE.

As the Fortran compiler/linker software transferred between companies from Microsoft to Digital to Compaq and now to Intel, it continued to be applied within the Microsoft Integrated Development Environment (IDE). The Digital and Compaq software products were sold as integrated packages that included then current versions of the Microsoft IDE along with the compiler and linker software. The Microsoft IDE was significantly expanded in 2002 and subsequently progressed through other versions, with the current version now being Microsoft Visual Studio 2005. The Microsoft Visual Studio 2005 IDE is used to develop programs in Visual Basic, C#, J#, C++, Fortran, and/or other programming languages. Components of a program may be written in different languages. Intel Visual Fortran 9.1 is sold as a separate product that requires and is implemented within the Microsoft Visual Studio 2005 Integrated Development Environment.

Standard versions of the Fortran programming language are officially approved by the American National Standards Institute (ANSI). The most recent versions of Fortran were formally adopted in 2003, 1995, 1990, and 1977. Fortran 2008 is under preparation. Marketing of compiler software implementing the improved versions of the Fortran language typically lag a couple of years behind official ANSI approval of the language standard. Compaq Visual Fortran 6.5 is based on Fortran 95. Intel Visual Fortran 9.1 is updated to Fortran 2003. The WRAP programs are compatible with both the 1995 and 2003 Fortran standards.

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The two versions of the software currently used to develop/modify the Fortran source code and convert it to executable WRAP programs are as follows.

- Compaq Visual Fortran 6.5 and Microsoft IDE with copyright date of 2000. This is the Compaq Visual Fortran Professional Edition V 6.5, Intel Version.

- Intel Visual Fortran 9.1 Professional Edition with copyright date of 2006 with 2007 updates combined with Microsoft Visual Studio 2005 IDE.

SIM was updated for compatibility with the new 2006 Intel complier. Several relatively minor changes to the Fortran code were made initially that were necessary to allow *SIM* to be compiled with the new Intel compiler without crashing. However, versions of *SIM* compiled with the new Intel compiler were found to yield small differences in simulation results for several of the TCEQ WAM System datasets than if *SIM* is compiled with the old Compaq compiler. Simulation results were also affected by whether *SIM* was compiled by the new compiler in debug or release mode (sets of configuration property settings). The variations were found to be caused primarily by problems occurring with the new Intel compiler applied in the release mode. These problems have been corrected in the current *SIM* primarily with Fortran code changes supplemented with choices of compiler configuration property settings.

Many of the problems could have been handled solely with optional compiler settings. However, code changes allow the Fortran program to be compiled with either default or other settings with either the Compaq or Intel compilers, without having to be concerned with compiler settings which can be tricky. The rules of Fortran were followed correctly with or without the modifications. The issues were related to the manner in which the alternative compilers implemented Fortran and defined default configuration property settings. The problems involved several issues ranging from simple to quite complex that were solved with various code revisions. The root causes of the more significant problems were very subtle. The greatest culprit was found to be problems with the new Intel compiler in release mode caused by the effects on conditional if statements of preciseness inconsistencies associated with floating point real number operations within the computer. These problems were corrected with a number of Fortran code revisions along with adoption of the *improve preciseness consistency* setting in the configuration properties which deactivates certain memory and run-time optimizations. The preciseness consistency problems occurred primarily within the iterative reservoir routines discussed below.

Refinements to the Reservoir and Hydropower Routines

Reservoir and hydropower computations are performed in the main program and Subroutines RELEASE, RESCAL, and POWER. The main program organizes the computational procedures based on the water right type specified on the *WR* record. Subroutine RELEASE is called for multiple-reservoir system rights to determine releases following multiple-reservoir operating rules defined by *WS* and *WR* records. Subroutine POWER is called for hydropower computations. The main program and Subroutines RELEASE and POWER call Subroutine RESCAL to perform reservoir calculations. Subroutine RESCAL computes end-of-month storage, net evaporation, and outflow volumes for each water right that has reservoir storage. Interdependencies between end-of-month storage, evaporation, and releases necessitate

an iterative simulation algorithm. The algorithm stops at a maximum of 50 iterations with a warning message if stop criteria are not satisfied.

Subroutine RESCAL performs computations for each reservoir. Multiple-reservoir release decisions are made within Subroutine RELEASE, which calls Subroutine RESCAL one or multiple times as each system water right is considered. Subroutine POWER implements an iterative hydropower algorithm in which the iterative RESCAL reservoir calculations are embedded within an iterative hydropower release algorithm.

These iterative algorithms in subroutines RESCAL, RELEASE, and POWER contain a number of conditional if statements that were revised in conjunction with dealing with the preciseness consistency issues discussed in the preceding section. These routines were also improved in general to make them easier to understand and more robust. The subroutines were reorganized to facilitate reading the code and understanding the computations. Refinements were also made to make the algorithms more robust in efficiently covering every type of situation that could possibly occur during the multitude of iterative computations.

New *SIM* Input and Output Options and Connections to HEC-DSS

TABLES has since 2004 provided options for writing *SIM* simulation results as DSS files to be read by HEC-DSSVue for plotting or other purposes. The *TABLES* time series records allow any of the *SIM* simulation results time series data to be written to a DSS file. However, in previous versions, *SIM* was not directly connected to HEC-DSS. The following new features activated by the new optional output files *OF* record are incorporated in the May 2007 *SIM*.

- Hydrology Input DSS File

  1. A new feature of *SIM* allows naturalized flows and evaporation-precipitation depths from the *IN* and *EV* records of FLO and EVA files to be converted to a DSS file with the filename rootHYD.DSS.

  2. Naturalized flows and evaporation-precipitation depths can be read by *SIM* from a DSS file as option 6 specified in *JO* record field 2 as a new alternative to FLO and EVA files.

- Simulation Results Output DSS and SOU Files

  3. *SIM* simulation results can be written to a DSS file with filename root.DSS to be read with HEC-DSSVue.

  4. *SIM* simulation results can be written to a text file with filename extension SOU in a new columnar format that can be read with any editor or transported to Microsoft Excel.

In addition to DSS input and output files, the new SOU output file provides a columnar table that is much easier for people to read than the OUT file. The DSS and SOU output files controlled by the new *OF* record contain the same simulation results as the OUT file read by *TABLES*. The DSS and SOU file options require much more computer memory than the conventional OUT file because the water right, control point, and reservoir output data are stored in memory as arrays and then written to files at the end of the simulation.

EA Record Evaporation Allocation Routines with Multiple
Rights and Right Types at the Same Component Reservoir

       EA records are used to model situations where multiple entities (owners) share the storage capacity of the same reservoir. The actual real-world reservoir is divided into multiple computational reservoirs. Without the complication of a nonlinear storage-area relationship used in the reservoir evaporation computations, *SIM* could handle this component reservoir modeling strategy with no special features required. The *EA* record feature was added originally solely to allocate net evaporation-precipitation between the component reservoirs representing the multiple owners. The *AF* record feature was added with the September 2006 *SIM* for use in combination with an *EA* record to allocate streamflow inflows between the component reservoirs. The following routines are applied in the water rights simulation sequence when considering a water right located at a *computational component* reservoir listed on an *EA* record.

1. For type 1 and 7 rights (*WR* record field 6), the net evaporation volume is computed based on evaporation allocation methods activated by the *EA* record field 3 options. The evaporation allocation methods are applied only to type 1 and 7 rights.

2. For hydropower rights, the head used in the hydropower computations corresponds to the summation of the storage contained in all the component reservoirs listed on the *EA* record. Likewise, the elevation of the bottom of the power pool refers to total storage capacity summed for all the reservoirs. However, the *EA* record evaporation allocation routines are not applied for hydropower rights. Evaporation is determined by the conventional *SIM* computation routine.

3. The streamflow availability allocation routine activated by the *AF* record is applied to all water rights associated with all reservoirs listed on the *EA* record. Storage and evaporation are not relevant to the *AF* record streamflow availability routine.

       The *EA* record evaporation allocation routines are activated within *SIM* only for type 1 and 7 rights. However, with caution, any number of water rights of any of the types can be applied at *EA* record reservoirs. Applying the *EA* record routines with multiple water rights of various types at the same component reservoir caused problems in the past from the perspectives of both problems in the Fortran code and inconsistencies regarding the requirements for developing input datasets. Previous versions of *SIM* worked correctly with some datasets but not others. The May 2007 code has been refined and corrected, and the *Reference and Users Manuals* have been expanded to better clarify how the *EA* record features can and can not be applied. The rules for combining *EA* records with multiple rights at the same component reservoir are outlined in detail in the May 2007 *Reference and Users Manuals*.

New EA Record NEAF Options

       Variations of the NEAF options 2 and 3 activated by *EA* record field 3 have been added as options 22 and 33. The only difference is that the option 2 and 3 feature described below is not applied with the new options 22 and 33. All component reservoirs listed on the *EA* record are treated the same with options 22 and 33.

The evaporation allocation computations occur in the water rights priority sequence. Thus, end-of-month storage for junior rights has not yet been computed when a particular more senior right is considered and thus must be estimated. The resulting approximations mean that the evaporation volumes allocated to the component reservoirs typically do not sum to the correct total evaporation volume for the actual reservoir. With NEAF options 2 and 3, in order to address this problem, the evaporation allocated to the last reservoir listed on the *EA* record is computed as the difference between the correct total evaporation and the sum of evaporation volumes for all the other reservoirs listed on the *EA* record. This forces the evaporation for the component reservoirs to sum to the correct total. The new options 22 and 33 omit this feature.

Dual Simulation Option Default

A new feature activated by the new *JO* record field 11 sets a default dual simulation option which is applied to all water rights, subject to being over-ridden by *PX* record field 2 or *SO* record field 14.

New Dual Simulation Cumulative Depletion Limit Options

With dual simulation options 3 and 5 (*JO* record field 11, *PX* field 2, *SO* field 14), streamflow depletions each month for a right determined during the first simulation serve as a maximum limit on streamflow depletions during the second simulation. The streamflow depletion for a given month during the second simulation is not allowed to exceed the depletion for that month occurring during the initial simulation. Options 33, 333, 55, and 555 are variations of options 3 and 5 that were added with the May 2007 *SIM* to allow the depletion constraints to be relaxed somewhat by allowing flexibility in the timing of the depletions.

Dual options 33 and 55 are similar to options 3 and 5 except the limits are based on cumulative depletions rather than depletions in each individual month. For any month, for a particular right, the total cumulative depletions since the beginning of the second simulation can not exceed the corresponding cumulative depletions occurring in the initial simulation.

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

PX Record Priority Circumvention Features in
Combination with Negative Incremental Option 5

The downstream control point flow availability limit options are activated by *PX* record fields 4 and 5 previously could be used only in combination with *JD* field 8 negative incremental flow options 1, 2, 3, and 4, not with option 5. The May 2007 *SIM* has been modified to allow the *PX* record options to be used in combination with negative incremental flow option 5.

Improved Computational Efficiency for Negative Incremental Option 4

Negative incremental option 4 (*JD* record field 8) previously required an excessive amount of execution time for datasets with a very large number of control points. The code has been revised to be much more efficient. Option 4 now has negligible effect on run times.

TL Limit Parameter for Number of Values in IS/IP Record Table

By default, a maximum of 12 pairs of values may be entered on *SA/SV*, *PV/PE*, *TQ/TE*, and *IS/IP* records. The TL parameter in *JD* record field 11 allows this maximum limit to be increased to any number above 12. The TL parameter was added with the September 2006 version of *SIM*, but applied only to *SA/SV*, *PV/PE*, and *TQ/TE* record tables. *SIM* has now been revised such that TL is also applicable to the *IS/IP* records. Thus, any number of values may be included in a *IS/IP* record table defining a drought index by raising the maximum limit above the default of 12 using *JD* record field 11.

Drought Index Interpolation Error Check

A drought index is defined by a pair of *IS* and *IP* records. Linear interpolation is applied to the *IS/IP* record table for a given storage to determine the drought index multiplier factor. The linear interpolation routine for the drought index *IS/IP* record table is different than the linear interpolation routine applied to the *SA/SV*, *PV/PE*, and *TQ/TE* record tables discussed in the next section. Whereas values in *SA/SV*, *PV/PE*, and *TQ/TE* record tables must progress sequentially from small to large, such restrictions are not imposed on a drought index. A drought index may exhibit essentially any configuration of linear segments. Extrapolation is not included in the drought index linear interpolation routine. The storage must fall within the range defined by the smallest and largest storage values on the *IS* record. An error check was already in *SIM* that activates an error message if the storage exceeds the highest storage value on the *IS* record. However, there was no error check for the storage following below the lowest value on the *IS* record. The interpolation routine in the May 2007 *SIM* has been revised to include such a check.

Linear Extrapolation Warning Message

Subroutine LINEAR applies linear interpolation to *SA/SV*, *PV/PE*, and *TQ/TE* record tables. Values in *SA/SV*, *PV/PE*, and *TQ/TE* record tables must progress from small to large. If a storage volume computed during the simulation exceeds the highest value in the table being interpolated, the highest value in the table is adopted. If a simulation storage falls below the lowest value in the table, interpolation is applied based on automatically inserting the zero-zero point.

SIM already wrote a warning message any time the highest value in an interpolated table is exceeded. A new warning message was added that is activated if a simulated value falls below the range covered by the interpolated table. *SV* and *PV* records typically begin with zero storage, and *TQ* records typically begin with zero discharge, in which case, the new warning message is never activated. However, if the tables begin with non-zero values and computed storage falls below this lowest value in the table, the warning message is activated.

Obsolete FO and DT Record Messages

The files options *FO* record is obsolete in the April 2005 and later versions of *SIM*. Several files are activated by the *JO* record, and *SIM* automatically determines which other files to activate. A warning message was added in the May 2007 *SIM* which is activated if a *FO* record is read indicating that the record is no longer needed.

The *DT* record is obsolete in the September 2006 and later versions of *SIM*, having been replaced by the *PX* record. An error message was added which is activated if a *DT* record is read.

TO Record TOTARGET Options 7, 9, and 12

Options 7, 9, and 12 activated by *TO* record field 2 adjust targets based on cumulative annual depletions, withdrawals, or diversions. However, the Fortran code never actually activated these annual options unless the water right also had a *SO* record. *SIM* has now been corrected such that *TO* record TOTARGET options 7, 9, and 12 work even if the water right has no *SO* record. None of the TCEQ WAM System datasets actually include these options to date.

SO record fields 4, 8, and 10 activate options based on cumulative annual or seasonal amounts. A season is defined by beginning and ending months entered in *SO* record fields 11 and 12, with defaults of months 1 and 12. *TO* record TOTARGET options 7, 9, and 12 use the year or season defined by the *SO* record. Before the correction, no year or season was defined without an *SO* record. The correction sets defaults of months 1 and 12 which are in effect even without an *SO* record for the water right. However, is a season is defined on a *SO* record, that season also applies to *TO* record TOTARGET options 7, 9, and 12 for that water right.

TO record field 2 TOTARGET options 6, 7, 8, 9, 11, and 12 require that a water right identifier TOWR be entered in *TO* record field 9. If field 9 is blank, an error message is activated. Previously, the error check was performed only with options 6, 7, 8, and 9. The code was revised to perform the TOWR error check with TOTARGET options 11 and 12 as well.

TO and TS Record Subtraction Options

The *TO* record field 4 subtraction option consists of subtracting the amount computed in accordance with *TO* record specifications from the previously computed target amount. The *TS* record field 2 also has a subtraction option. These subtractions may result in a negative value for the target amount. The *SIM* code was revised to set a negative result equal to zero.

MS Record Combined with TO Record Field 2 Option 5

TO record TOTARGET option 5 sets targets based on reservoir draw-down. The *MS* record specifies seasonal rule curve reservoir operations with the storage capacity varying monthly. Previously, *TO* record TOTARGET options 5 and −5 draw-downs were based solely on the storage capacity specified on the *WS* record without consideration of *MS* record monthly maximum storage limits. The code has been revised to include consideration of *MS* record storage limits in computing draw-downs for TOTARGET options 5 and −5.

The September 2006 *SIM* included expanded backup right features associated with the new *BU* record that replaced the old backup feature activated by *SO* record field 6. The intent was for the old *SO* field 6 option to continue to work, though it is superseded by the new *BU* record. However, the old *SO* record feature was not maintained correctly. The BUX multiplier factor entered in *BU* record field 3 should default to 1.0 if the *SO* field 6 is used instead of the *BU* record, but did not. This coding error was corrected in the December 2006 version of SIM.

Summation of Diversion Targets at Control Points

Simulation results include the control point summation of the diversion targets and shortages for all water rights located at each control point. The summations are performed each month at the end of the simulation computations and affect no other simulation results. The control point summary data are used by *TABLES* in developing control point and basin (2SCP and 2SBA) summary tables. Previously, water rights were excluded from the summation if the annual target amount entered in *WR* record field 3 was zero, even if a non-zero target was established during the simulation computations by *TS* or *TO* record options. This has been corrected to include all diversion targets in the control point summaries, even if the target amount in *WR* record field 3 is zero. The parameter ISHT in *SO* record field 9 can be used to select which intermediate diversion target is included in the recorded simulation results.

Modifications between the May 2007 and November 2007 Versions

Modifications to the *SIM* and *TABLES* programs between the May 2007 and November 2007 versions are noted as follows. The modifications are included in a December 2007 draft fourth edition of the *Users and Reference Manuals*. The draft manual updates have been refined throughout as well as updated with the new software features.

Modifications Common to SIM and TABLES *(May 2007 − November 2007)*

Unformatted Output File Option

A new option has been added to *SIM* and *TABLES* to allow *SIM* simulation results to be recorded in the OUT or CRM output file in "unformatted" binary machine language. *SIM* simulation results have always been recorded in the OUT file in a "formatted" text file format which can be read by any editor as well as read by *TABLES*. With the new option, the OUT file can be read only with *TABLES*. The advantages of the new option are a significant reduction in the size of the OUT file and for simulations with large amounts of output a significant reduction in computer execution time. Also, since simulation results are stored on the hard drive in the same form as computed by the processor, there is no loss in precision. The standard formatted text file of the past remains the default with the new option requiring activation by the *JD* field 7 in *SIM* and the new SOUT record in TABLES.

The *JD* record has been modified to allow the new binary machine language output file option to be activated by the new switch OUTFILE in *JD* record field 7. The seldom-used

parameter IDSET previously occupying field 7 is moved to the end of the *JD* record as field 12. The new machine language form of OUT or CRM file is flagged by entering a SOUT record any place in the *TABLES* input TIN file. The SOUT record has no input parameters. An error message is printed if *TABLES* reads an unformatted binary OUT file but has no SOUT record in its TIN file or reads a formatted text OUT file while having a SOUT record in the TIN file.

Miscellaneous Program Updates and Refinements

SIM and *TABLES* are fully compatible with Fortran 95 and Fortran 2003 standards. The Fortran programs compile correctly with either the Compaq Version 6.1 (copyright 2000), Intel Version 9.1 (copyright 2006), or Intel Version 10.0 (June 2007 update) compilers, with minimal required concern with selection of compiler options. The May 2007 *SIM* incorporated revisions making *SIM* fully compatible with the latest versions of the Fortran language and Intel compiler. The September 2007 *TABLES* reflects revisions made during July-September 2007 to update to latest Fortran language standards. Various minor revisions were also made throughout the *TABLES* code to more concisely and systematically organize the Fortran program. Several new error checks were added, and minor refinements to various table formats were also made.

Another minor refinement to both *SIM* and *TABLES* consisted of expanding the standard error routine. *SIM* and *TABLES* both have an array of error checks. Each error check has its own individual message followed by activating a subroutine which writes a standard message and terminates program execution. The standard error message routine has been expanded a little to provide more information when Fortran IOSTAT errors occur.

SIM Modifications *(May 2007 − November 2007)*

New Instream Flow Target Feature

A new feature for defining instream flow requirements is activated by a new parameter entered in *IF* record field 6. The new feature is pertinent only if more than one *IF* record (optionally with their associated *FS*, *TO*, *TS*, *SO*, and *WS* records) set a target for the same control point. As the multiple *IF* records (with auxiliary *FS*, *TO*, *TS*, *SO*, *WS* records) connected to the same control are activated in the water rights priority sequence each month, the new *IF* record field 6 parameter controls the combination of *IF* record minimum instream flow targets. With the default option 1, the current *IF* record target replaces the preceding target set at the control point by a more senior *IF* record right. With option 2, the largest of the new versus preceding target is adopted. With option 3, the *IF* record instream flow target is adopted only if it is smaller than the target already set by the preceding more senior *IF* right.

In past versions of *SIM*, if more than one *IF* record referred to the same control point, the latest target computed in the water rights priority sequence always replaced the preceding target. This is still the default option 1. However, the new added feature now allows each *IF* record target to be compared with the latest preceding target, with adoption of either the largest (option 2) or smallest (option 3) of the two. This new feature allows any number of *IF* record rights with their supporting *FS*, *TO*, *TS*, *SO*, and *WS* record features to be combined at the same control point to model multiple-tiered instream flow requirements.

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New Naturalized Flow and Evaporation-Precipitation Features Accessed on CP Record

A new option 9 has been added for the parameter *INMETHOD(cp)* in control point *CP* record field 6. A new *NEXT* option has been added for the parameter *CPEV(cp)* in *CP* record field 8. These options allow a control point to have no naturalized flows and/or to repeat the evaporation-precipitation rates from the next downstream control point.

CP record field 6 specifies the manner in which naturalized flows are provided for the control point. The new option 9 allows control points to be included in the model with no assigned naturalized flows, which is different from flows of zero. *SIM* simulation computations to determine the amount of streamflow available to a water right consider flows at the control point of the water right and all downstream control points except now the new option 9 control points. Any control point assigned option 9 is skipped (not considered) in determining flow availability for water rights. In simulation computations dealing only with that option 9 control point, the naturalized, regulated, and unappropriated flows are zero, but this has no effect on flow availability for water rights. Flows available to water rights at an option 9 control point are controlled only by flows at other control points.

CP record field 6 specifies the manner in which net evaporation-precipitation rates are assigned to the control point. In past versions of *SIM*, net evaporation-precipitation rates from another control point are repeated by entering a control point identifier. With the new modification, if the term *NEXT* is entered, net evaporation-precipitation rates from the next downstream control point that has net evaporation-precipitation rates are repeated.

New Message with Second IF Pass Count

An optional feature that activates a second pass through the water rights simulation under certain conditions is controlled by parameters entered in instream flow *IF* record field 7 and *JO* record field 10. A new counting feature was added that counts the number of months during which the second pass simulation is performed. The count is written to the message MSS file. The new message provides a quick check of whether or not and the frequency that conditions occurred that activate the second pass through the water rights simulation loop.

Negative Streamflow Depletions with Multiple Rights at Same Reservoir

SIM was modified to better deal with negative streamflow depletions generated by multiple *WR* record water rights at the same reservoir that refill to different storage capacities. Previously, all of the multiple storage refilling rights at the same reservoir could generate negative streamflow depletions. *SIM* has been modified to allow only the most junior storage refilling right at a reservoir to generate negative streamflow depletions. In most cases, the correction has little or no impact on simulation results. It is pertinent only in months in which a reservoir is full to capacity and precipitation on the reservoir water surface exceeds evaporation in an amount that also exceeds diversion demands.

A negative streamflow depletion can occur if a negative net evaporation-precipitation depth from an *EV* record occurs concurrently with a full reservoir. A negative net evaporation-

precipitation depth means simply that the precipitation depth exceeded the evaporation depth during that month. Streamflow is depleted to refill storage and supply net evaporation and diversion requirements. For a negative streamflow depletion to occur in a particular month, a negative net evaporation-precipitation volume must be greater than the reservoir refilling and diversion volume. A negative streamflow depletion increases streamflow below the reservoir.

With multiple water rights with different storage capacities at the same reservoir, total cumulative net evaporation-precipitation volumes are recomputed for each water right in the priority sequence. The net evaporation-precipitation volumes have always been handled correctly, without double-counting. However, the generation of negative streamflow depletions could previously be "double-counted". The basic problem dates back to the initial versions of WRAP, but is further complicated when a multiple-right reservoir is also an *EA* record component reservoir. In the past, multiple rights at the same reservoir were treated the same in regard to generating negative streamflow depletions. *SIM* has been revised to allow only the most junior right at the reservoir to generate negative streamflow depletions.

SO record field 13 provides options to switch-off the application of specified modeling features to a particular water right. The NONSFD option was added that activates a feature that sets all negative streamflow depletions generated by a right to zero. Thus, negative streamflow depletions are switched off and not allowed to increase streamflow. The new NEGSFD option in *SO* record field 13 is applicable only to multiple rights at the same reservoir. It allows each of the rights to generate negative depletions. As discussed above, without the NEGSFD switch activated, *SIM* has been modified to allow only the most junior right to increase streamflow with negative streamflow depletions.

Minor *BU* Record Problem Potentially Terminating Program Execution

The *BU* record allows specification of a water right identifier in field 4 and a water right group identifier in field 5. Leaving either field 4 and 5 blank or neither or both the fields blank should all be fine. However, in some cases the previous version of *SIM* could terminate execution if a group identifier was entered in field 5 while field 4 was left blank. The problem was related to lack of robustness of the program in handling a water right integer identifier of zero. The problem has been corrected.

Error Message Correction

An invalid record identifier or blank record in the DAT input file activates an error message routine. In the previous version of *SIM*, the first part of the error message was written correctly followed by abrupt termination of the program. The error routine has been corrected to write the entire message and then terminate execution in the standard manner.

Evaporation-Precipitation Depth Output Correction

Evaporation-precipitation rates read from *EV* records or a DSS file may be included in the OUT file to be read by a *TABLES* 2EVR record. An error was corrected that allowed *SIM* to write depths to the OUT file for the wrong control points. *SIM* computations are not affected.

TABLES Modifications (May 2007 − November 2007)

Several features described in the May 2007 revised _Users Manual_ were not actually implemented in _TABLES_ until July-November 2007. If users attempt to activate these features associated with the 2FRE record in the May 2007 version of _TABLES_, a message is activated stating that the feature is still under construction. These features have been completed in the November 2007 _TABLES_. The new features are as follows.

- A frequency table option activated by 2FRE record field 5 allows frequency tables to be created in a tabular format with ten more frequencies than the old standard table which is in row format. Data also are printed with more digits to right of the decimal than in the standard table which has limited space.

- Frequency method options activated by 2FRE record field 6 allow use of the normal and log-normal probability distributions.

- Moving average and moving total options are activated by 2FRE record fields 7 and 8. This feature was added to the time series records in the May 2007 version and the 2FRE record routine in the November 2007 version.

- The addition factor AF in field 11 of time series records and field 10 of the 2FRE record is also first implemented in the November 2007 _TABLES_.

All the capabilities described in the draft May 2007 _Users Manual_ are fully operational in the November 2007 _TABLES_. However, the 5CRM, 5CR1, 5CR2, and 5COR records documented in the _Supplemental Manual_ also have not yet been implemented in _TABLES_ and still activate a "_feature under construction_" message.

Various refinements were also made throughout the _TABLES_ program to update to the latest Fortran language features and better organize the code. Several new error checks were added. Table formats were refined.

Modifications between the November 2007 and March 2008 Versions

The March 2008 WRAP includes an expanded and refined Fourth Edition of the _Reference_, _Users_, and _Fundamentals Manuals_ as well as the new software features described below that are incorporated in programs _SIM_, _SIMD, TABLES_, _HYD_, and _WINWRAP_. The modifications described here are limited to those modeling features covered in the _Reference_ and _Users Manuals_, excluding modeling capabilities covered in the _Supplemental Manual_. Thus, additional improvements to _SIMD_ that are not also included in _SIM_ and improvements to _SALT_ are not addressed in this _WRAP Additions and Revisions Report_.

The feature described below for assessing stream flow availability in the water rights priority sequence was added to _SIM_ and _TABLES_ between the November 2007 and March 2008 versions. The other major set of modifications consisted of extensively updating, refining, and expanding program _HYD_. _WinWRAP_ was also updated primarily for consistency with revisions to TABLES. Other minor software improvements are also noted in the following.

The software improvements are documented in the March 2008 Fourth Edition of the *Users and Reference Manuals* along with a general editorial rewrite of the manuals. Documentation of new model features and editorial refinements are reflected throughout all of the chapters of the March 2008 Fourth Edition of the *Reference*, *Users*, and *Fundamentals Manuals*. Chapters 6 and 7 of the *Reference Manual* are new chapters added in the fourth edition. Chapter 5 of the *Users Manual* dealing with program *HYD* has been rewritten and expanded along with significant revisions in Chapter 3 of the *Reference Manual*.

SIM and TABLES Modifications *(November 2007 − March 2008)*

Flow Availability in the Water Rights Priority Sequence

A new *SIM* and *TABLES* feature described in the new Chapter 6 of the *Reference Manual* is designed to facilitate assessments of the effects of each individual water right on regulated and available stream flows at specified control points. The *SIM ZZ* input record and ZZZ output file and *TABLES* 4ZZF and 4ZZZ input records are added to implement the new modeling capability. Regulated flows, available flows, and upstream reservoir releases at specified control points are tabulated by *SIM* in a ZZZ file as each water right is simulated in the priority loop. These three stream flow variables have always been computed and recorded at the completion of the simulation each month. However, the new *SIM* feature tracks the flows at the beginning of the water rights loop and the intermediate flows after each individual water right is simulated in the priority sequence.

The ZZZ file table may be read directly with any editor. The new *TABLES* 4ZZF and 4ZZZ records activate *TABLES* options for reading a ZZZ file and organizing the simulation results in optional time series formats or developing frequency tables. The 4ZZF record builds frequency tables similar to the 2FREQ record. The 4ZZZ record organizes the flows as tables in the TOU file or as DSS file records in a manner similar to the type 2 time series records.

New Water Rights Priority Options

Two new options as well as the one previous option for assigning water right priorities are activated by the parameter NPOPT in *JO* record field 9. Previously, *JO* field 9 activated only the option for automatically assigning priorities in upstream-to-downstream order. This feature remains as option 1. The two new options 2 and 3 assign water right priorities based on the sequence that the water right *WR* and *IF* records (option 2) and control point *CP* records (option 3) are placed in the DAT input file.

New and Revised Warning Messages

SIM has always included error and warning checks associated with reading *IN* and *EV* records from FLO and EVA files. However, this set of checks has been refined and expanded. The primary type of input data error addressed by the revisions was the error of including *IN* or *EV* records in the FLO or EVA file for a control point while the *CP* record indicates that the flows or evaporation rates will be determined by other alternative means, not read from *IN* or *EV* records.

Warning messages associated with reading data from the recently added stream flow allocation *AF* record were also revised.

WinWRAP Update (November 2007 − March 2008)

The last previous update of *WinWRAP* was the May 2007 version. The *TABLES* input *TIN* file editor in *WinWRAP* has been updated to reflect new or revised *TABLES* input records added or revised since May 2007. Other relatively minor refinements are also incorporated in the March 2008 *WinWRAP*. The update included an intermediate version of WinWRAP dated March 2008 that included all revisions except the updating of the TIN file editor. The banner included a message that work was in progress on updating the TIN file editor. A final March 2008 *WinWRAP* includes all modifications.

HYD Modifications (November 2007 − March 2008)

The WRAP program *HYD* is a set of routines designed to facilitate developing the hydrology input data for *SIM*. Improvements described here are the first significant revisions to *HYD* since its original development during 1999-2001. *HYD* has been applied very little to date because the hydrology datasets of naturalized flows (*IN* records) and net evaporation-precipitation depths (*EV* records) incorporated in the Texas WAM System were completed prior to completion of the *HYD* program. The March 2008 WRAP includes a comprehensive update of *HYD*. New modeling features added to *HYD* are described in the rewritten Chapter 5 of the *Users Manual* and expanded Chapter 3 and added Chapter 6 of the *Reference Manual*.

Extensive modifications were made to upgrade the *HYD* Fortran code to a level of refinement comparable to *SIM* and *TABLES*. New features activated by the new *OI* and *AN* records were added. New features associated with old input records were also added. Significant modifications reflected in the new March 2008 *HYD* are as follows.

- The *HYD* file options *FO* and dimension limits *DL* records were removed along with automation of file activation and array dimensioning. File organization was revised. The Fortran code was restructured and refined.

- DSS input and output file capabilities were added.

- Several existing computational features were refined.

- The parameters entered on the job control *JC* record were restructured and expanded.

- New features allow *HYD* to read a *SIM* output OUT file along with other input and use pertinent *SIM* output to adjust a flow dataset following specifications defined by parameters entered on records in the *HYD* input HIN file.

- The new *OI* record converts *SIM* OUT file simulation results to *SIM* or *HYD* input records.

- The new *AN* record applies alternative methods for defining a representative annual set of flows and/or net evaporation-precipitation rates that can be repeated for multiple years.