Development of Tools to Improve the State's Water Availability Models

Completion Report
Prepared for the

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by

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Introduction

This final completion report documents a project sponsored by the Texas Water Development Board and performed at Texas A&M University to add new modeling capabilities to the Water Rights Analysis Package (WRAP) which is the generalized simulation model incorporated in the Texas Water Availability Modeling (WAM) System. An initial version of this report dated January 2008 as been revised to reflect review comments and other modifications reflected in the March 2008 version of the WRAP software and documentation.

The initial January 2008 draft of this report was submitted to the TWDB by letter to Dr. Yang from Dr. Wurbs dated January 9, 2008. The contractor (Wurbs) participated in a meeting with TWDB staff in the TWDB offices in Austin on January 14 to discuss the project. Review comments regarding the report were provided to the contractor by letter of March 11 from the TWDB Deputy Executive Administrator. Improvements to the WRAP model made in response to the review comments have been discussed with TWDB staff and are described as follows.

Review Comment: The program does not read entire evaporation dataset and leaves out the last record.

Response: The problem was found to be an incorrect data entry in a particular input dataset. Additional error checks and warning messages were added to the WRAP-SIM program to alert model-users whenever this type of input data problem occurs.

Review Comment: It is not clear which flows the users should use when the dual-simulation option is involved.

Response: WRAP-SIM was incorrectly writing certain information to the output file twice when the dual simulation option was activated. This error has been corrected.

Stream Flow Availability in the Water Rights Priority Sequence

The work summarized by this report consists of improvements to the Water Rights Analysis Package (WRAP) modeling system. WRAP is a generalized river/reservoir system model that simulates the development, management, allocation, and use of the water resources of a river basin or multiple-basin region. The Texas Water Availability Modeling (WAM) System consists of the WRAP modeling system, WRAP input datasets for the river basins of Texas, and other supporting databases and modeling tools. The WAM System is routinely applied by the Texas Water Development Board (TWDB), Texas Commission on Water Quality (TCEQ), other water management agencies, regional planning groups, and consulting firms in regional and statewide planning studies, preparation and evaluation of water right permit applications, and other water management activities. The new modeling feature reported here is incorporated as an integral part of the public domain WRAP software and documentation.

The amount of stream flow available to meet instream flow, diversion, and/or storage requirements at a particular location on a stream is affected by the water management and use activities of other entities at locations throughout the river basin. The WRAP model defines

water resources development, management, allocation, and use in terms of water rights administered within the framework of a priority system. Regulated and available flows at a control point are affected in the water right priority sequence by water rights located throughout the river basin. Improving capabilities for analyzing these impacts of water management/use on other water users/uses is important for a variety of planning and regulatory applications.

The purpose of the new feature added to the WRAP simulation model is to track the impacts of each water right in a river basin on flows at locations of interest. The new feature determines regulated flow and the amount of the regulated flow that is available for appropriation at each of any number of user-selected control points in each month of the simulation as each water right is considered in the priority sequence. Model results show the impacts of each individual water right on the amount of stream flow available to a particular right located at a specified control point. The new feature improves capabilities for modeling subordination agreements, resolving competing demands for water, and assessing the impacts of alternative management strategies on river flows.

The number of control points in the WAM System datasets range from less than a hundred for several of the smaller river basins to over 2,000 for the Colorado and 3,800 for the Brazos. Likewise, the number of water rights range from less than 100 for smaller river basins to over 1,000 for the larger basins. WRAP simulation results includes naturalized, regulated, and unappropriated stream flows at all control points and flow amounts available to each water right for each month of the period-of-analysis. The new feature reported here expands the model to compute and display both the regulated flow and the amount of the regulated flow that is still available for appropriation in each month at user-specified control point locations, after each individual water right is considered in the priority sequence. Thus, the impact on flow available to a particular right resulting individually from each of the many other water rights in the river basin can be assessed. This additional new information to be provided by WRAP is designed to contribute to a better understanding of the interactions between water management and use by different water suppliers and users and water uses in a river basin.

WRAP Documentation

The WRAP model is documented by the following manuals.

Water Rights Analysis Package (WRAP) Modeling System Reference Manual, TR 255, Texas Water Resources Institute, First Edition August 2003, Second Edition April 2005, Third Edition September 2006, Fourth Edition March 2008. (*Reference Manual*)

Water Rights Analysis Package (WRAP) Modeling System Users Manual, Technical Report 256, Texas Water Resources Institute, 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, Technical Report-283, Texas Water Resources Institute, 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.A. Wurbs, R.J. Hoffpauir, H.E. Olmos, and A.A. Salazar, TR-284, Texas Water Resources Institute, September 2006. (*Supplemental Manual*)

WRAP is a set of Fortran programs. The new modeling capabilities for assessing stream flow availability in the water rights priority sequence are incorporated in the *WRAP-SIM* simulation program and *TABLES* post-simulation program. The expanded capabilities are documented in the expanded March 2008 Fourth Edition of the *Reference* and *Users Manuals* cited above. The example simulation from the *Fundamentals Manual* is expanded in the *Reference Manual* to illustrate the new feature.

Information regarding the new feature is integrated throughout the *Reference* and *Users Manuals*. The manuals in their entirety are required to document the new feature in the context of the overall modeling system. However, key portions of the *Reference* and *Users Manuals* describing the new modeling feature added by the project reported here are excerpted as follows.

The following sections from the manuals documenting the new WRAP feature are followed by a discussion of modifications to the Fortran code. Most of the code modifications are new subroutines which are reproduced in this summary completion report.

Description of New Feature in Reference Manual Chapter 6 (Pages 197-201)

A *SIM* feature controlled by the *ZZ* record and associated *TABLES* routines controlled by the 4ZZZ and 4ZZF records are designed to facilitate assessments of the effects of other water rights located throughout the river basin on the amount of stream flow that is available to water users at particular locations of concern. For each control point specified with a *SIM ZZ* record, regulated flows, available flows, and upstream reservoir releases are tabulated in a ZZZ file after each individual water right is simulated in the priority loop. These monthly flows are recorded at the beginning of the water rights loop and after each individual water right is simulated in the priority sequence. *TABLES* reads the ZZZ file and organizes the flow information.

All *SIM* output OUT file variables are defined in Chapter 5 of the *Reference Manual* and listed in Table 5.1. An identifying label is listed in the second column of Table 5.1. Three of these previously defined variables (regulated flows, available stream flows, and upstream reservoir releases), labeled 2REG, 2ASF, and 2URR in Table 5.1, are included in the ZZZ file. Intermediate available stream flows (2ASF in Table 5.1) in the water rights priority sequence become unappropriated flows (2UNA) after the most junior water right is simulated. The reservoir releases (2URR) included in the ZZZ table are a component of regulated flows (2REG) and include only releases from reservoirs located at or upstream of a control point that are made to meet water right diversion, storage, or instream flow requirements at a control point located further downstream.

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

tables in optional formats or DSS files, and the 4ZZF record creates frequency analysis tables similar to the 2FRE record frequency tables discussed in *Reference Manual* Chapter 5.

During each month of the *SIM* simulation, flows at designated control points are tabulated in the ZZZ file at the beginning of the water rights priority loop and after each water right is simulated in the priority sequence. By default, all water rights from the most senior to most junior are included in the tabulation. However, an optional parameter entered on the *ZZ* record sets a minimum flow change required for a water right to be included in the table. Monthly flow volumes are tabulated after a water right is simulated only if the change in either the regulated flow, available flow, or upstream release equals or exceeds the specified limit at one or more of the control points being considered. Another option allows the tabulation to stop after reaching a specified water right in the priority sequence. The larger Texas WAM System datasets contain hundreds of water rights. These *ZZ* record options allow the length of the ZZZ file table to be greatly reduced. *TABLES* deals with variations in water right listings between months by assigning flows to missing rights by repeating flows for the preceding right listed.

Instructions for applying the *SIM ZZ* record and *TABLES* 4ZZZ and 4ZZF records are provided in Chapters 3 and 4 of the *Users Manual*. Incorporation of these features in the example presented in the *Fundamentals Manual* results in the following Tables 6.3, 6.4, and 6.5. The ZZZ file partially reproduced as Table 6.3 was created by inserting the following *ZZ* record in the DAT file for the example presented in the *Fundamentals Manual*.

```
ZZ     2    0.01                    George   Grang
```

All other *SIM* input and output remain unchanged. The time series and frequency tables reproduced as Tables 6.4 and 6.5 were developed with the data from the ZZZ file with *TABLES* using the 4ZZZ and 4ZZF records shown on the next page.

The ZZZ file covers the entire period-of-analysis which is 1940-1997 for the example in the *Fundamentals Manual*. Only the first six months are shown in Table 6.3. The year and month are tabulated in the first two columns of the ZZZ file table. The month (M) in the second column is an integer between 1 and 12 repeating each year, and the month (M) in the fourth column is an integer between 1 and 696 covering the 696 months in the 1940-1997 period-of-analysis. The third column is the water right identifier. The sixth column with heading WR is the integer water right index with 1 denoting the most senior water right in the *SIM* input dataset. The table includes flows at control points with identifiers George and Grang.

The ZZZ table is constructed as the simulation proceeds through the water rights priority sequence each month. The default is to include all water rights in the table. However, in creating the ZZZ file of Table 6.3, a *ZZ* record option was used that allows specification of a minimum flow change required to include a water right in the table. A minimum limit of 0.01 acre-feet was entered on the ZZ record for this example, which essentially means a non-zero change. Thus, an additional row is added to the ZZZ file table only if at least one of the flows in the row is different from the preceding row of the table in an amount of at least 0.01 acre-feet. With a total of 30 water rights in the example, this option greatly reduces the length of the table.

Using the third month (March 1940) as an example, the ZZZ file is interpreted as follows. The purpose of the ZZZ file is to display the impacts of all water rights on regulated and available flows at each of the two control points with identifiers George and Grang. At the beginning of the water rights priority loop for the third month, prior to simulating any of the water rights, the March 1940 regulated and available flow are both 464.0 acre-feet/month at control point George and 1,493.0 acre-feet/month at control point Grang. The initial flows are always naturalized flows plus, if next-month return flow or next-month hydropower options are activated, any return flows or hydropower releases from the preceding month.

Table 6.3
Beginning of Example ZZZ File Created with ZZ record

```
REGULATED AND AVAILABLE STREAMFLOWS COMPUTED IN WATER RIGHTS
PRIORITY SEQUENCE AT CONTROL POINTS SPECIFIED BY ZZ RECORD

First year and number of years:  1940  58
Number of water rights and control points:   30   2
```

Control Point				George			Grang		
Year	M	Water Right	M	WR	Reservoir Releases	Regulated Flow	Available Flow	Reservoir Releases	Regulated Flow	Available Flow
1940	1	*** Beginning **	1	0		156.0	156.0		502.0	502.0
1940	1	WR-10	1	16	0.0	0.0	0.0	0.0	1147.1	1147.1
1940	1	WR-11	1	17	0.0	0.0	0.0	0.0	0.0	0.0
1940	2	*** Beginning **	2	0		1320.0	1320.0		4249.0	4249.0
1940	2	WR-10	2	16	0.0	0.0	0.0	0.0	3714.8	3714.8
1940	2	WR-11	2	17	0.0	0.0	0.0	0.0	0.0	0.0
1940	3	*** Beginning **	3	0		464.0	464.0		1493.0	1493.0
1940	3	WR-10	3	16	0.0	0.0	0.0	0.0	1844.8	1844.8
1940	3	WR-11	3	17	0.0	0.0	0.0	0.0	0.0	0.0
1940	3	WR-15	3	22	0.0	0.0	0.0	2141.7	2141.7	0.0
1940	3	WR-24	3	24	0.0	0.0	0.0	42661.4	42661.4	0.0
1940	4	*** Beginning **	4	0		4019.0	4019.0		12931.0	12931.0
1940	4	WR-10	4	16	0.0	0.0	0.0	0.0	9793.2	9793.2
1940	4	WR-11	4	17	0.0	0.0	0.0	0.0	0.0	0.0
1940	5	*** Beginning **	5	0		4673.0	4673.0		15037.0	15037.0
1940	5	WR-10	5	16	0.0	1247.8	1247.8	0.0	12648.2	12648.2
1940	5	WR-11	5	17	0.0	1247.8	0.0	0.0	0.0	0.0
1940	6	*** Beginning **	6	0		22485.0	22485.0		72349.0	72349.0
1940	6	WR-10	6	16	0.0	20043.5	20043.5	0.0	71219.0	71219.0
1940	6	WR-11	6	17	0.0	20043.5	20043.5	0.0	38700.1	38700.1

Note: The ZZZ file is actually much longer extending from January 1940 through December 1997.

In month 3 (March 1940), one or more of the flows are affected by water rights WR-10, WR-11, WR-15, and WR-24. The relative priority rankings of these four water rights are 16, 17, 22, and 24. The 15 other rights senior to WR-10 do not affect the flows at Grang. After simulating water right WR-10, the regulated and available flows are reduced to 0.0 at George and are increased to 1,844.8 acre-feet at Grang. The increase at Grang is due to return flow from a diversion at George located upstream. Water right WR-11 reduces the regulated and available

flows to zero at both George and Grang. The flows at George remain zero throughout the reminder of the priority sequence simulation. Water rights WR-15 and WR-24 increase the regulated flows at Grang to 2,141.7 and 42,661.4 acre-feet. WR-15 and WR-24 are diversions at a downstream control point for which releases are made from the reservoir at control point Grang. The reservoir release column of the ZZZ file table is a component of regulated flow, which for the 2,141.7 and 42,661.4 acre-feet flows happen to account for the total regulated flow.

With the 4ZZZ and 4ZZF input records reproduced below, *TABLES* reads the ZZZ file of Table 6.3 and creates the tables reproduced as Tables 6.4 and 6.5 which are stored in the *TABLES* output TOU file. Only tables for control point Grang are shown in Tables 6.4 and 6.5 on the next two pages.

```
4ZZZ   1   0   0   3   2   WR-15
IDEN  George   Grang
4ZZF   3   0  -2
```

The 4ZZZ record time series table reproduced as Table 6.4 is for available stream flows at the Grang control point. The flows in the table represent flow volumes available to a right located at the Grang control point during each month of the 1940-1997 hydrologic period-of-analysis after consideration in the priority sequence simulation of water right WR-15 and all other rights that are senior to WR-15. Water right WR-15 has an integer priority rank identifier of 22 shown in Tables 6.3 and 6.5 meaning 21 other more senior rights are found in the *SIM* input. The flows in Table 6.4 represent the amount of stream flow available at control point Grang in the water rights priority sequence between water right WR-15 with a priority rank WR of 22 and water right WR-23 with rank WR of 23. Similar 4ZZZ tables can be easily created from the ZZZ file of Table 6.3 for either of the three flow variables (reservoir releases, regulated flows, available flows) at either of the two control points (George and Grang) at the beginning of the priority sequence or after simulation of either of the 22 water rights included in the ZZZ file. The flows can also be written in a columnar format for transport to a spreadsheet program or as records in a DSS file for plotting with HEC-DSSVue.

The 4ZZF frequency table of Table 6.5 was developed by *TABLES* based on computing the mean and standard deviation (Equations 5.6 and 5.7) and applying the relative frequency formula (Equation 5.3) similarly as for the 2FRE frequency table of Table 5.12 of Chapter 5. A 4ZZF record frequency table is developed from the ZZZ file for a selected variable at a selected control point. With no specific month such as August specified, all 696 months of the 1940-1997 simulation are included in the computations. The available flows after considering water right WR-15 in the priority sequence have a mean of 8,584 acre-feet/month, and a volume of 3,816 ac-ft/month is equaled or exceeded during 25 percent of the months. The available flow at this point in the priority sequence is at least 30,847 ac-ft/month during ten percent of the time.

Table 6.4
4ZZZ Time Series Table for the Example

AVAILABLE FLOWS (AC-FT) AT CONTROL POINT Grang AFTER WATER RIGHT WR-15

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1940	0.0	0.0	0.0	0.0	0.0	38700.1	41287.8	0.0	0.0	0.0	61450.0	93787.7	235225.6
1941	47665.1	71520.6	65411.5	79235.1	75511.2	52022.0	9154.9	0.0	0.0	0.0	0.0	0.0	400520.4
1942	0.0	0.0	0.0	16669.8	10531.5	34323.2	0.0	0.0	0.0	13617.2	5202.0	4431.2	84774.9
1943	3690.2	762.1	1386.1	0.0	894.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6733.0
1944	0.0	0.0	16695.6	11904.1	76071.8	40817.2	0.0	0.0	0.0	0.0	0.0	0.0	145488.7
1945	8710.6	30961.5	36545.4	57386.8	20764.5	30247.0	1537.5	0.0	0.0	0.0	0.0	0.0	186153.3
1946	2333.2	19700.4	24500.5	17174.1	21782.2	2816.9	0.0	0.0	0.0	0.0	0.0	0.0	88307.3
1947	47824.1	24090.8	22910.0	17035.0	6888.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	118748.2
1948	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1949	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1950	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1951	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1952	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1953	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1954	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1955	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1956	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1957	0.0	0.0	0.0	57748.0	60822.6	76943.6	0.0	0.0	0.0	23389.1	27267.5	22420.3	268591.1
1958	20269.5	81094.1	44542.2	15465.1	19635.8	3816.3	0.0	0.0	0.0	0.0	0.0	0.0	184823.0
1959	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80410.6	19759.1	60720.1	160889.8
1960	46932.2	37634.5	20155.5	9534.6	1557.8	0.0	0.0	0.0	0.0	0.0	11930.6	53450.1	181195.3
1961	50107.7	91158.9	27546.0	7423.2	856.9	0.0	13895.9	0.0	0.0	942.5	2199.2	2482.4	196612.7
1962	1744.3	911.0	0.0	1837.3	1503.1	3563.1	0.0	0.0	0.0	0.0	0.0	0.0	9558.8
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1964	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1965	0.0	0.0	0.0	8642.4	114853.4	19204.5	266.1	0.0	0.0	0.0	0.0	0.0	142966.4
1966	6659.0	15905.0	12100.8	47844.8	33275.7	6862.2	0.0	0.0	0.0	0.0	0.0	0.0	122647.5
1967	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1968	81538.4	35804.3	50647.1	30769.9	54905.2	30144.3	10842.7	0.0	0.0	0.0	0.0	3068.3	297720.2
1969	3142.9	11365.6	17459.1	49687.6	43873.2	4400.9	0.0	0.0	0.0	0.0	0.0	0.0	129929.3
1970	0.0	0.0	34690.2	24135.9	43064.8	14486.7	0.0	0.0	0.0	0.0	0.0	0.0	116377.6
1971	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1973	0.0	0.0	0.0	14490.6	28854.9	6869.1	0.0	0.0	0.0	0.0	10438.8	7636.2	68289.6
1974	11279.5	6065.6	4024.0	1876.3	43321.1	0.0	0.0	0.0	0.0	0.0	31212.2	18659.0	116437.7
1975	16018.5	69636.0	16367.9	7876.2	82738.8	38475.3	10031.4	6730.4	616.9	0.0	0.0	0.0	248491.4
1976	0.0	0.0	0.0	15827.4	40592.0	11626.5	17646.2	0.0	0.0	0.0	869.7	13032.8	99594.6
1977	9006.1	24895.4	10357.7	62683.0	22267.0	2037.6	0.0	0.0	0.0	0.0	0.0	0.0	131246.8
1978	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1979	0.0	0.0	747.0	33283.5	57798.1	41649.8	11956.4	1375.3	0.0	0.0	0.0	0.0	146810.1
1980	0.0	512.9	4124.0	2479.9	19074.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26191.7
1981	0.0	0.0	0.0	0.0	0.0	136074.1	28240.5	0.0	0.0	0.0	0.0	1877.5	166192.1
1982	1637.1	595.9	1171.6	7866.5	31890.4	9626.9	0.0	0.0	0.0	0.0	0.0	0.0	52788.4
1983	0.0	0.0	0.0	0.0	0.0	14082.0	0.0	0.0	0.0	0.0	0.0	0.0	14082.0
1984	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1985	0.0	25312.6	21349.5	13650.4	16792.7	3680.3	0.0	0.0	0.0	0.0	0.0	0.0	80785.5
1986	0.0	41366.8	6358.0	1448.6	7143.4	25233.5	0.0	0.0	0.0	1737.8	8969.7	60533.3	152791.1
1987	15532.1	20799.2	23212.9	8466.4	35306.5	148868.0	4999.1	595.1	0.0	0.0	0.0	0.0	257779.3
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	23364.6	23620.5	8594.6	0.0	0.0	0.0	0.0	0.0	108390.5	163970.2
1992	90167.7	200100.3	94046.9	23436.9	61136.4	50273.7	17781.1	2492.2	0.0	0.0	0.0	7388.0	546823.2
1993	9844.1	25049.5	31405.0	22333.5	39097.1	49705.4	9685.5	0.0	0.0	0.0	0.0	0.0	187120.1
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	15153.7	6974.1	16555.3	10306.2	0.0	0.0	0.0	0.0	0.0	0.0	48989.3
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	727.2	26897.3	39670.0	142082.3	84805.0	83054.5	11581.9	0.0	0.0	0.0	0.0	0.0	388818.2
MEAN	8186.7	14864.5	11078.9	14493.7	20651.5	17215.6	3257.0	193.0	10.6	2070.6	3091.4	7894.4	103008.0

Table 6.5
4ZZF Frequency Analysis Table for the Example

FREQUENCY TABLE FOR AVAILABLE FLOWS AT CONTROL POINT Grang

WR	WATER RIGHT	MEAN	STANDARD DEVIATION	PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE 100%	99%	98%	95%	90%	75%	60%	50%	40%	25%	10%	MAXIMUM
0	Beginning	15772.4	25225.	0.0	0.0	0.0	175.4	481.4	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
1	IF-1	15769.9	25226.	0.0	0.0	0.0	157.6	481.4	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
4	WR-1	15767.9	25227.	0.0	0.0	0.0	135.4	471.4	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
5	WR-2	15767.9	25227.	0.0	0.0	0.0	135.4	471.4	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
6	WR-14	15767.5	25228.	0.0	0.0	0.0	135.4	467.0	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
7	WR-20	15767.2	25228.	0.0	0.0	0.0	129.4	467.0	1805.0	3652.	5489.	8552.	19998.	45534.	212283.
8	WR-22	15757.6	25233.	0.0	0.0	0.0	44.6	455.2	1780.0	3652.	5489.	8552.	19998.	45534.	212283.
9	WR-16	15756.9	25234.	0.0	0.0	0.0	22.6	447.6	1780.0	3652.	5489.	8552.	19998.	45534.	212283.
10	WR-17	15754.2	25236.	0.0	0.0	0.0	3.2	445.0	1780.0	3652.	5489.	8552.	19998.	45534.	212283.
11	WR-13	15750.3	25238.	0.0	0.0	0.0	0.0	435.8	1780.0	3652.	5489.	8552.	19998.	45534.	212283.
12	WR-19	15749.1	25239.	0.0	0.0	0.0	0.0	398.6	1780.0	3652.	5489.	8552.	19998.	45534.	212283.
13	WR-21	15743.6	25242.	0.0	0.0	0.0	0.0	341.8	1762.0	3652.	5489.	8552.	19998.	45534.	212283.
14	WR-8	15729.6	25249.	0.0	0.0	0.0	0.0	283.0	1755.0	3600.	5469.	8552.	19998.	45534.	212283.
16	WR-10	14014.6	22907.	0.0	0.0	0.0	72.0	633.5	2137.1	3740.	4946.	7594.	16014.	36328.	200743.
17	WR-11	8621.7	21301.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	4024.	30847.	200100.
18	WR-3	8609.3	21306.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	4024.	30847.	200100.
19	WR-12	8586.5	21314.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3816.	30847.	200100.
22	WR-15	8584.0	21314.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3816.	30847.	200100.
24	WR-24	8560.6	21321.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3690.	30847.	200100.
25	WR-4	8625.7	21299.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3816.	30847.	200100.
26	WR-5	8551.6	21324.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.	0.	3563.	30847.	200100.

Instructions in Users Manual Chapters 3 and 4 (Pages 51, 141-143)

The new feature is activated in program *SIM* with a *ZZ* record and in program *TABLES* with 4ZZF and 4ZZZ records. Explanation of these input records provided in Chapter 3 (page 51) and Chapter 4 (pages 141-143) of the *Users Manual* are reproduced as follows. The *TABLES* TIN file editor in WinWRAP has been modified to include the new 4ZZZ and 4ZZF records.

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

field	columns	variable	format	value	description
1	1-2	CD	A2	ZZ	Record identifier
2	3-8	ZZ	I6	+ blank,0,1	Number of control points. Default is one control point.
3	9-16	ZZX	I8	+ blank,0	Change required to include right in output table. All water rights are included in ZZZ file output table.
4	17-24	ZZWR	A16	AN blank,0	Most junior water right included in the output table. All water rights are included in ZZZ file output table.
5-no limit	25-no limit	ZZCP(Z) Z=1,ZZ	2x,A6	+	Identifiers of control points for which flows are determined and tabulated in ZZZ file output table.

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

The ZZZ file table may be read directly with any editor. The *TABLES* 2ZZZ and 2ZZF records activate *TABLES* options for reading a ZZZ file and organizing the simulation results in optional time series formats or developing frequency tables.

Explanation of ZZ Record Fields

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

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

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

field	columns	variable	format	value	description
1	1-4	CD	A4	4ZZF	Record identifier.
2	8	VAR	I4	1	Reservoir releases.
				2	Regulated flows.
				blank, 0, 3	Available flows.
3	12	MON	I4	blank,0	All months are included in the computations.
				+	The month for which the analysis is performed.
4	20	NUM	I4	blank,0	Tables for all control points included in ZZZ file.
				−	Develop tables for the NUM control points already listed with preceding record.
				+	Number of control points to follow on IDEN records.

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

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

Explanation of 4ZZF Record Fields

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

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

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

4ZZZ Record – Flows in Water Rights Priority Loop

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

The *SIM ZZ* record and associated *TABLES* 4*ZZZ* and 4ZZF record routines discussed in *Reference Manual* Chapter 6 are designed to track the effects of each water right in a *SIM* dataset on the regulated flows and available (still unappropriated) flows at specified control points. *SIM* records the flows in a ZZZ file as each water right is simulated in the priority sequence. *TABLES* reads the ZZZ file. The 4ZZZ record organizes the flows as tables in the TOU file or as DSS file records in the similar manner as the time series records described on pages 133-135.

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

Explanation of 4ZZZ Record Fields

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

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

A TOU file table activated by entering a 1, 2, or 3 in 4ZZZ record field 3 consists of a single column for each control point with multiple control points being included as separate columns in the same table. This format is designed to be read by spreadsheet programs for plotting or additional computational manipulations. The column may contain either the entire time series of monthly flow data (PT=1 in field 3), annual totals for each year of the simulation (PT=2), or a set of 12 means for each of the 12 months of the year (PT=3). The parameter *MORE* in field 4 controls whether another column is added to the current table or a new table is started.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a DSS file, accessible to graphing and other capabilities provided by HEC-DSSVue. The HEC-DSS data storage system references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. The pathname is assigned automatically by *TABLES* as indicated below.

A – filename root of *TABLES* output files
B – control point identifier
C – ZZ_RES_REL or ZZ_REG_FLOW or ZZ_AVAIL_FL
D – date of the beginning of the time series such as 01JAN1938
E – time interval = MON or YEAR for *SIM* results
F – water right identifier from 4ZZZ record field 7

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

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

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

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

Subroutines in the Fortran Code

The new feature is incorporated in the Fortran programs *SIM* and *TABLES* and in the *Programming Manual* that documents the programs. The main program of both *SIM* and *TABLES* includes modifications scattered throughout the programs to incorporate the new feature. However, the subroutines reproduced below account for most of the new code.

New Variables in SIM

ZZ − number of control points specified by ZZ record [integer, COVAR]

ZZX − criteria from ZZ record of the flow volume change that results in a water right being included in the ZZZ file output table [real, COMVAR]

ZZWR − most junior water right considered in determining flows for the ZZZ file table as specified on ZZ record [character(len=16), COMVAR]

ZZCP(zz) − identifiers from ZZ record of control points included in ZZZ output file [character(len=6), COMVAR]

ZZCALL − counter of whether subroutine ZZFLOW has been called more than once used to signal writing the table headings only the first time the subroutine is called [integer, COMVAR]

ZZR − integer identifier of water rights in priority order with 1 and 2 being the first and second most senior rights [integer, COMVAR]

ZZI(zz) − integer identifier of control points ZZCP(zz) listed on ZZ record [integer, COMVAR]

ZZFLAG − switch of whether or not to include a water right in the ZZZ file output table activated by ZZ record [integer, ZZFLOW]

ZZF(zz,3) − reservoir releases, regulated flow, and available flow tabulated in the ZZZ file output table activated by ZZ record [real, ZZFLOW]

ZZFX(zz,3) − a reproduction of ZZF(zz,3) used to compare with the next values for ZZF(zz,3) in applying the ZZX criteria to determine whether a particular water right is included in the ZZZ file table [real, ZZFLOW]

New Subroutine ZZFLOW in Program SIM

```
!
! **********************************************************************
!
      Subroutine ZZFLOW
!
!  Subroutine ZZFLOW develops a table of reservoir releases, regulated flows,
!  and available flows as specified by the ZZ record.  The flows are written
!  to the ZZZ file during each month of the simulation at the beginning of
!  the priority loop and after each water right is considered in the loop.

!
      Use COMVAR
      Integer I,J,M,Z,ZZFLAG
      Real,Allocatable,Dimension(:,:)::ZZF,ZZFX
```

```
      Allocate(ZZF(ZZ,3),ZZFX(ZZ,3))
!
      M=(YEAR-YRST)*12+MT
!
!  Headings for ZZZ file table.
!
      If(ZZCALL.EQ.0) Then
         ZZCALL=99
         Write(17,10)
10       Format('REGULATED AND AVAILABLE STREAMFLOWS COMPUTED IN WATER',
     +          ' RIGHTS',/,'PRIORITY SEQUENCE AT CONTROL POINTS',
     +          ' SPECIFIED BY ZZ RECORD',/)
         J=NWRTS
         If(ZZWR.NE.'                ') Then
            Do I=1,NWRTS
               If(WRID(RANK(I)).EQ.ZZWR) Then
                  J=I
                  Goto 20
               Endif
            End Do
         Endif
20       Write(17,30) YRST,NYRS
30       Format('First year and number of years:',I6,I4)
         Write(17,40) J,ZZ
40       Format('Number of water rights and control points:',I5,I4,/)
         Write(17,50)
50       Format(34('-'),<ZZ>(30('-')))
         Write(17,60) (CPID(ZZI(Z),1),Z=1,ZZ)
60       Format('Control Point',21x,
     +          <ZZ>('|---------  ',A6,'   ---------'),/,
     +          34x,<ZZ>('|Reservoir Regulated Available'))
         Write(17,70)
70       Format('Year M  Water Right        M   WR ',
     +           <ZZ>('| Releases    Flow      Flow  '))
         Write(17,80)
80       Format(34('-'),<ZZ>(30('-')),/)
      Endif
!
!  Flows are written initially each month before the water rights sequence.
!
      If(ZZR.EQ.0) Then
         Do Z=1,ZZ
            ZZF(Z,2)=CPFLOW(ZZI(Z),MT,2)
            If(ADJINC.EQ.4) Then
               ZZF(Z,2)=ZZF(Z,2)-CPFLOW(ZZI(Z),MT,1)
               If(ZZF(Z,2).LT.0.0) ZZF(Z,2)=0.0
            Endif
            LOCNUM=ZZI(Z)
            Call AVALB
            ZZF(Z,3)=AVAMT
         End Do
         Write(17,90) YEAR,MT,M,ZZR,(ZZF(Z,2),ZZF(Z,3),Z=1,ZZ)
90       Format(I4,I2,2x,'*** Beginning **',I4,I5,<ZZ>(10x,2F10.1))
      Else
!
!  The array ZZF contains reservoir releases, regulated flows, and available
!  flows computed after a water right is simulated in the priority sequence.
!  ZZF array includes each the ZZ control points specified on the ZZ record.
!
         ZZFLAG=0
         Do Z=1,ZZ
            ZZF(Z,1)=RESREL(ZZI(Z))
            ZZF(Z,2)=CPFLOW(ZZI(Z),MT,2)+RESREL(ZZI(Z))
```

```
            If(ADJINC.EQ.4) Then
               ZZF(Z,2)=ZZF(Z,2)-CPFLOW(ZZI(Z),MT,1)
               If(ZZF(Z,2).LT.0.0) ZZF(Z,2)=0.0
            Endif
            LOCNUM=ZZI(Z)
            Call AVALB
            ZZF(Z,3)=AVAMT
!
!  If ZZX from the ZZ record is greater than zero, only rights causing
!  flow changes are included in the ZZZ file output.
!
            If(ZZX.GT.0.0) Then
               If(Abs(ZZF(Z,1)-ZZFX(Z,1)).GE.ZZX) ZZFLAG=ZZFLAG+1
               If(Abs(ZZF(Z,2)-ZZFX(Z,2)).GE.ZZX) ZZFLAG=ZZFLAG+1
               If(Abs(ZZF(Z,3)-ZZFX(Z,3)).GE.ZZX) ZZFLAG=ZZFLAG+1
            Else
               ZZFLAG=99
            Endif
         End Do
!
!  The flows are recorded as an output record in the ZZZ file.
!
         If(ZZFLAG.GT.0) Then
            Write(17,100) YEAR,MT,Adjustl(WRID(WR)),M,ZZR,
     +                   (ZZF(Z,1),ZZF(Z,2),ZZF(Z,3),Z=1,ZZ)
100         Format(I4,I2,2x,A16,I4,I5,<ZZ>(3F10.1))
!
!  Since with nonzero ZZX only rights causing flow changes are included in
!  the output, array ZZFX stores flows for comparison with flows after the
!  next water right to determine whether changes occur.
!
            If(ZZX.GT.0.0) Then
               Do Z=1,ZZ
                  ZZFX(Z,1)=ZZF(Z,1)
                  ZZFX(Z,2)=ZZF(Z,2)
                  ZZFX(Z,3)=ZZF(Z,3)
               End Do
            Endif
         Endif
      Endif
!
!  End of Subroutine ZZFLOW.
!
      Return
      End Subroutine ZZFLOW
!
! ***************************************************************************
```

New Subroutines ZZZZ, ZZFLOW, and ZZFREQ in TABLES

```
!
!***************************************************************************
!
      Subroutine ZZZZ
!
!  *-*-*-*-*-*  4ZZZ and 4ZZF Records  *-*-*-*-*-*
!  Subroutine ZZZZ is called by Subroutines ZZFLOW and ZZFREQ to read and
!  store the information from the ZZZ file generated by a SIM ZZ record.
!  Subroutine ZZZ is called only once, and the ZZZ file data is stored in
!  memory for shared use by any number of 4ZZZ and 4ZZF records.
!
      Use COMVAR
```

```
!
      Integer I,J,M,MT,NM,WR,WRZ,Z
      Integer,Allocatable,Dimension(:)::WRCOUNT
      Character(len=4) CD
      Character(len=16) WRIDZ
      Character(len=16),Allocatable,Dimension(:)::WRIDZZZ
!
      Write(20,10)
10    Format('*** Starting to read ZZZ file.')
!
!  Header data are read.
!
      Do I=1,3
         Read(17,100,IOSTAT=STATUS) CD
100      Format(A4)
         If(STATUS.NE.0) Then
            Write(20,110)
110         Format(' ERROR: Fortran IOSTAT error occured reading',
     +             ' the heading at beginning of ZZZ file.')
            Call ERROR
         Endif
      End Do
      Read(17,120,IOSTAT=STATUS) YR1,NYR
120   Format(31x,I6,I4)
      If(STATUS.NE.0) Then
         Write(20,130)
130      Format(' ERROR: Fortran IOSTAT error reading the first',
     +          ' year and number of years from ZZZ file.')
         Call ERROR
      Endif
      Backspace(17)
      Read(17,140) YRSTDSS
140   Format(33x,A4)
      Read(17,150) NWR,ZZ
150   Format(42x,I5,I4)
      Do I=1,7
         Read(17,100) CD
      End Do
!
!  The number of water rights in the ZZZ file are counted,
!  The number of water rights ZZWRNUM found in the ZZZ file
!  is usually less than the number NWR in the SIM DAT file.
!  Integer identifiers WR for water rights found in the ZZZ
!  file are recorded as array ZZCOUNT(NWR) and 16-character
!  identifiers WRIDZ are recorded as WRIDZZZ(NWR).
!
      Allocate(WRCOUNT(NWR),WRIDZZZ(NWR))
      WRCOUNT=-9
      NM=NYR*12
      Do 200 MT=1,NM
160      Read(17,170,IOSTAT=STATUS,End=190) CD,WRIDZ,M,WR
170      Format(A4,4x,A16,I4,I5)
         If(STATUS.NE.0) Then
            Write(20,180)
180         Format(' ERROR: IOSTAT error reading ZZZ file.')
            Call ERROR
         Endif
         If(WR.GT.0) Then
            WRCOUNT(WR)=WR
            WRIDZZZ(WR)=WRIDZ
         Endif
         If(CD.EQ.'End ') Goto 200
         If(M.GT.MT) Goto 200
```

```
         Goto 160
190      Write(20,*)' WARNING: Reached end of ZZZ file inappropriately.'
200   End Do
!
!  The counter ZZWRNUM includes the number of water rights found in one
!  or more months in the ZZZ file plus one representing the beginning.
!
      ZZWRNUM=1
      J=1
      Do I=1,NWR
         If(WRCOUNT(I).GE.0) Then
            J=J+1
            ZZWRNUM=ZZWRNUM+1
         Endif
      End Do
!
!  Arrays are allocated and initialized.
!
      NM=NYR*12
      Allocate(ZZCP(ZZ),ZZWRI(NWR),ZZWR(ZZWRNUM))
      Allocate(ZZF(NM,ZZWRNUM,ZZ,3))
      ZZCP='      '
      ZZWR='                '
      ZZWRI=-9
      ZZF=-9.0
      If(ZZFLAG.GT.0) Then
         Allocate(ZPLOT(NM,100))
         ZPLOT=0.0
      Endif
!
!  Water right identifiers are initially read from the ZZZ file as
!  WRCOUNT(NWR) and WRIDZZZ(NWR). ZZWRI(NWR) connects the new integer
!  identifiers (sequenced from 1 to ZZWRNUM) to the original integer
!  identifiers WR read from the ZZZ file and stored as WRCOUNT(NWR).
!  The 16-character WRIDZZZ(NWR) are converted to ZZWR(ZZWRNUM).
!
      ZZWRI(1)=0
      ZZWR(1)='*** Beginning **'
      J=1
      Do I=1,NWR
         If(WRCOUNT(I).GE.0) Then
            J=J+1
            ZZWRI(J)=WRCOUNT(I)
            ZZWR(J)=WRIDZZZ(I)
         Endif
      End Do

!
!  The first 7 lines at the beginning of the ZZZ file are skipped
!  allowing the control point identifiers to be read from the 8th
!  line.  Lines 9-12 are then skipped allowing the actual reading
!  of data to begin at the 13th record.
!
      Rewind(17)
      Do I=1,7
         Read(17,100,IOSTAT=STATUS) CD
         If(STATUS.NE.0) Then
            Write(20,110)
            Call ERROR
         Endif
      End Do
      Read(17,300) (ZZCP(Z),Z=1,ZZ)
300   Format(34x,<ZZ>(12x,A6,12x))
```

```
      Do I=1,4
         Read(17,100) CD
      End Do
!
!  ZZZ file flow data are read.
!
      Do MT=1,NM
         WRZ=0
!
310      Read(17,320,IOSTAT=STATUS,End=410) WR
320      Format(28x,I5)
         If(STATUS.NE.0) Then
            Write(20,330)
330         Format(' ERROR: IOSTAT error reading WR from ZZZ file.')
            Call ERROR
         Endif
         Backspace(17)
!
340      WRZ=WRZ+1
         If(WR.EQ.ZZWRI(WRZ)) Then
            Read(17,350,IOSTAT=STATUS) WRIDZ,M,(ZZF(MT,WRZ,Z,1),
     +                    ZZF(MT,WRZ,Z,2),ZZF(MT,WRZ,Z,3),Z=1,ZZ)
350         Format(8x,A16,I4,5x,<ZZ>(3F10.0))
            If(STATUS.NE.0) Then
               Write(20,360)
360            Format(' ERROR: Fortran IOSTAT error reading',
     +                ' flow data from ZZZ file.')
               Call ERROR
            Endif
            If(WRIDZ.NE.ZZWR(WRZ)) Then
               Write(20,370) WRIDZ,ZZWR(WRZ)
370            Format(' ERROR: Following water right identifiers read',
     +                ' from ZZZ file should be same.',/,8x,A16,5x,A16)
               Call ERROR
            Endif
            If(MT.NE.M) Then
               Write(20,380) M,MT
380            Format(' ERROR: Month M of',I4,' read from ZZZ file',
     +                ' should be',I4,'.')
               Call ERROR
            Endif
            If(WRZ.LT.ZZWRNUM) Goto 310
         Else
            If(WRZ.LE.1) Then
               Write(20,390) WRIDZ,M,WR,MT,WRZ
390            Format(' ERROR: A beginning row with WR=0 appears to be',
     +                ' missing in ZZZ file in row with Water Right,'
     +                ' M, and WR as follows MT,WRZ.',/,8x,A16,3x,4I5)
               Call ERROR
            Endif
            Do Z=1,ZZ
               ZZF(MT,WRZ,Z,1)=ZZF(MT,WRZ-1,Z,1)
               ZZF(MT,WRZ,Z,2)=ZZF(MT,WRZ-1,Z,2)
               ZZF(MT,WRZ,Z,3)=ZZF(MT,WRZ-1,Z,3)
            End Do
            If(WRZ.LT.ZZWRNUM) Goto 340
         Endif
      End Do
!
!   Return from Subroutine ZZZZ to Subroutine ZZFLOW or ZZFREQ.
!
      Write(20,400)
400   Format('*** Finished reading ZZZ file.')
```

```
      Return
410   Write(20,420) MT
420   Format('*** Reached end of ZZZ file reading data for month',I4,
     +       '.')
      Write(20,400)
      Return
      End Subroutine ZZZZ
!
!**********************************************************************
!
      Subroutine ZZFLOW
!
!  *-*-*-*-*-*  4ZZZ Record  *-*-*-*-*-*
!  Subroutine ZZFLOW develops TOU file tables or DSS file records for
!  priority loop available flows, regulated flows, and reservoir releases
!  read from a ZZZ file generated by a SIM ZZ record. The ZZZ file is read
!  by Subroutine ZZZZ which is called by Subroutines ZZFLOW and ZZFREQ.
!
      Use COMVAR
!
      Real MDATA(12),MEAN(13),SUM(13),TDATA,YTOTAL
!
      Integer CP,I,IP,L,MONTH,MORE,MYR,MM,MT,NM,NN,NUM,
     +        PERIOD,PT,TA,VAR,WRI,YEAR,Z
      Integer IPLAN,ISTAT,NDSS,NPATH,NVALS
!
      Character(len=2)  DSSDAY
      Character(len=3)  M(23)
      Character(len=4)  CD,CTIME,CTYPE
      Character(len=5)  CUNITS
      Character(len=8)  HEAD(100,3)
      Character(len=9)  CDATE
      Character(len=16) RIGHT
      Character(len=32) A,B,C,D,E,F
      Character(len=64) CPATH,CNAME
!
      MDATA=0.0
      MEAN=0.0
      SUM=0.0
!
!  The ZZZ file is read if it has not already been read.
!
      If(ZZZFILE.EQ.0) Then
         ZZZFILE=99
         Call ZZZZ
      Endif
      NM=NYR*12
!
!   Table specifications are read from the input file (unit=1) record.
!
      Read(1,100,IOSTAT=STATUS) CD,TA,PT,MORE,VAR,NUM,RIGHT
100   Format(A4,5I4,A16)
      If(VAR.EQ.0) VAR=3
      RIGHT=Adjustl(RIGHT)
      If(RIGHT.EQ.'BEGIN           '.or.RIGHT.EQ.'begin           '.or.
     +   RIGHT.EQ.'Begin           ') Then
         RIGHT='*** Beginning **'
         WRI=1
      Endif
!
!     Input error checks.
!
      If(STATUS.NE.0) Then
```

```
         Write(20,110) CD
110      Format(' ERROR: Fortran IOSTAT error reading an',
     +          ' input record with CD of ',A4)
         Call ERROR
       Endif
       If(PT.GT.5.or.PT.LT.0) Then
         Write(20,120) PT
120      Format(' ERROR: PT of',I3,' in 4ZZZ field 3 is not valid.')
         Call ERROR
       Endif
       If(VAR.LT.1.or.VAR.GT.3) Then
         Write(20,130) VAR
130      Format(' ERROR: VAR of',I3,' in 4ZZZ field 5 is not valid.')
         Call ERROR
       Endif
       If(NUM.GT.ZZ) Then
         Write(20,140) NUM,ZZ
140      Format(' ERROR: NUM of',I3,' in 4ZZZ field 6 exceeds ZZ of',I3)
         Call ERROR
       Endif
!
!  With NUM greater than zero, control point identifiers are read
!  by Subroutine IDEN from IDEN records.
!
       If(NUM.GT.0) Then
         TID=0
         NID=NUM
         Call IDEN
         Do I=1,NUM
            Do Z=1,ZZ
               If(IDCP(I).EQ.ZZCP(Z)) Goto 160
            End Do
            Write(20,150) IDCP(I)
150         Format(' ERROR: Control point ',A6,' from IDEN record',
     +             ' matches no control point in ZZZ file.')
            Call ERROR
160      End Do
       Endif
       NUM=Abs(NUM)
!
!  With NUM of zero, frequency tables are created for all the
!  control points in the ZZZ file.
!
       If(NUM.EQ.0) Then
         NUM=ZZ
         Do Z=1,ZZ
            IDCP(Z)=ZZCP(Z)
         End Do
       Endif
!
!  Water right integer identifier WRI is set.
!
       Do I=1,ZZWRNUM
         If(RIGHT.EQ.ZZWR(I)) Then
            WRI=I
            Go to 180
         Endif
       End Do
       Write(20,170) RIGHT
170    Format(' ERROR: Water right ',A16,' from 4ZZZ record matches no',
     +       ' water right in ZZZ file.')
       Call ERROR
!
```

```
!  HEC-DSS file is opened and array allocated.
!
180   If(PT.EQ.4.or.PT.EQ.5) Then
         HECDSS=HECDSS+1
         If(HECDSS.EQ.1) Then
            Call ZSET('MUNIT',' ',20)
            Call ZSET('MLEVEL','',DSSMES)
            Call ZSET('UNIT','',25)
            IFLTAB=0
            CNAME=OROOT
            Call ZOPEN(IFLTAB,CNAME,ISTAT)
            If(ISTAT.NE.0) Then
               Write(20,190) ISTAT,Adjustl(CNAME)
190            Format(' ERROR: DSS IOSTAT error',I12,' occurred',
     +                ' opening DSS file: ',A32)
               Call ERROR
            Endif
         Endif
!
!  HEC-DSS file VALUES array is allocated.
!
         If(PT.EQ.4) Then
            NVALS=NM
            Allocate(VALUES(NM))
         Elseif(PT.EQ.5) Then
            NVALS=NYR
            Allocate(VALUES(NYR))
         Endif
      Endif
!
!   The order in which months are listed in the table headings is set based
!   on MONTH1 specified in the UNIT record, with a default of MONTH1=JAN.
!
      L=1
      If(MONTH1.EQ.'  JAN'.or.MONTH1.EQ.'  Jan') L=1
      If(MONTH1.EQ.'  FEB'.or.MONTH1.EQ.'  Feb') L=2
      If(MONTH1.EQ.'  MAR'.or.MONTH1.EQ.'  Mar') L=3
      If(MONTH1.EQ.'  APR'.or.MONTH1.EQ.'  Apr') L=4
      If(MONTH1.EQ.'  MAY'.or.MONTH1.EQ.'  May') L=5
      If(MONTH1.EQ.'  JUN'.or.MONTH1.EQ.'  Jun') L=6
      If(MONTH1.EQ.'  JUL'.or.MONTH1.EQ.'  Jul') L=7
      If(MONTH1.EQ.'  AUG'.or.MONTH1.EQ.'  Aug') L=8
      If(MONTH1.EQ.'  SEP'.or.MONTH1.EQ.'  Sep') L=9
      If(MONTH1.EQ.'  OCT'.or.MONTH1.EQ.'  Oct') L=10
      If(MONTH1.EQ.'  NOV'.or.MONTH1.EQ.'  Nov') L=11
      If(MONTH1.EQ.'  DEC'.or.MONTH1.EQ.'  Dec') L=12
      M(1) ='JAN'
      M(2) ='FEB'
      M(3) ='MAR'
      M(4) ='APR'
      M(5) ='MAY'
      M(6) ='JUN'
      M(7) ='JUL'
      M(8) ='AUG'
      M(9) ='SEP'
      M(10)='OCT'
      M(11)='NOV'
      M(12)='DEC'
      M(13)='JAN'
      M(14)='FEB'
      M(15)='MAR'
      M(16)='APR'
      M(17)='MAY'
```

```
      M(18)='JUN'
      M(19)='JUL'
      M(20)='AUG'
      M(21)='SEP'
      M(22)='OCT'
      M(23)='NOV'
!
!   ++++++++++  Begin Control Point Loop  ++++++++++
!   Beginning of loop to develop tables for the ZZ control points,
!
      CP=0
500   CP=CP+1
!
!   Variable initialization.
!
      Do I=1,13
         SUM(I)=0.0
      End Do
      NDSS=0
!
!   Headings for table with annual rows and monthly columns.
!
      If(TA.GE.1) Then
         Call TITLES
         If(VAR.EQ.1) Write(2,510)UNIT,Adjustl(IDCP(CP)),Adjustl(RIGHT)
         If(VAR.EQ.2) Write(2,520)UNIT,Adjustl(IDCP(CP)),Adjustl(RIGHT)
         If(VAR.EQ.3) Write(2,530)UNIT,Adjustl(IDCP(CP)),Adjustl(RIGHT)
         Write(2,540)
         Write(2,550) 'YEAR',M(L),M(L+1),M(L+2),M(L+3),M(L+4),M(L+5),
     +               M(L+6),M(L+7),M(L+8),M(L+9),M(L+10),M(L+11),'TOTAL'
         Write(2,560)
      Endif
510   Format('RESERVOIR RELEASES (',A5,') AT CONTROL POINT ',A6,
     +       ' AFTER WATER RIGHT ',A16)
520   Format('REGULATED STREAMFLOWS (',A5,') AT CONTROL POINT ',A6,
     +       ' AFTER WATER RIGHT ',A16)
530   Format('AVAILABLE FLOWS (',A5,') AT CONTROL POINT ',A6,
     +       ' AFTER WATER RIGHT ',A16)
540   Format(/,127('-'))
550   Format(A4,8x,A3,11(6x,A3),7x,A5)
560   Format(127('-'))
!
!   Increment column counter (MPLOT) and develop heading array for plot table.
!
      If(PT.EQ.1.or.PT.EQ.2.or.PT.EQ.3) Then
         MPLOT=MPLOT+1
         If(VAR.EQ.1) Then
            HEAD(MPLOT,1)=' RES REL'
         Elseif(VAR.EQ.2) Then
            HEAD(MPLOT,1)='REG FLOW'
         Else
            HEAD(MPLOT,1)='AVAIL FL'
         Endif
         HEAD(MPLOT,2)=IDCP(CP)
         HEAD(MPLOT,3)=Adjustr(RIGHT(1:8))
      Endif
!
!  ++++++++++  Begin Inner Loop For Periods ++++++++++
!   Begin loop which is repeated for each of N=NYR*12 periods (months).
!
      PERIOD=0
      MONTH=0
      YEAR=YR1
```

```
      YTOTAL=0.0
      Do 610 MT=1,NM
         PERIOD=PERIOD+1
         MONTH=MONTH+1
         If(MONTH.EQ.1) MDATA=0.0
!
!  Flow data TDATA is obtained from ZZZ file array ZZF.
!
         TDATA=ZZF(MT,WRI,CP,VAR)
!
!  Totals for month (January-December) and year.
!
         MDATA(MONTH)=MDATA(MONTH)+TDATA
         YTOTAL=YTOTAL+MDATA(MONTH)
!
!  Values for DSS file.
!
         If(PT.EQ.4) Then
            NDSS=NDSS+1
            VALUES(NDSS)=MDATA(MONTH)
         Endif
         If(PT.EQ.5) Then
            If(MONTH.EQ.12) Then
               NDSS=NDSS+1
               VALUES(NDSS)=YTOTAL
            Endif
         Endif
!
!  Write a row in regular table.
!
         If(MONTH.EQ.12) Then
            If(TA.GE.1) Then
               Write(2,600) YEAR,(MDATA(I),I=1,12),YTOTAL
600            Format(I4,3X,12F9.1,F12.1)
            Endif
!
!  Develop 12 months (a year) of a column of plot table array.
!
            If(PT.EQ.1) Then
               Do I=1,12
                  IP=PERIOD-12+I
                  ZPLOT(IP,MPLOT)=MDATA(I)
               End Do
            Endif
            If(PT.EQ.2) Then
               MYR=YEAR-YR1+1
               ZPLOT(MYR,MPLOT)=YTOTAL
            Endif
!
!  Compute means for each month (January-December) and year if
!  monthly/annual data are finished or otherwise go to next month.
!
            Do I=1,12
               SUM(I)=SUM(I)+MDATA(I)
            End Do
            SUM(13)=SUM(13)+YTOTAL
            YTOTAL=0.0
            MONTH=0
            YEAR=YEAR+1
         Endif
!
!  End of monthly period loop.
!
```

```
610   End Do
!
!  Means are computed.
!
      Do I=1,12
         MEAN(I)=SUM(I)/NYR
      End Do
      MEAN(13)=SUM(13)/NYR
!
!  Means are placed as last row of regular table.
!
      If(TA.GE.1) Then
         Write(2,620) (MEAN(I),I=1,13)
620      Format('MEAN',3x,12F9.1,F12.1)
         Write(2,560)
      Endif
!
!  Means are placed in plot array.
!
      If(PT.EQ.3) Then
         Do I=1,12
            ZPLOT(I,MPLOT)=MEAN(I)
         End Do
      Endif
!
!  DSS data is written to the HEC-DSS file.
!
      If(PT.EQ.4.or.PT.EQ.5) Then
         DSSDAY='01'
         If(DSSMON.EQ.'   ') Then
            CDATE=DSSDAY//M(L)//YRSTDSS
         Else
            CDATE=DSSDAY//DSSMON//YRSTDSS
         Endif
         CDATE=DSSDAY//M(L)//YRSTDSS
         CTIME='0000'
         CUNITS=UNIT
         CTYPE=CD
         IPLAN=0
!
!     DSS pathname /A/B/C/D/E/F/ is defined.
!
         A=OROOT
         B=Adjustr(IDCP(CP))
         If(VAR.EQ.1) Then
            C='ZZ_RES_REL'
         Elseif(VAR.EQ.2) Then
            C='ZZ_REG_FLOW'
         Else
            C='ZZ_AVAIL_FL'
         Endif
         D=CDATE
         If(PT.EQ.4) Then
            E='1MON'
         Elseif(PT.EQ.5) Then
            E='1YEAR'
         Endif
         F=Adjustr(RIGHT)
!
!     DSS routines are called.
!
         Call ZPATH(A,B,C,D,E,F,CPATH,NPATH)
         Call ZCHKPN(CPATH,NPATH,ISTAT)
```

```
         If(ISTAT.NE.0) Then
            Write(20,630) ISTAT,Adjustl(CPATH)
630         Format(' ERROR: DSS ISTAT error',I3,' occurred',
     +             ' for DSS pathname: ',A80)
            Call ERROR
         Endif
         Call ZSRTS(IFLTAB,CPATH,CDATE,CTIME,NVALS,VALUES,
     +              CUNITS,CTYPE,IPLAN,ISTAT)
         If(ISTAT.NE.0) Then
            Write(20,640) ISTAT
640         Format(' ERROR: DSS ISTAT error',I3,' occurred',
     +             ' writing data to DSS file.')
            Call ERROR
         Endif
      Endif
!
!  Start over with the next control point.
!
      If(CP.LT.NUM.and.PT.LE.0) Goto 500
      If(CP.LT.NUM.and.PT.GE.1.and.MPLOT.LT.100) Goto 500
!
!  The HEC-DSS file VALUES array is deallocated.
!
      If(PT.EQ.4.or.PT.EQ.5) Deallocate(VALUES)
!
!  The plot table is written.
!
      If(((MPLOT.GE.1.and.MORE.EQ.0).or.MPLOT.EQ.100))Then
         Call TITLES
         Write(2,650) (HEAD(I,1),I=1,MPLOT)
650      Format(/,8x,100(2x,A8))
         Write(2,660) (Adjustr(HEAD(I,2)),I=1,MPLOT)
660      Format(8x,100(2x,A8))
         Write(2,660) (Adjustr(HEAD(I,3)),I=1,MPLOT)
         Write(2,670)
670      Format('  ')
         YEAR=YR1-1
         MM=0
         If(PT.EQ.1) Then
            Do MYR=1,NYR
               YEAR=YEAR+1
               Do MT=1,12
                  MM=MM+1
                  Write(2,680) YEAR,MT,(ZPLOT(MM,NN),NN=1,MPLOT)
680               Format(1x,I4,I3,100(F10.1))
               End Do
            End Do
         Elseif(PT.EQ.2) Then
            Do MYR=1,NYR
               YEAR=YEAR+1
               Write(2,690) YEAR,(ZPLOT(MYR,NN),NN=1,MPLOT)
690            Format(1X,I4,3x,100(F10.1))
            End Do
         Elseif(PT.EQ.3) Then
            Do MT=1,12
               Write(2,700) MT,(ZPLOT(MT,NN),NN=1,MPLOT)
700            Format(1X,4x,I3,100(F10.1))
            End Do
         Endif
         MPLOT=0
         If(CP.LT.NUM) Goto 500
      Endif
!
```

```
!  Return to main program from Subroutine ZZFLOW.
!
      Return
      End Subroutine ZZFLOW
!
!**********************************************************************
!
      Subroutine ZZFREQ
!
!  *-*-*-*-*-*  4ZZF Record  *-*-*-*-*-*
!  Subroutine ZZFREQ develops frequency tables for priority loop flows
!  generated by SIM with a ZZ record and stored in a ZZZ file. The ZZZ
!  file is read by Subroutine ZZZZ which is called by Subroutines
!  ZZFLOW and ZZFREQ.
!
      Use COMVAR
!
      Real DXF,MEAN,STDDEV,SUM,SUMSD,TEMP,XF
      Real F(10),QFREQ(10)
      Real,Allocatable,Dimension(:)::Q
!
      Integer CP,IF1,IF2,I,J,K,M,MON,NM,NQ,NUM,VAR,Z
!
      Character(len=4) CD
      Character(len=16) ZZWRID
!
      Logical SORTED
!
!  Frequenies included in frequency table.
!
      F(1)=0.99
      F(2)=0.98
      F(3)=0.95
      F(4)=0.90
      F(5)=0.75
      F(6)=0.60
      F(7)=0.50
      F(8)=0.40
      F(9)=0.25
      F(10)=0.10
!
!  Subroutine ZZZZ is called to read the ZZZ file if it has not
!  already been read with a preceding 4ZZF or 4ZZZ record.
!
      If(ZZZFILE.EQ.0) Then
         ZZZFILE=99
         Call ZZZZ
      Endif
!
!  Specifications for building the frequency table are read from
!  the 4ZZF record (unit=1).
!
      Read(1,10,IOSTAT=STATUS) CD,VAR,MON,NUM
10    Format(A4,4I4)
      If(VAR.EQ.0) VAR=3
!
!  Input error checks.
!
      If(STATUS.NE.0) Then
         Write(20,20) CD
20       Format(' ERROR: Fortran IOSTAT error occurred reading an',
     +          ' input record with CD of ',A4)
         Call ERROR
```

```
      Endif
      If(VAR.LT.1.or.VAR.GT.3) Then
         Write(20,30) VAR
30       Format(' ERROR: VAR of',I3,' in 4ZZF field 2 is not valid.')
         Call ERROR
      Endif
      If(MON.LT.0.or.MON.GT.12) Then
         Write(20,40) MON
40       Format(' ERROR: MON of',I3,' in 4ZZF field 3 is not valid.')
         Call ERROR
      Endif
      If(NUM.GT.ZZ) Then
         Write(20,50) NUM,ZZ
50       Format(' ERROR: NUM of',I3,' in 4ZZF field 4 exceeds ZZ of',I3)
         Call ERROR
      Endif
!
!  With NUM greater than zero, control point identifiers are read
!  by Subroutine IDEN from IDEN records.
!
      If(NUM.GT.0) Then
         TID=0
         NID=NUM
         Call IDEN
         Do I=1,NUM
            Do Z=1,ZZ
               If(IDCP(I).EQ.ZZCP(Z)) Goto 70
            End Do
            Write(20,60) IDCP(I)
60          Format(' ERROR: Control point ',A6,' from IDEN record',
     +             ' matches no control point in ZZZ file.')
            Call ERROR
70       End Do
      Endif
      NUM=Abs(NUM)
!
!  With NUM of zero, frequency tables are created for all the
!  control points in the ZZZ file.
!
      If(NUM.EQ.0) Then
         NUM=ZZ
         Do Z=1,ZZ
            IDCP(Z)=ZZCP(Z)
         End Do
      Endif
!
!  Total number of months NM and number of flows per year NQ are set.
!  Flow array Q(NQ) is allocated.
!
      NM=NYR*12
      If(MON.GE.1) Then
         NQ=NYR
      Else
         NQ=NM
      Endif
      Allocate(Q(NQ))
      Q=0.0
!
!  ++++++++++++++ Beginning of Control Point Loop ++++++++++++++
!  Beginning of loop to develop tables for the NUM control points.
!
      CP=0
100   CP=CP+1
```

```
!
!  Table headings are written.
!
      Call TITLES
      If(VAR.EQ.1) Write(2,410) IDCP(CP)
      If(VAR.EQ.2) Write(2,420) IDCP(CP)
      If(VAR.EQ.3) Write(2,430) IDCP(CP)
      If(MON.GT.0) Write(2,440) MON
      Write(2,*) ' '
      Write(2,400)
      Write(2,450)
      Write(2,460)
      Write(2,400)
!
!  ++++++++++++++ Beginning of Water Right Loop ++++++++++++++
!  Beginning of loop to develop ZZWRNUM rows of data in a frequency table.
!  First row in frequency table corresponds to beginning of priority loop.
!  Each subsequent row in the table corresponds to a water right.
!
      Do 310 K=1,ZZWRNUM
!
!  Q(I) is either reservoir releases (VAR=1), regulated flows (VAR=2), or
!  available flows (VAR=3) read from the ZZZ file as ZZF(NM,ZZWRNUM,ZZ,3).
!
        I=0
        J=0
        Do M=1,NM
          J=J+1
          If(J.EQ.13) J=1
          If(MON.EQ.0.or.MON.EQ.J) Then
            I=I+1
            Q(I)=ZZF(M,K,CP,VAR)
          Endif
        End Do
!
!  Q(I) is sorted in descending order.
!
        SORTED=.FALSE.
200     If(.NOT.SORTED) Then
          SORTED=.TRUE.
          Do I=1,NQ-1
            If(Q(I).LT.Q(I+1)) Then
              TEMP=Q(I)
              Q(I)=Q(I+1)
              Q(I+1)=TEMP
              SORTED=.FALSE.
            Endif
          End Do
          Goto 200
        Endif
!
!  Mean and standard deviation are computed.
!
        SUM=0
        SUMSD=0.0
        Do I=1,NQ
          SUM=SUM+Q(I)
        End Do
        MEAN=SUM/NQ
        Do I=1,NQ
          SUMSD=SUMSD+(Q(I)-MEAN)**2
        End Do
        STDDEV=(SUMSD/(NQ-1))**0.5
```

```
!
!  Flows QFREQ(I) for each specified frequency F(I) are determined.
!
         Do I=1,10
            XF=F(I)*Real(NQ)
            IF1=INT(XF)
            IF2=IF1+1
            DXF=XF-Real(IF1)
            If(IF1.GT.0.and.IF2.GT.0) Then
               QFREQ(I)=(Q(IF1)-Q(IF2))*(1.0-DXF)+Q(IF2)
            Else
               QFREQ(I)=Q(1)
            Endif
         End Do
!
!  Row of table is written corresponding to beginning or a water right.
!
         If(ZZWR(K).EQ.'*** Beginning **') Then
            ZZWRID='Beginning       '
         Else
            ZZWRID=Adjustl(ZZWR(K))
         Endif
         Write(2,300) ZZWRI(K),ZZWRID,MEAN,STDDEV,Q(NQ),
     +               (QFREQ(I),I=1,10),Q(1)
300      Format(I4,2x,A16,F10.1,F8.0,6F8.1,4F8.0,2F9.0)
!
!  End of water right loop that adds rows to the frequency table.
!
310   End Do
      Write(2,400)
!
! +++++++++++++++  End of Control Point Loop  ++++++++++++++++++
!
      If(CP.LT.NUM) Goto 100
!
!  Format statements for table headings.
!
400   Format(138('-'))
410   Format('FREQUENCY TABLE FOR RESERVOIR RELEASES AT CONTROL POINT ',
     +       A6)
420   Format('FREQUENCY TABLE FOR REGULATED FLOWS AT CONTROL POINT ',A6)
430   Format('FREQUENCY TABLE FOR AVAILABLE FLOWS AT CONTROL POINT ',A6)
440   Format('for Month',I3)
!
450   Format(6x,'WATER',22x,'STANDARD',6x,'PERCENTAGE OF MONTHS WITH ',
     +       'FLOWS EQUALING OR EXCEEDING VALUES SHOWN IN THE TABLE')
!
460   Format('  WR  RIGHT',16x,'MEAN DEVIATION   100%',4x,'99%',5x,
     +       '98%',5x,'95%',5x,'90%',5x,'75%',5x,'60%',5x,'50%',5x,
     +       '40%',5x,'25%',6x,'10%   MAXIMUM')
!
!  Return to main program from Subroutine ZZFREQ.
!
      Deallocate(Q)
      Return
      End Subroutine ZZFREQ
!
!**********************************************************************
```