V.3.3-RES-J JOINT RESERVOIR REGULATION OPERATION

Identifier: RES-J

Application: All programs

Description: Operation RES-J models either a single reservoir or a system of reservoirs and connecting reaches. It uses topological information to describe the network to be modeled as a interconnected group of component objects. Networks may consist of reservoir, reach and node components. The RES-J Operation solves the entire network from upstream to downstream one time step at a time. Local flows to reaches and reservoirs and inflows to the upstream-most components must be generated before the RES-J Operation so that they are available as network inputs.

Methods are used to provide modeling functionality to each of the components. Methods are internal RES-J operations assigned to and acting upon network components, causing them to act in certain ways during simulation. For example, a SETRELEASE Method could be assigned to a Reservoir component to cause the reservoir to spill in a prescribed fashion. Methods are analogous to the Schemes/Utilities that are used in Operation RES-SNGL. They are referred to as Methods because their design is consistent with the object-oriented methodology and to emphasize the fact that Method functionality may not be the same as comparable Schemes in RES-SNGL. Table 1 lists the available RES-J Methods, the type of network component to which they are applied and a brief description of their functionality.

A Rule consists of a listing of one or more Methods and a governing conditional expression. When the expression evaluates to true the Methods will be enacted. This allows for variable operation of the system based on the state of the reservoir(s). For example, a rule based on the pool elevation of a downstream reservoir may evaluate to true when its elevation reaches a certain low level. The rule would then execute Methods which may include a SETRELEASE on an upstream reservoir to release larger quantities of water to help maintain a water level on the downstream reservoir.

A complete description of the reservoir system simulation is presented in Chapter II.4-RES-J.

Developed By: Riverside Technology, inc.

Input Summary: The input for the RES-J Operation contains every piece of necessary parametric information for a complete model run. Because this input file has the potential to be quite large depending on the complexity of the reservoir system, the input is organized in four sections: time series information; topology definition; parameter and states definition, including Method and component descriptions; and rules definition. This discussion will address each of these sections of the input and will provide examples of each.

Organization: The input deck's individual sections must be organized in a specific order, with the beginning and end of each section's information identified with a keyword and companion keyword syntax:

```
SECTIONNAME
   .
   .
   .
   ENDSECTIONNAME
```

A complete input deck's section organization would be:

```
RES-J     identifier
   TIMESERIES
      .
      .
      .
      ENDTIMESERIES
   TOPOLOGY
      .
      .
      .
      ENDTOPOLOGY
   PARAMETERS
      .
      .
      .
      ENDPARAMETERS
   RULES
      .
      .
      .
      ENDRULES
   ENDRES-J
```

General Syntax Rules

Input is in free format with fields separated by at least one blank.

Keywords are used by RES-J to enable rapid processing of parameter information while maintaining user readability. Most keywords (but not all) have companion keywords. The keyword, such as 'TOPOLOGY' and its companion keyword, such as 'ENDTOPOLOGY' surround the information associated with the topology definition. Keywords are identified within this documentation by full-capitalization. Optional keywords are enclosed in brackets '[]'.

Input is not case sensitive. All words and strings are converted to uppercase.

Comments are allowed throughout the input deck and are specified by the '#' character. Any characters on the same line and after the '#' will be ignored.

Information required to be on one line may be continued over multiple lines by ending each line with ' \' (a blank space and backslash). No line in the input file should extend beyond column 72 because it may not be decoded correctly.

Time Series Definition

This identifies input and output time series and prepare for the data transfer to and from the Forecast System. It also facilitates use of the time series by assigning an alias to each time series. These time series must correspond to component state variables.

Keyword	Definition and Format
TIME SERIES	Indicates the beginning of the time series section
TIMESTEP	Simulation time interval in hours (must be an integer fraction of 24)
INPUT	Indicates an input time series for the operation. Following 'INPUT' and on the same line, define the time series using: - A Forecast system time series identifier up to 8 characters in length - Data type code - Data time interval - An alias used by RES-J to facilitate reference of the time series. The alias must be unique among time series aliases and can be up to 12 characters in length.
OUTPUT	Indicates a time series that is an output from the Operation. Following 'OUTPUT' and on the same line, define the time series using: - A Forecast system time series identifier up to 8 characters in length - Data type code - Data time interval - An alias used by RES-J to facilitate reference of the time series. The alias must be unique among time series aliases and can be up to 12 characters in length. All output time series must be of the TIMESTEP interval.
ENDTIMESERIES	Indicates the end of the time series section

The following is an example of a time series definition section:

```
TIME SERIES
   TIMESTEP 06
   INPUT PREC_MAD MAP 01 Mad_Map
   INPUT MAD_INFL QME 06 Mad_In
```

```
    INPUT GAT_INFL QME 06 Gat_In
    OUTPUT MAD_RELS RQOT 06 Mad_Out
    OUTPUT GAT_POOL PELE 06 Gat_Elev
  ENDTIMESERIES
```

Time series are referenced by components, Methods, rules and expressions using the time series alias and a time series keyword. The time series keyword specifies the contents of the time series (e.g. INFLOW or OBSERVEDRELEASE). Table 2 lists the valid time series keywords, a description, an indicator to show whether the time series is input or output and the components/Methods to which the time series are applicable. The time series keywords required to parameterize each component and Method are also included in their respective syntax explanations.

Topology Definition

This section identifies each component of the system and its position relative to other components.

Keyword	Definition and Format
TOPOLOGY	Indicates the start of input for the topology section
RESERVOIR	Indicates a reservoir component. 'RESERVOIR' must be followed by: - an identifier (or name) for the reservoir, unique to all component identifiers. The identifier may be followed by one or more sets of topologic information used to identify components upstream from the current reservoir being defined: - topological keyword 'BELOW' - an identifier of the upstream component
REACH	Indicates a reach component. 'REACH' must be followed by: - an identifier (or name) for the reach, unique to all component identifiers. The identifier may be followed by one or more sets of topologic information used to identify components upstream from the current reach being defined: - topological keyword 'BELOW' - an identifier of the upstream component
NODE	Indicates a node component. 'NODE' must be followed by: - an identifier (or name) for the node, unique to all component identifiers. The identifier may be followed by one or more sets of topologic information used to identify components upstream from the current reach being defined: - topological keyword 'BELOW' - an identifier of the upstream component

Keyword	Definition
ENDTOPOLOGY	Indicates the end of input for the topology section

Important considerations when defining topology are:

1. RESERVOIR, REACH and NODE are the defining members (components) of topology.

2. The definition of the topology must proceed from upstream to downstream. Therefore, no component can be defined 'BELOW' another component until the second component has been defined.

3. A component may be linked to any number of upstream components.

4. A component cannot have more than one downstream component.

The following is an example of the topology definition section:

```
TOPOLOGY
   RESERVOIR Madden
   REACH Charges BELOW Madden
   REACH YourReach
   RESERVOIR Gatun BELOW Charges BELOW YourReach
   NODE YourNODE BELOW Gatun
ENDTOPOLOGY
```

Parameters Definition

This section characterizes each component in the system and describe each Method used during simulation.

In discussing the parameters definition section, component parameterization is addressed first and foremost. Despite being integrated with component definition in the input file parameters section, Method parameterization will only be briefly treated here. Each Method requires in-depth discussion of unique parameter syntax and functionality and therefore will be discussed later.

The parameters section begins with the keyword 'PARAMETERS' and ends with its companion keyword 'ENDPARAMETERS' with all component and Method parameters embedded between.

Keyword	Definition
PARAMETERS	Indicates the start of parameter information
[UNITS]	Units of the input. 'UNITS' must be followed by: - 'ENGLISH' or 'METRIC' 'UNITS' must be the first item after 'PARAMETERS'. The default is 'METRIC'.

Keyword	Definition
	Standard units for input are:

	English	Metric
Elevation	FT	M
Instantaneous discharge	CFS	CMS
Mean discharge	CFSD	CMSD
Storage	ACFT	M3
Rainfall	INCH	MM

ENDPARAMETERS — Indicates the end of parameter information.

Parametric Information for each RESERVOIR Component

The reservoir is the most basic and necessary component in a RES-J implementation. The following information describes the characteristics, states and limitations of the physical reservoir. Information parameterizing the operation of the reservoir is contained in various Methods to be described later.

Keyword	Definition
RESERVOIR	Indicates the start of reservoir parametric information. 'RESERVOIR' must be followed by a reservoir-type identifier defined in the topology section.
[CONSTANT]	Indicates specification of a constant to be used in the RULES definition section. These constants should not be used more than once in an English unit parameterization. Otherwise the conversion to **ResJ** internal units (SI units) will be erroneously performed more than once. 'CONSTANT' must be followed by: - 'component identifier.constant identifier' - the constant's value The following example assigns a value of 253.0 to a Madden reservoir constant called Flood_Elevation: CONSTANT Madden.Flood_Elevation 253.0
TSINPUT	Indicates the existence of an 'inflow' time series. 'TSINPUT' must be followed by: - time series keyword 'INFLOW' - an input time series alias defined in the TIMESERIES definition section. 1/ All reservoirs located at the top of the system topology tree (no components further upstream) must have at least one usage of 'TSINPUT'. Reservoirs elsewhere in the system may use 'TSINPUT' to define a local inflow, if desired, with outflow from an upstream component acting as the primary (and necessary) inflow to the reservoir. Outflow from upstream components MUST

Keyword	Definition
	NOT be defined using TSINPUT. Multiple uses of TSINPUT are acceptable.
[TSOUTPUT]	Indicates that one of the reservoir state time series will be output from RES-J. 'TSOUTPUT' must be followed by: - time series keyword 'POOL', 'RELEASE', 'STORAGE' or 'WITHDRAW' - an output time series alias defined in the TIMESERIES definition section. 1/ Multiple uses of TSOUTPUT are acceptable.
TABLE	Keyword indicating start of the elevation-storage table. 'TABLE' must be followed by: - table keyword 'ELEV_STOR' signifying the table's use as an elevation-storage table on the same line. Subsequent lines must contain the table data: - One elevation and its corresponding storage value pair, per line. Units are as defined above for elevation and storage.
ENDTABLE	Indicates the end of the elevation-storage table.
INITIALPOOL	Initial pool elevation; value must follow.
[INITIALRELEASE]	Initial instantaneous release; value must follow. Defaults to 0.0.
[INITIALWITHDRAW]	Initial instantaneous withdrawal; value must follow. Defaults to 0.0.
[INITIALINFLOW]	Total initial instantaneous inflow; value must follow. Defaults to 0.0.
[PREVIOUSPOOL]	Pool elevation one time step prior to carryover save; value must follow. Defaults to INITIALPOOL.
[PREVIOUSRELEASE]	Instantaneous release one time step prior to carryover save; value must follow. Defaults to 0.0.
[PREVIOUSWITHDRAW]	Instantaneous withdrawal one time step prior to carryover save; value must follow. Defaults to 0.0.
[PREVIOUSINFLOW]	Total instantaneous inflow one time step prior to carryover save; value must follow. Defaults to 0.0.

[MINPOOL] Minimum allowable pool elevation; value must follow. If 'MINPOOL' is not explicitly defined it will default to the lowest elevation specified in the elevation-storage table

[MINRELEASE] Minimum allowable instantaneous release; value must follow. If 'MINRELEASE' is not explicitly defined it will default to 0.0.

ENDRESERVOIR Indicates the end of reservoir parametric information.

Carryover transfer:

Pool elevation, release, withdrawal and inflows (initial and previous values) are saved.

During segment redefinition, the carryover is treated as 'general' carryover, that is data are considered independent of defined Methods for a given reservoir. Therefore, transformation of carryover will only occur if the carryover pool elevation lies outside the range of elevation on a modified elevation-storage curve. Otherwise, the carryover will simply be transferred from the old carryover array to the new carryover array. Both initial and previous values are handled identically.

The following rules apply:

```
release(new) = release(old)
withdrawal(new) = withdrawal(old)
inflow(new) = inflow(old)
```

The pool elevation will be changed by the following rule if elevation-storage curve is changed during segment redefinition.

```
pool elevation:
   if pool(old) > max elev. (new), then
      pool(new) = max elev. (new)
   if pool(old) < min pool (new), then
      pool(new) = min elev. (new)
   otherwise,
      pool(new) = pool(old)
```

The following are examples of RESERVOIR component input:

```
#Beginning of Reservoir definition
RESERVOIR Madden                  #Madden's declaration (as a
                                  #reservoir) and state information.
    TSINPUT INFLOW MAD_INFLOW     #Specification of the time series
                                  #with alias. Mad_In as providing
                                  #the INFLOW data for Madden. The
                                  #specification below displays the
                                  #option of specifying an input time
                                  #series using the full identifier.
                                  #An inflow time series is
```

```
                                    #required if the component is the
                                    #most upstream. The only input time
                                    #series type that may be specified
                                    #in the RESERVOIR/REACH/NODE
                                    #section is inflow-every other time
                                    #series is considered to be
                                    #method-specific and must be
                                    #declared with its associated
                                    #method.
      TSOUTPUT RELEASE MADRELES RQIE 01
                                    #Specification of output of RELEASE
                                    #values to the Mad_sim_rel time
                                    #SERIES. Any output from any
                                    #COMPONENT MUST be declared in the
                                    #RESERVOIR/REACH/NODE section.
      TABLE elev_stor               #Definition of Madden's elevation-
         80  1000000                #storage table. Must begin and
         100 10000000               #end with TABLE and
         110 10500000               #ENDTABLE. If units are English,
         115 11200000               #then storage units are ACFT,
         125 12100000               #otherwise M 3/. This table must
         130 12600000               #otherwise M 3/. This table must
         135 12600000               #be named elev_stor.
         140 13000000
         ENDTABLE
      INITIALPOOL     135           #Required.
      INITIALRELEASE  38.371
      MINPOOL         100           #Optional - defaults to lowest pool
                                    #from the elev_stor table.
      ENDRESERVOIR                  #Signifies the end of Madden's
                                    #information.
   RESERVOIR Gatun
      TSOUTPUT POOL Gat_elev        #Output of pool elevation.
      CONSTANT Gatun.Identifier  56.5
                                    #Use of the CONSTANT is for the
                                    #rules definitions. The Identifier
                                    #can be any text and it must
                                    #be preceded by the
                                    #component name. See the rules
                                    #section for details on how
                                    #CONSTANT values are used.
      TABLE elev_stor
         80  1000000
         100 10000000
         110 10500000
         115 11200000
         125 12100000
         130 12400000
         140 13000000
         ENDTABLE
      INITIALPOOL                   132.5
      INITIALRELEASE                45
      ENDRESERVOIR
   #End of reservoir information
```

Parametric Information for each REACH Component

The reach is used primarily to route water from one component to another through use of routing Methods parameterized elsewhere. Because reach characteristics are part of the routing Methods, reach parameters consist only of constants and time series labels.

Keyword	Definition
REACH	Indicates the start of reach parametric information. 'REACH' must be followed by a reach-type identifier defined in the topology section.
[CONSTANT]	Indicates specification of a constant to be used in the RULES definition section. These constants should not be used more than once in an English unit parameterization. Otherwise the conversion to RES-J internal units (SI units) will be erroneously performed more than once. 'CONSTANT' must be followed by: - 'component identifier.constant identifier' - the constant's value
TSINPUT	Indicates the existence of an inflow time series to be applied at the top of the reach. 'TSINPUT' must be followed by: - time series keyword 'INFLOW' - an input time series alias defined in the TIMESERIES definition section. 1/ All reaches located at the top of the system topology tree (no components further upstream) must have at least one usage of 'TSINPUT'. Reaches elsewhere in the system may use 'TSINPUT' to define a local inflow, if desired, with outflow from an upstream component acting as the primary (and necessary) inflow to the reach. Outflow from upstream components MUST NOT be defined using TSINPUT. Multiple uses of TSINPUT are acceptable.
[TSOUTPUT]	Indicates that one of the reach state time series will be output from RES-J. 'TSOUTPUT' must be followed by: - time series keyword 'OUTFLOW' or 'RELEASE', which are synonymous. - an output time series alias defined in the TIMESERIES definition section. 1/
ENDREACH	Keyword indicating end of reach parametric information.

Carryover Transfer:

No carryover is saved.

The required carryover for a reach is dependent on the routing Method used within the reach. Since LAGK is the only routing Method available, carryover related to a Reach component is described in the Method LAGK description.

Parametric Information for each NODE Component

A node is used as a confluence point of flows and as a checkpoint for certain stage / discharge relationships found in Method MAXSTAGE. Because a node is a point in the system, no routing or other transformation of inflow to outflow occurs; what comes in immediately goes out.

Keyword	Definition
NODE	Indicates the start of node parametric information; 'NODE' must be followed by a node-type identifier defined in the topology section.
[CONSTANT]	Indicates specification of a constant to be used in the RULES definition section. These constants should not be used more than once in an English unit parameterization. Otherwise the conversion to RES-J internal units (SI units) will be erroneously performed more than once. 'CONSTANT' must be followed by: - 'component identifier.constant identifier' - the constant's value
TSINPUT	Indicates the existence of an inflow time series to be applied at the top of the reach. 'TSINPUT' must be followed by: - time series keyword 'INFLOW' - an input time series alias defined in the TIMESERIES definition section. 1/ While there is no foreseeable reason to place a node at the top of the system topology tree (no components further upstream) any node so positioned must have at least one usage of 'TSINPUT'. Nodes elsewhere in the system may use 'TSINPUT' to define a local inflow, if desired, with outflow from another component acting as the primary (and necessary) inflow to the reach. Outflow from upstream components must not be defined using TSINPUT. Multiple uses of TSINPUT are acceptable.
[TSOUTPUT]	Indicates that one of the node state time series will be output from RES-J. 'TSOUTPUT' must be followed by: - time series keyword 'OUTFLOW' - an output time series alias defined in the TIMESERIES definition section. 1/

	Multiple uses usage of TSOUTPUT are acceptable.
[DISCHARGE]	Initial discharge at the node; value must follow. 4/
[PREVIOUSDISCHARGE]	Discharge at the node one step prior to carryover save; value must follow. 4/
ENDNODE	Indicates the end of node parametric information.

Carryover Transfer:

DISCHARGE and PREVIOUSDISCHARGE values are saved. Transfer of these data are direct, without transformation:

```
DISCHARGE(NEW) = DISCHARGE(OLD)
PREVIOUSDISCHARGE(NEW) = PREVIOUSDISCHARGE(OLD)
```

1/ The time series identifier, data type and time interval can be used in place of the alias to identify a time series.

Rules Definition

The simulation rules are specified by grouping one or more Methods (a Method list) with an expression. The expression evaluates a system state, such as a reservoir inflow, outflow or pool elevation. Only when the expression evaluates to true do the Methods associated with the expression execute. Because system solution proceeds from upstream components to downstream components, actual execution of Methods listed in the RULES section may vary from the order in which they are listed. For a given component, however, each Method listed in the RULES section will test its conditional expression (and execute, if TRUE) in the order the component's Methods are listed in the RULES section.

Although the syntax suggests a one-to-many relationship between an expression and the Methods in its list, RES-J actually parses the RULES into a one-to-one type relationship. Each Method explicitly listed under an expression will receive a copy of the expression. If a Method is explicitly listed more than once in the RULES definition section, the Method's execution will be conditional on the last expression assigned to the Method. Any Method implied in the RULES section by explicitly listing a combo-type Method such as SETSUM, SETMIN or SETMAX (the implied Method having been defined as part of the combo-type Method in the parameters definition section) does not require an expression to be executed. Execution of the implied Method depends solely on the execution of the explicitly listed combo-type Method. Any Method defined in the parameters section which is not explicitly listed or implied in the RULES definition section will never execute, as it is never assigned an expression capable of evaluating to TRUE. States, used in evaluation of the expression, are updated following solution of a loss-type Method such as RAINEVAP or upon complete solution of the system for a given timestep. Release and withdrawal-type Methods do not update the state. 1/

PREVIOUS* refers to the value at the beginning of the previous timestep; STARTING* refers to the value at the start of the current timestep; ENDING* refers to the value at the end of the current timestep. For complete discussion of states and how and when they are updated, see Chapter II.4-RES-J.

The RULES defined in this section are not a progression of state checks. Note that while the concept is in the format of a series of 'If-Then' statements, there is neither an 'Else' statement nor default condition applicable if none of the expressions evaluate to true. Use of the 'TRUE' conditional expression, which always evaluates to true, can be used to provide a type of default condition when placed at the top of the RULES definition.

Keyword	Definition and Format
RULES	Indicates the start of the Rules Section
[	Indicates the beginning of an expression

A simple expression is a comparison of two values through use of a conditional.

Values can be references to component states, component-defined constants, numerical constants, summations of any combination of two states or constants, dates and 'TRUE'. 2/

Valid values include:

- Reservoir states:
  - PREVIOUSPOOL, STARTINGPOOL, ENDINGPOOL, PREVIOUSINFLOW, STARTINGINFLOW, ENDINGINFLOW, PREVIOUSRELEASE, STARTINGRELEASE, ENDINGRELEASE, PREVIOUSWITHDRAW, STARTINGWITHDRAW and ENDINGWITHDRAW. The states POOL and RELEASE are also valid. Because these states refer to the same values as STARTINGPOOL and STARTINGRELEASE, respectively, their use is discouraged. 3/
  - Format is '<ReservoirName>.<state>'.
  - Example: 'ReservoirA.PREVIOUSPOOL'
- Node states:
  - Format is '<ReservoirName>.<state>': PREVIOUSINFLOW, STARTINGINFLOW, ENDINGINFLOW, PREVIOUSDISCHARGE, STARTINGDISCHARGE and ENDINGDISCHARGE. 4/
  - Example: 'Node.PREVIOUSDISCHARGE'
- Component-defined constants as defined in the Component parameter section:
  - These constants should only be used once in a rule set parameterized using English units. Otherwise the conversion to RES-J

internal units (SI units) will be erroneously performed more than once.
Example: 'ReservoirA.BottomOfSpillway'

Numerical constants:

Any numerical value. Units associated with the value are determined by the UNITS state (ENGLISH or METRIC) and the type of units associated with the preceding value. 4/
Examples: 98.3, -15.4.

Sums or Differences:

Two or more values can be summed or their difference can be calculated using the '+' or '-' signs, respectively, to form a single value. 5/
Example:

```
ResA.PREVIOUSINFLOW -
ResA.STARTINGINFLOW
```

Dates:

The keyword 'DATE' refers to the current date time the model is solving.
A user specified constant can also be used. 6/

TRUE:

The keyword 'TRUE' defines an expression that always evaluates to true.

Conditionals are symbolic references of equality, non-equality, less-than, less-than-or-equal-to, greater-than and greater-than-or-equal-to.

Valid conditionals respective to the description above are:

'==', '!=', '<', '<=', '>' and '>='

Examples of simple expressions include:

```
[TRUE]
[ResA.STARTINGPOOL >= 95]
[ResB.ENDINGPOOL < ResB.MinLockageElev]
[NodeA.STARTINGDISCHARGE > NodeA.PREVIOUSDISCHARGE]
[NodeB.STARTINGDISCHARGE - \
  NodeA.PREVIOUSDISCHARGE > 100]
[DATE > 06/01]
```

Complex expressions can be constructed using logical operators.

Valid logical operators are '&&' and '||' representing AND and OR logic, respectively. Parentheses can be used to group portions of the complex expression, but should be limited in their use. Line continuation symbols ('\') can also be used for long expressions. The following syntax example demonstrates construction of complex expressions from multiple expressions. 7/

```
[ ResA.STARTINGPOOL > 280 || \
```

```
                    (ResA.PREVIOUSINFLOW  > 1000 && \
                    NodeB.STARTINGDISCHARGE < 450) ]
```

] Indicates the end of an expression

:: Indicates the beginning of a Method. '::' must be followed by:
- A component identifier defined in the topology section
- A Method identifier defined in the parameters section

ENDRULES Indicates the end of the Rules definition

1/ Note that prior to NWSRFS release 22, a given component's states were updated immediately following its solution. Because of this, an expression based on the states of an upstream component might evaluate differently for the Methods associated with upstream components than it would for Methods associated with downstream components within a time step.

2/ Expressions can test states unrelated to the objects owning the Methods to be executed if the expression is true. Be warned that use of the MAXSTAGE Method may create a copied subsystem with expressions linked to components which are not included in the subsystem. This will cause the system to fail.

3/ ENDING* states are not defined until after the component solves for the current timestep-only components downstream of the object should test the state. An exception to this limitation is ENDINGINFLOW which becomes available as soon as all inflows to a reservoir become known (meaning upstream components have solved for outflow).

4/ Note that the units with these numbers could only be determined by parsing the previous value. Therefore, numerical constants should generally follow a Component state who's dimensionality can be determined (ie: PREVIOUSPOOL has units of length). Do not begin an expression with a numerical constant. Always begin with a component state, date or TRUE.

5/ Note that no check for appropriate dimensionality (consistency of units) is made.

6/ All dates are considered with equal precision. For example, 2/2 will be interpreted as 2/2_00:00. Date expressions are evaluated using the fractional portion of the date following conversion to decimal years. To specify a date constant use one of the following formats:

```
'2-digit_month'/'2-digit_day'
'2-digit_month'/'2-digit_day'_'2-digit_hour'
'2-digit_month'/'2-digit_day'_'2-digit_hour':'2-digit_minute'
```

7/ No line in the input file should extend beyond column 72 because it may not be decoded correctly.

The following is an example of a set of rules:

```
RULES
[(Madden.STARTINGpool > 120) && (DATE > 10/15) ]
                                   #Condition which, if satisfied,
                                   #will cause execution of these
                                   #three methods.
   ::RAINEVAP Madden mad_rel       #Each method must be identified
   ::LAGK YourReach lagk           #using the method type,
   ::SETWITHDRAW Gatun gat_with    #component name and method name.


[(Gatun.previouspool < Gatun.Identity)]
                                   #This conditional will be
                                   #evaluated next. If satisfied,
                                   #it will cause execution of
                                   #these three methods and
                                   #overwrite anyp revious TRUE
                                   #RULES. Notice the use of the
                                   #CONSTANT value, Gatun.Identity.
   ::SETELEVATION Madden mad_elev  #Each method must be identified
   ::LAGK YourReach lagk           #using the method type,
   ::SETWITHDRAW Gatun gat_with    #component name and method name.

 [(Gatun.STARTINGRELEASE < 3000.)]
                                   #This conditional will be
                                   #evaluated next. If satisfied,
                                   #it will cause execution of the
                                   #next method and overwrite any
                                   #previous TRUE RULES.
   ::SETRELEASE Gatun power        #Each method must be identified
                                   #using the method type,
                                   #component name and method name.
ENDRULES
```

RES-J Method Syntax

A system of reservoir, reach and node components is able to mass balance the water in a network at every time step solving Methods that are specific to each individual component. Table 3 lists the Methods in RES-J and shows the type of component to which they apply, as well as the computational variable.

A combination Method is one that can act on several Methods that solve for the same type of output variable. For example, a SETMAX can be applied to a SETRELEASE Method and a MAXDECREASE Method since both solve for release. SETMAX will select the largest of the two computed releases. Similarly, a SETSUM Method could be applied to multiple SETWITHDRAW Methods and it would sum the individual withdrawal values.

While the necessary parametric data varies significantly from Method to Method some syntax is common across all Methods:

1. Methods must be uniquely declared using the Method keyword, component identifier that it acts upon and the Method identifier (e.g. RAINEVAP Madden mad_re).
   This declaration indicates the beginning of this Method's definition and its end must be declared by ENDRAINEVAP.

2. Method-specific time series data in the input deck may have a distribution applied to them. If a distribution is used, there must be one distribution value for each time step in a day (e.g., 4 values for a 6-hour time step) and the values must sum to 1.0. If no distribution is specified, a uniform distribution is assumed.

The following Sections describe each Method.

The following is an example of a complete RES-J input deck:

```
RES-J       GAT&MAD

TIMESERIES
   TIMESTEP        01
   INPUT   GATUN    MAP  01 GAT_MAP           # GATUN PRECIPITATION
   INPUT   MADDENSM SQIN 01 MAD_INFLOW        # LOCAL INFLOWS
   INPUT   GATUNSM  SQIN 01 GAT_INFLOW
   INPUT   MADPOOL  PELV 01 MAD_OBS_POOL      # OBSERVED POOL11G
   INPUT   GATPOOL  PELV 01 GAT_OBS_POOL
   INPUT   MADSPILL RQSW 01 MAD_OBS_SPILL     # OBSERVED SPILL
   INPUT   GATSPILL RQSW 01 GAT_OBS_SPILL
   INPUT   MADPOWER RQIE 01 MAD_OBS_POWER     # OBSERVED POWER
   INPUT   GATPOWER RQIE 01 GAT_OBS_POWER
   INPUT   MADMUNI  DQIN 01 MAD_OBS_MUNI      # OBSERVED MUNICIPAL DEMAND
   INPUT   GATMUNI  DQIN 01 GAT_OBS_MUNI
   INPUT   GATUNLOX DQIN 01 GAT_OBS_LOCK      # OBSERVED GATUN LOCK DEMAND
   INPUT   PEDMGLOX DQIN 01 PED_OBS_LOCK      # OBSERVED PEDRO MIGUEL LOCK DEMAND
   OUTPUT  GATWITHD SDQI 01 GAT_SIM_WITH      # SIMULATED WITHDRAW
   OUTPUT  MADWITHD SDQI 01 MAD_SIM_WITH
   OUTPUT  GATRELES RQIE 01 GAT_SIM_REL       # SIMULATED RELEASE
   OUTPUT  MADRELES RQIE 01 MAD_SIM_REL
   OUTPUT  GATPOOL  PELE 01 GAT_SIM_POOL      # SIMULATED POOL
   OUTPUT  MADPOOL  PELE 01 MAD_SIM_POOL
   ENDTIMESERIES

TOPOLOGY
   RESERVOIR        MADDEN
   REACH            CHAGRES BELOW MADDEN
   RESERVOIR        GATUN BELOW CHAGRES
   ENDTOPOLOGY

PARAMETERS
   UNITS ENGLISH

   RESERVOIR MADDEN
      CONSTANT MADDEN.DROUGHT_ELEVATION_205 205.0
      CONSTANT MADDEN.FLOOD_ELEVATION_253 253.0
      TSINPUT INFLOW MADDENSM SQIN 01
      TSOUTPUT RELEASE MAD_SIM_REL
      TSOUTPUT WITHDRAW MAD_SIM_WITH
      TSOUTPUT POOL MAD_SIM_POOL
      TABLE   ELEV_STOR
         72.0    0.0
         201.0   184068.0
         202.0   189922.0
         203.0   195914.0
         ...
         272.0   913797.0
```

```
         273.0   927319.0
         274.0   940840.0
         ENDTABLE
      INITIALPOOL     247.0
      INITIALRELEASE  1200
      INITIALWITHDRAW 1000
      ENDRESERVOIR

   REACH CHAGRES
      ENDREACH

   RESERVOIR GATUN
      CONSTANT GATUN.DROUGHT_ELEVATION_81P5 81.5
      CONSTANT GATUN.FLOOD_ELEVATION_88 88.0
      TSINPUT INFLOW GAT_INFLOW
      TSOUTPUT RELEASE GAT_SIM_REL
      TSOUTPUT WITHDRAW GAT_SIM_WITH
      TSOUTPUT POOL GAT_SIM_POOL
      TABLE   ELEV_STOR
         40.0    0.0
         77.0    3393274.0
         77.5    3440588.0
         78.0    3487925.0
         ...
         98.5    5666244.0
         99.0    5721423.0
         99.5    5776607.0
         100.0   5831807.0
         ENDTABLE
      INITIALPOOL    85.5
      INITIALRELEASE 1200
      INITIALWITHDRAW 1000
      ENDRESERVOIR

   # MADDEN COMPONENT METHODS

   # DAILY MUNICIPAL DEMANDS FOR MADDEN RESERVOIR.  THESE VALUES REPRESENT
   # THE AVERAGE DAILY WITHDRAWAL IN CFS/D AND WERE COMPILED USING THE
   # AVERAGE DEMAND OVER THE YEARS 1994-1996.
   SETWITHDRAW MADDEN MUNICIPAL_DEMAND
      TSINPUT OBSERVEDWITHDRAW MAD_OBS_MUNI
      VALUES
         ELEV    0.0     ENDELEV
         01/01   189.0
         02/01   189.0
         03/01   192.0
         04/01   193.0
         05/01   192.0
         06/01   187.0
         07/01   187.0
         08/01   185.0
         09/01   187.0
         10/01   179.1
         11/01   183.0
         12/01   184.0
         ENDVALUES
      BLENDTBL 0         # NO BLENDING
      BLENDTS 0          # NO BLENDING OF TIME SERIES VALUES
      NORMAL             # NO INTERPOLATION BETWEEN DATES
      ENDSETWITHDRAW

   # RELEASE WATER FROM MADDEN RESERVOIR IN ORDER TO KEEP POOL ELEVATION AT A
   # CONSTANT 205 FT. THIS ELEVATION REPRESENTS THE MINIMUM POOL ELEVATION AT
   # WHICH MADDEN LAKE SHOULD BE KEPT.
   SETELEVATION MADDEN POOLELEVATION_205
      VALUES
         01/01   205.0
         ENDVALUES
```

```
   BLENDTBL 0
   BLENDTS 0
   NORMAL
   ENDSETELEVATION

# RELEASES FOR POWER AT MADDEN RESERVOIR. RELEASES FOR POWER ARE MADE BASED
# BOTH ON TIME OF YEAR AND CURRENT POOL ELEVATION. THE SETRELEASE METHOD
# BELOW ASSUMES FULL POWER IS APPROXIMATELY 3500 CFS/D. NO ALLOWANCES FOR
# DIURNAL POWER HAS BEEN INCLUDED WITHIN THIS METHOD YET. THIS TABLE IS A
# VERY ROUGH ESTIMATE OF WATER USE IN GENERATION BY ANALYSIS OF THE YEARS
# 1987-1996 WATER USE IN GENERATION. THE RELEASE FOR 215 AND BELOW IS BASED
# ON THE ALL TIME MONTHLY LOW FOR THE 10 YEAR PERIOD.
SETRELEASE MADDEN POWER
   TSINPUT OBSERVEDRELEASE MADPOWER RQIE 01
   VALUES
      ELEV   215  217  222  228  233  236  243  247  249  251  252 ENDELEV
      01/01 1249 1250 1250 1300 1400 1600 1800 2000 2200 2400 2600
      02/01 1476 1500 1700 1800 1900 2000 2100 2200 2400 2600 2800
      03/01 1441 1500 1700 1800 1900 2000 2100 2200 2400 2600 2800
      04/01  954 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
      05/01 1302 1500 1700 2000 2000 2300 2400 2400 3000 3000 3000
      06/01  763 1502 1500 1700 2000 2000 2300 2400 2400 3000 3000
      07/01 1639 1700 1700 1800 1900 2000 2100 2200 2300 2400 2500
      08/01 1019 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
      09/01 1606 1800 2000 2200 2400 2600 2800 3000 3200 3500 3500
      10/01 1645 1800 2000 2200 2400 2600 2800 3000 3200 3500 3500
      11/01 1981 1800 2000 2200 2400 2600 2800 3000 3200 3500 3500
      12/01 1506 1800 2000 2200 2400 2600 2800 3000 3200 3500 3500
      ENDVALUES
   BLENDTBL 0
   BLENDTS 0
   NORMAL
   ENDSETRELEASE

# CRITICAL FLOODING PERIOD FOCUS ON SAVING THE DAM AT MADDEN BASED ON FLOOD
# CONTROL MANUAL PMF CASE SCENARIO. REST IS BASED ON HISTORICAL SPILLS AT
# MADDEN (1987-1996).
SETRELEASE MADDEN SPILL
   TSINPUT OBSERVEDRELEASE MAD_OBS_SPILL
      VALUES
         ELEV     0  250.0  252.5 255.00  255.78 263.00  ENDELEV
         01/01  0    250   2000  75000  168000 226000
         ENDVALUES
      BLENDTBL 0
      BLENDTS 0
      NORMAL
      ENDSETRELEASE

SETSUM MADDEN POWER&SPILLS
   SETRELEASE MADDEN POWER
   SETRELEASE MADDEN SPILL
   ENDSETSUM

ADJUST MADDEN MADDEN_ADJUST
   OBSERVEDPOOL MAD_OBS_POOL
   BLENDTS 5
   ENDADJUST

# GATUN COMPONENT METHODS

# THE RAINEVAP METHOD ACCOUNTS FOR DIRECT RAINFALL AND EVAPORATION OVER THE
# GATUN LAKE SURFACE. AVERAGE DAILY EVAPORATION VALUES HAVE BEEN TAKEN FROM
# DAILY PAN VALUES.
RAINEVAP GATUN GATUN_RAINEVAP
   TSINPUT OBSERVEDPRECIP GAT_MAP
   PRECIP
      VALUES
         01/01 0.0
```

```
        ENDVALUES
     ENDPRECIP
     EVAP
        VALUES
           01/15 0.127
           02/15 0.148
           03/15 0.154
           04/15 0.141
           05/15 0.104
           06/15 0.091
           07/15 0.094
           08/15 0.093
           09/15 0.097
           10/15 0.095
           11/15 0.093
           12/15 0.101
        ENDVALUES
     ENDEVAP

  # DAILY MUNICIPAL DEMANDS FOR GATUN RESERVOIR.  THESE VALUES REPRESENT THE
  # AVERAGE DAILY WITHDRAWAL IN CFS/D AND WERE COMPILED USING THE 1987-1996
  # HISTORICAL DATA.
  SETWITHDRAW GATUN MUNICIPAL_DEMAND
     TSINPUT OBSERVEDWITHDRAW GAT_OBS_MUNI
     VALUES
        ELEV    80.0    ENDELEV
        01/01   122.2
        02/01   127.1
        03/01   119.0
        04/01   128.7
        05/01   113.9
        06/01   122.3
        07/01   119.8
        08/01   119.8
        09/01   113.7
        10/01   115.2
        11/01   122.9
        12/01   121.8
        ENDVALUES
     BLENDTBL 0
     BLENDTS 0
     NORMAL
     ENDSETWITHDRAW

  # AVERAGE LOCKS DEMAND FOR GATUN LOCKS. VALUES BELOW 81.5 FT REPRESENT 80%
  # OF THE AVERAGE WATER USE FOR THE GATUN LOCKS OVER THE YEARS 1992-1995.
  # VALUES FOR POOL ELEVATIONS ABOVE 81.5 REPRESENT 100% OF THE AVERAGE WATER
  # USE FOR THE GATUN LOCKS OVER THE YEARS 1992-1996.
  # VALUES ARE REPRESENTED IN CFS/D.
     SETWITHDRAW GATUN GATUNLOCKS
        TSINPUT OBSERVEDWITHDRAW GAT_OBS_LOCK
        VALUES
           ELEV         0     81.5    ENDELEV
           01/01   1266.0   1581.0
           02/01   1257.0   1570.0
           03/01   1259.0   1573.0
           04/01   1223.0   1530.0
           05/01   1156.0   1445.0
           06/01   1113.0   1393.0
           07/01   1124.0   1404.0
           08/01   1146.0   1431.0
           09/01   1104.0   1379.0
           10/01   1215.0   1518.0
           11/01   1158.0   1448.0
           12/01   1190.0   1486.0
           ENDVALUES
        BLENDTBL 0
        BLENDTS 0
```

```
      NORMAL
      ENDSETWITHDRAW

# AVERAGE LOCK DEMAND FOR THE PEDRO MIGUEL LOCKS. THESE VALUES REPRESENT 100%
# OF THE AVERAGE WATER USE FOR THE PEDRO MIGUE LOCKS OVER THE YEARS 1992-1996.
# VALUES ARE REPRESENTED IN CFS/D.
SETWITHDRAW GATUN PEDROMIGUELLOCKS
   TSINPUT OBSERVEDWITHDRAW PED_OBS_LOCK
      VALUES
         ELEV       0.0       81.5    ENDELEV
         01/01   1235.1     1543.8
         02/01   1268.8     1586.1
         03/01   1284.3     1605.4
         04/01   1247.8     1559.8
         05/01   1177.7     1472.1
         06/01   1125.9     1407.4
         07/01   1131.4     1414.3
         08/01   1144.6     1430.7
         09/01   1082.1     1352.7
         10/01   1164.0     1455.0
         11/01   1129.3     1411.7
         12/01   1216.8     1521.1
         ENDVALUES
      BLENDTBL 0
      BLENDTS 0
      NORMAL
      ENDSETWITHDRAW

SETSUM GATUN MUNI&LOCKS
   SETWITHDRAW GATUN MUNICIPAL_DEMAND
   SETWITHDRAW GATUN GATUNLOCKS
   SETWITHDRAW GATUN PEDROMIGUELLOCKS
   ENDSETSUM

SETRELEASE GATUN POWER
   TSINPUT OBSERVEDRELEASE GAT_OBS_POWER
   VALUES
      ELEV    0    84.95   85.25   85.65   86.15   87.55   87.75   ENDELEV
      01/01   0        0       0       0       0       0       0
      04/01   0        0       0    1500    1500    1500    3000
      05/01   0     1500    1500    1500    3000    4500    4500
      10/01   0        0    1500    1500    3000    3000    4500
      11/01   0        0       0       0    1500    3000    4500
      ENDVALUES
   BLENDTBL 0
   BLENDTS 0
   NORMAL
   ENDSETRELEASE

SETRELEASE GATUN SPILL
   TSINPUT OBSERVEDRELEASE GAT_OBS_SPILL
   VALUES
      ELEV       0   87.60  87.75   88.00   89.14   92.55  ENDELEV
      01/01      0   26000  52000  182000  268000  329000
      ENDVALUES
   BLENDTBL 0
   BLENDTS 0
   NORMAL
   ENDSETRELEASE

SETSUM GATUN POWER&SPILLS
   SETRELEASE GATUN POWER
   SETRELEASE GATUN SPILL
   ENDSETSUM

ADJUST GATUN GATUN_ADJUST
   TSINPUT OBSERVEDPOOL GAT_OBS_POOL
   BLENDTS 5
```

```
   ENDADJUST

   # CHAGRES COMPONENT METHODS

   # CURRENTLY THE REACH TIME BETWEEN MADDEN AND GAMBOA IS APPROXIMATELY 9 HOURS.
   # CURRENTLY, NO ATTENUATION HAS BEEN IMPLEMENTED WITHIN THIS IMPLEMENTATION
   # OF THE LAG/K METHOD.
   LAGK CHAGRES CHAGRESLAGK
      LAG         9   # 9 HOURS
      K           0
      COINFLOW
         VALUES
            1000  # EACH CARRYOVER VALUE MUST HAVE SEPARATE LINE OF DATA
            1000  # SEPARATE LINE OF DATA
            1000
            1000  #Must have LAG/TIMESTEP+1
         1000  #TIMESTEP= 1 hour
            1000  #10 carryover values for the Inflow
            1000
            1000
            1000
            1000
            ENDVALUES
         ENDCOINFLOW
      ENDLAGK

   ENDPARAMETERS

RULES

   # ALL THE RULES EXPRESSIONS ARE EXECUTED FOR EVERY TIME STEP TO DETERMINE IF THE
   #EXPRESSION IS TRUE OR FALSE.  IF THE EXPRESSION IS TRUE, ALL THE METHODS UNDER
   #THIS EXPRESSION WILL BE EXECUTED.  THE METHODS EXECUTED IN AN EARLIER TRUE
   #EXPRESSION WILL BE OVERWRITTEN BY THE METHODS FROM A LATER TRUE EXPRESSION.

   [TRUE]

   # THE FOLLOWING METHODS ARE EXECUTED FOR EVERY TIME STEP:

   # METHODS FOR MADDEN RESERVOIR

   # SETWITHDRAW ACCOUNTS FOR WATER REMOVED FROM THE RESERVOIR FOR MUNICIPAL
   # CONSUMPTIVE DEMAND
   ::SETWITHDRAW MADDEN MUNICIPAL_DEMAND

   # SETSUM ACCOUNTS FOR WATER WHICH IS RELEASED FROM MADDEN EITHER THROUGH
   # GENERATION OR BY SPILL.
   ::SETSUM MADDEN POWER&SPILLS
   #::SETRELEASE MADDEN POWER
   #::SETRELEASE MADDEN SPILL

   # ADJUST MADDEN'S SIMULATED RELEASE AND POOL ELEVATIONS WITH OBSERVATIONS
   # WHEN POSSIBLE
   ::ADJUST MADDEN MADDEN_ADJUST

   # LAG/K ROUTES WATER FROM MADDEN TO GATUN VIA THE CHAGRES REACH
   ::LAGK CHAGRES CHAGRESLAGK

   # RAINEVAP ACCOUNTS FOR DIRECT RAINFALL AND EVAPORATION OVER THE GATUN LAKE
   # SURFACE.
   ::RAINEVAP GATUN GATUN_RAINEVAP

   # SETSUM ACCOUNTS FOR WATER WHICH IS WITHDRAWN FROM GATUN EITHER FOR
   # MUNICIPAL CONSUMPTION OR LOCK USAGE
   ::SETSUM GATUN MUNI&LOCKS
   #::SETWITHDRAW GATUN MUNICIPAL_DEMAND
   #::SETWITHDRAW GATUN GATUNLOCKS
   #::SETWITHDRAW GATUN PEDROMIGUELLOCKS
```

```
   # SETSUM ACCOUNTS FOR WATER WHICH IS RELEASED FROM GATUN EITHER THROUGH
   # GENERATION OR BY SPILL.
   ::SETSUM GATUN POWER&SPILLS
   #::SETRELEASE GATUN POWER
   #::SETRELEASE GATUN SPILL

   # ADJUST GATUN'S SIMULATED RELEASE AND POOL ELEVATIONS WITH OBSERVATIONS
   # WHEN POSSIBLE
   ::ADJUST GATUN GATUN_ADJUST

   ######### SEVERE DROUGHT CONDITIONS ###############
   # MADDEN LAKE IS ABOVE THE 205 FOOT POOL LEVEL, GATUN LAKE IS BELOW THE 81.5
   # FOOT POOL LEVEL.  UNDER THIS SCENARIO, MADDEN RESERVOIR MAKES RELEASES FOR
   # MUNICIPAL DEMANDS AND RELEASES WATER TO GATUN RESERVOIR UNTIL THE 205 POOL
   # LEVEL IS ACHIEVED AT MADDEN.  GATUN RESERVOIR IS LIMITED TO MUNICIPAL
   # WITHDRAWALS AS WELL AS WITHDRAWALS FOR RESTRICTED GATUN LOCK AND RESTRICTED
   # PEDRO MIGUEL LOCK OPERATION.
   [ ((MADDEN.POOL > MADDEN.DROUGHT_ELEVATION_205)  && \
      (GATUN.POOL  < GATUN.DROUGHT_ELEVATION_81P5)) ]
      # MADDEN RESERVOIR
      ::SETELEVATION MADDEN POOLELEVATION_205

   ENDRULES

ENDRES-J
```

Table 1. RES-J Methods

Name	Type	Description
ADJUST	Reservoir	Adjusts reservoir output
BALANCE	Reservoir	Balances reservoir storage for multiple reservoir systems
CONSTANT	General	Associates a static numeric constant with a name
LAGK	Reach	Routes water through a reach according to the LAGK routing Method
MAXDECREASE	Reservoir	Generates maximum daily decrease in reservoir discharge
MAXINCREASE	Reservoir	Generates maximum daily increase in reservoir discharge
MAXSTAGE	Reservoir	Generates a maximum release from a reservoir given a maximum allowable discharge downstream
RAINEVAP	Reservoir	Accounts for direct meteorological effects on a reservoir lake surface area
SETELEVATION	Reservoir	Prescribes elevation
SETMAX	Reservoir	Selects the maximum release of any two or more specified reservoir Methods
SETMIN	Reservoir	Selects the minimum release of any two or more specified reservoir Methods
SETRELEASE	Reservoir	Generates a single reservoir release based on multiple criteria
SETSUM	Reservoir	Sums prescribed releases
SETWITHDRAW	Reservoir	Generates a single reservoir withdrawal based on multiple criteria
SPILLWAY	Reservoir	Augments a single reservoir's previously determined release according to the pseudo-implicit solution of pool elevation vs. spill.

Table 2. Time series keyword parameters

Applicable Types	Time Series Keywords	Description	Input/Output
All components	INFLOW	Inflow	Input
RAINEVAP Method	OBSERVEDEVAP	Evaporation	Input
RAINEVAP Method	OBSERVEDPRECIP	Precipitation	Input
SETELEVATION, ADJUST Methods	OBSERVEDPOOL	Observed reservoir pool elevation	Input
SETRELEASE, ADJUST Methods	OBSERVEDRELEASE	Observed reservoir release	Input
SETWITHDRAW Method	OBSERVEDWITHDRAW	Observed reservoir withdrawals	Input
Reservoir component	POOL	Pool elevation	Output
Reservoir component	RELEASE	Reservoir release	Output
Reservoir component	STORAGE	Reservoir storage	Output
Reservoir component	WITHDRAW	Reservoir withdrawals	Output
Reach component	INFLOW	Reach inflow	Input
Reach component	OUTFLOW/RELEASE	Reach outflow	Output
Node component	INFLOW	Node inflow	Input
Node component	OUTFLOW	Node outflow	Output

Table 3. RES-J Methods, components and variables

Method Type	Component Acted Upon	Solves For
ADJUST	Reservoir	Release
BALANCE	Reservoir	Release
LAGK	Reach	Outflow
MAXDECREASE	Reservoir	Release
MAXINCREASE	Reservoir	Release
MAXSTAGE	Reservoir	Release
RAINEVAP	Reservoir	Loss
SETELEVATION	Reservoir	Release
SETMAX	Reservoir, Reach	Combination
SETMIN	Reservoir, Reach	Combination
SETRELEASE	Reservoir	Release
SETSUM	Reservoir, Reach	Combination
SETWITHDRAW	Reservoir	Withdrawal
SPILLWAY	Reservoir	Release (spill augmented) and pool elevation

V.3.3-RES-J-ADJUST JOINT RESERVOIR REGULATION OPERATION METHOD ADJUST

Description

Method ADJUST is applied to a reservoir to adjust the release and/or pool elevation to observed values.

Input

Keyword	Definition
ADJUST	Keyword specifying the beginning of input for an ADJUST Method; must be followed by: - component identifier - Method identifier
TSINPUT	Keyword specifying an input time series; must be followed by: - 'OBSERVEDPOOL' or 'OBSERVEDRELEASE' - time series alias
[BLENDTS]	Causes blending of observed time series. Blending occurs from the last non-missing observed release to the release prescribed by the last Method active which prescribed a reservoir release over a given number of time steps. 'BLENDTS' must be followed by: - an integer number of time steps over which to blend - an optional integer number representing the next time step counter within an ongoing blend. Defaults to the blend value + 1 (representing a complete blend). This value is used to initialize carryover. 1/
[ADJSIM]	Keyword used to explicitly define whether the Adjust Method will adjust the simulation each timestep or will only adjust the states being saved into carryover (leaving simulation untouched). Defaults to adjusting the simulation at each timestep (equivalent to 'ADJSIM ON'). 'ADJSIM' must be followed by: - 'ON' or 'OFF' 2/ 3/
ENDADJUST	

1/ BLENDTS is ignored when ADJSIM is set to OFF. No blending is done.

2/ When preparing the carryover array containing the states of the reservoir, ADJSIM OFF will replace the simulated states with observed states in input observation pool and / or release time series as available. If a time series does not exist or is missing data for either the current timestep (carryover date) or the previous timestep (previous date), the simulated value is preserved.

3/ An ADJUST Method containing 'ADJSIM OFF' should be included in the rules section under the [TRUE] conditional expression. Because the Method affects nothing directly in the simulation but does its work 'between' time steps, evaluation of the conditional expression is not considered. The Method will activate at each carryover save date.

Example

```
ADJUST RESERVOIRNAME ADJUSTNAME
   TSINPUT OBSERVEDRELEASE ALIAS
                          #RELEASE TIME SERIES TO WHICH THE
                          #SIMULATED TIME SERIES IS ADJUSTED
   BLENDTS 3              #BLENDS THE OBSERVED RELEASE INTO
                          #THE SIMULATED RELEASE OVER
                          #THREE TIME STEPS.
   ADJSIM ON              #THE SIMULATION WILL BE ADJUSTED AT
                          #EACH TIMESTEP.
ENDADJUST
```

V.3.3-RES-J-BALANCE JOINT RESERVOIR REGULATION OPERATION METHOD BALANCE

Description

Method BALANCE computes the release from a reservoir in an attempt to balance the available flood storage in a system of reservoirs. The calculated release is then subject to minimum and maximum limits.

Input

Keyword	Definition
BALANCE	Keyword indicating the start of input for the Balance Method. Must be followed by: - component identifier (reservoir 'owning' this BALANCE Method) - Method identifier
VOLUME	Keyword indicating that balancing should be performed by distributing the available storage evenly across the BALANCE reservoirs. Specify either VOLUME or PERCENT, but not both.
PERCENT	Keyword indicating that balancing should be performed by applying the percent of the total flood storage still available (over all BALANCE reservoirs) to the 'owning' reservoir. Specify either VOLUME or PERCENT, but not both.
ACE	Keyword pseudonym for the Attenuation Constant for Evacuation. The keyword should be followed by a value, generally between 0.0 and 1.0, used as a coefficient to scale the evacuated change in storage required to reach balance. While BALANCE determines what storage is required for balancing it does not understand what impacts the release required to reach that target storage will have on the balance of the system. ACE reduces the zeal of BALANCE causing it to approach a balanced condition over more than one timestep, thus preventing oscillations in the reservoir system. A suggested first-try value for ACE can be calculated as the model timestep divided by the longest lag time in the BALANCE reservoir system from the owning reservoir--either to the upstream-most or downstream-most reservoir. 1/ 2/
BALRES	Keyword specifying one of the reservoirs in the BALANCE system. Must be followed by: - component name 3/
VALUES	Keyword indicating the start of a list of values

Keyword	Definition
	for the previously identified reservoir.
[LOWER POOL]	Keyword should be followed by the lowest pool elevation to be considered as part of the flood storage pool for the reservoir. Defaults to minimum elevation in the elevation-storage table. Specify either LOWER POOL or LOWER STORAGE, but not both. - If balancing in PERCENT mode, LOWER POOL (or LOWER STORAGE) is required for all reservoirs. - If balancing in VOLUME mode, LOWER POOL (or LOWER STORAGE) is only required for the owning reservoir.
[LOWER STORAGE]	Keyword should be followed by the lowest pool storage to be considered as part of the flood storage pool for the reservoir. Default to minimum storage in the elevation-storage table. Specify either LOWER POOL or LOWER STORAGE, but not both. - If balancing in PERCENT mode, LOWER STORAGE (or LOWER POOL) is required for all reservoirs. - If balancing in VOLUME mode, LOWER STORAGE(or LOWER POOL) is only required for the owning reservoir.
[UPPER POOL]	Keyword should be followed by the highest pool elevation to be considered as part of the flood storage pool for the reservoir. Default to maximum elevation in the elevation-storage table. Specify either UPPER POOL or UPPER STORAGE for all reservoirs (independent of balancing mode), but not both.
[UPPER STORAGE]	Keyword should be followed by the highest pool storage to be considered as part of the flood storage pool for the reservoir. Default to maximum storage in the elevation-storage table. Specify either UPPER POOL or UPPER STORAGE for all reservoirs (independent of balancing mode), but not both.
MINRELEASE	Keyword should be followed by the minimum release from the reservoir that the BALANCE Method will specify.
MAXRELEASE	Keyword should be followed by the maximum release from the reservoir that the BALANCE Method will specify.
ENDVALUES	Keyword indicating the end of the list of values for the downstream reservoir.
ENDBALRES	Keyword indicating the end of the parameters for the reservoir. 3/

Keyword Definition

Repeat the above keywords, BALRES through ENDBALRES for each reservoir in the BALANCE system.

ENDBALANCE Keyword indicating the end of the parameters for the Balance Method.

1/ ACE can also be specified using its full name: ATTENUATION_CONSTANT_FOR_EVACUATION

2/ ACE is only used when the current pool elevation is above the target pool elevation for a balanced state. Thus it reduces releases from the owning reservoir which often cause a downstream reservoir's pool elevation to rise, throwing the system beyond balance and introducing an oscillation into the system. One can imagine a case where an upstream reservoir releases a large pulse of water to arrive at balance with a downstream reservoir only to find that the pulse caused the downstream reservoir's pool elevation to rise, preventing the balanced condition.

3/ BALRES can also be specified using the historical syntax keyword RESERVOIR. Use of RESERVOIR is discouraged, however, as it requires special handling to avoid confusion with the keyword used to specify a reservoir component. ENDRESERVOIR can also replace ENDBALRES although its use is also discouraged.

Example

```
BALANCE OWNER_RESERVOIRNAME BALANCENAME
   VOLUME                           #OR PERCENT MODE OF BALANCING.
   ACE 0.33                         #VALUE WILL MULTIPLY AN
                                    #EVACUATION TO PREVENT
                                    #OSCILLATION.
   BALRES DSRESNAME                 #NAME OF A RESERVOIR.
      VALUES
         LOWER POOL 135             #OPTIONAL - WILL USE THE LOWEST
                                    #ELEVATION FROM DSRESNAME'S
                                    #ELEV_STOR BY DEFAULT.
                                    #ALSO, NOT REQUIRED FOR VOLUME
                                    #MODE BALANCING SINCE DRESNAME
                                    #IS NOT THE OWNING RESERVOIR.

         UPPER POOL 140             #OPTIONAL - WILL USE THE HIGHEST
         MINRELEASE 12.4            #ELEVATION FROM DSRESNAME'S
         MAXRELEASE 500.            #ELEV_STOR BY DEFAULT.
         ENDVALUES
      ENDBALRES
   BALRES OWNER_RESERVOIRNAME       #NAME OF THE RESERVOIR ON WHICH
                                    #THIS METHOD WAS DECLARED.
      VALUES
         LOWER STORAGE 12004342     #UPPER AND LOWER BOUNDS CAN BE
                                    #IN TERMS OF
         UPPER STORAGE 18922000     #POOL ELEVATION OR STORAGE.
         MINRELEASE 11.8
```

```
        MAXRELEASE 450.
        ENDVALUES
    ENDBALRES
ENDBALANCE
```

V.3.3-RES-J-LAGK JOINT RESERVOIR REGULATION OPERATION METHOD LAGK

Description

Method LAGK performs Lag and K routing for a Reach component.

Each reach component must have a routing Method defined. LAGK is the only routing Method available.

Input

Keyword	Definition
LAGK	Keyword indicating the start of the input for the LAGK Method. Must be followed by: - component identifier - Method identifier
[LAG]	Lag time in hours. - integer - default to zero
[K]	Coefficient required for lag and K routing. Can be specified as a single value or as a table. - default to zero
[TABLE]	Keyword indicating the start of a table of outflow versus K values. Must be followed by: - 'OUTFLOW_K' - list of outflow/k pairs
[ENDTABLE]	Keyword indicating the end of the table. - optional
[ENDK]	Keyword indicating the end of the K information. Only needed when the OUTFLOW_K table is specified.
[COINFLOW]	Keyword indicating the start of the inflow carryover information. 1/
[VALUES]	Omit if COINFLOW is not entered. Keyword indicating the start of a list of carryover values. Must be followed by a list of carryover values. The required number of inflow values can be determined by comparing the computational time step and the lag: - if lag = 0, 1 value is required - if lag < time step, 2 values are required - if (lag % time step) equals 0, lag / time step + 1 values are required ('%' represents the remainder following integer division of the

Keyword	Definition
	first number by the second) - otherwise lag / time step + 2 values are required
[ENDVALUES]	Omit if COINFLOW is not entered. Keyword indicating the end of the list of values.
[ENDCOINFLOW]	Omit if COINFLOW is not entered. Keyword indicating the end of the inflow carryover information.
[INITIALOUTFLOW]	Indicates the initial discharge from the reach; value must follow. Defaults to 0.0. If K = 0, this value must be consistent with the COINFLOW values or RES-J will force it to be so.
ENDLAGK	Keyword indicating the end of the LAG/K Method parameters.

Carryover Transfer

Carryover values saved are inflow and outflow values.

Inflow carryover consists of (reach lag / computational time interval) + 1 inflows with the 'oldest' inflow value occurring first, proceeding to the inflow 'current' at the time of carryover output. These values are un-lagged inflows to the reach. Thus, only a change in Lag time will affect the inflow carryover.

The inflow carryover transfer is a function of Lag. For each Lag (OLD and NEW), the number of carryover values required is calculated according to the following:

```
If (reach_lag % computational_time_interval) is 0 ('%' represents
the remainder following integer division of the first number by the
second) then
   nVals = (reach lag / computational time interval) + 1
   e.g.: 12/6+1=3
Otherwise,
   nVals = int((reach_lag)/computational_time_interval)+2 ('int'
   represents truncation of a real value to an integer value)
   e.g: int(15/6)+2=4
```

Using nValsNEW and nValsOLD as decision criteria, the following carryover rules apply:

```
If nValsNEW == nValsOLD, then
   Q[i](NEW) = Q[i](OLD) for 0<=i<nValsOLD

If nValsNEW < nValsOLD, then
   diffN = nValsOLD - nValsNEW and
   Q[i](NEW) = Q[i+diffN](OLD) for 0<=i<nValsNEW
```

In essence, this trims off the 'oldest' inflows that with the new, shorter lag time, would have already passed through the reach.

If nValsNEW > nValsOLD, then
diffN = nValsNEW - nValsOLD and
Q[i](NEW) = 0.000000 for 0<=i<diffN and
Q[i+diffN](NEW) = Q[i](OLD) for 0<i<=nValsOLD
In essence, this files the 'oldest' (unavailable) inflows with 0.000000 although these unavailable inflows would still be traveling through the reach with the new, longer lag time.

where Q is the array of inflow values to the LAGK Method as stored in carryover
i is the index used to access values in Q
(NEW) is the new carryover array
(OLD) is the old carryover array

Outflow carryover consists of the INITIALOUTFLOW value only. Transfer of the carryover is direct, without transformation:

INITIALOUTFLOW(NEW) = INITIALOUTFLOW(OLD)

Example

```
LAGK ReachName MethodName
   LAG 6                       #The Lag value has units of hours.
   K
      TABLE outflow_k          #K can either be a single value or
         100 2                 #derived from a table, as it is here.
         200 3                 #Syntax for a single value would, for
         300 5                 #example, simply be K 3.
         500 7
         ENDTABLE
      ENDK
   COINFLOW
      VALUES
         100                   #Must have LAG/TIMESTEP+1
         110                   #carryover values for the Inflow
         ENDVALUES
      ENDCOINFLOW
   ENDLAGK
```

V.3.3-RES-J-MAXDECREASE JOINT RESERVOIR REGULATION OPERATION METHOD MAXDECREASE

Description

Method MAXDECREASE computes the reservoir release that is a specified decrease in the flow over the previous release.

Input

Keyword	Definition
MAXDECREASE	Keyword indicating the start of parameters for the MAXDECREASE Method. Must be followed by: - component identifier - Method identifier
DECREASE	Maximum decrease in flow/time step.
ENDMAXDECREASE	Keyword indicating the end of parameters for the MAXDECREASE Method.

Example

```
MAXDECREASE ReservoirName MethodName
   DECREASE 10.2
   ENDMAXDECREASE
```

V.3.3-RES-J-MAXINCREASE JOINT RESERVOIR REGULATION OPERATION METHOD MAXINCREASE

Description

Method MAXINCREASE computes the reservoir release that is a specified increase in the flow over the previous release.

Input

Keyword	Definition
MAXINCREASE	Keyword indicating the start of parameters for the MAXINCREASE Method. Must be followed by: - component identifier - Method identifier
INCREASE	Maximum increase in flow/time step.
ENDMAXINCREASE	Keyword indicating the end of parameters for the MAXINCREASE Method.

Example

```
MAXINCREASE ReservoirName MethodName
    INCREASE 10.2
    ENDMAXINCREASE
```

V.3.3-RES-J-MAXSTAGE JOINT RESERVOIR REGULATION OPERATION METHOD MAXSTAGE

Description

Method MAXSTAGE iteratively solves for the release of a reservoir until the downstream stage (corresponding to the routed release plus any additional inflows downstream of the reservoir) at a control point (node) is within a specified tolerance of a specified maximum value.

In essence, MAXSTAGE suspends simulation of the RES-J system, copies the affected portion of the system and runs the copy from the current time step forward sufficient time for the prescribed release to reach the control point. Simulation of the copy RES-J system is according to the same rules and Methods as for the original system. The prescribed release is adjusted and simulation repeats until an acceptable release is determined or the maximum number of iterations is reached.

Input

Keyword	Definition
MAXSTAGE	Indicates the start of parametric information for the MAXSTAGE Method. 'MAXSTAGE' must be followed by: - a reservoir-type component identifier as defined in the TOPOLOGY section - an identifier for this Method
TABLE	Indicates the start the stage/discharge rating curve table. 'TABLE' must be followed by: - table keyword 'RATING_CURVE' Beginning on the next line after 'RATING_CURVE', create a table of stage elevation / discharge pairs describing the channel hydraulic conditions at the node.
ENDTABLE	Indicates the end of the rating curve table.
MAXIMUMSTAGE	Maximum allowed stage at the downstream control point.
MINRELEASE	Minimum allowed reservoir release. This will likely be equal to MINRELEASE as defined in the reservoir parameter definition section, but may be different.
[CRITERION]	Convergence criterion. The value is used as an absolute allowable difference in simulated stage and MAXIMUMSTAGE where the value compared to CRITERION is calculated according to the equation: D = abs((MAXIMUMSTAGE-SIM_STAGE)/MAXIMUMSTAGE)*100

Keyword	Definition
DSCONTROL	Indicates the downstream control point. 'DSCONTROL' must be followed by: - a node-type component identifier as defined in the TOPOLOGY section
[MAXITERATIONS]	Maximum number of iterations. If not user-defined, MAXITERATIONS defaults to 20.
ENDMAXSTAGE	Indicates the end of MAXSTAGE parametric information.

Example

```
MAXIMUMSTAGE ReservoirName MethodName
   TABLE rating_curve          #This is the rating curve at the
      0  0                     #downstream control point.
      2  100
      4  150
      6  200
      8  280
      10 350
      ENDTABLE
   MAXSTAGE     7.5            #Stage at downstream control point
                               #not to be exceeded.
   MINRELEASE   100            #Reservoir's minimum release.
   CRITERION    2.5            #Convergence criterion
                               #(percentage: absolute difference
                               #in simulated and maximum
                               #allowable stage divided by the
                               #maximum allowable stage)
   DSCONTROL    NodeName       #downstream control point
   MAXITERATIONS 35            #Optional-defaults to 20
   ENDMAXSTAGE
```

V.3.3-RES-J-RAINEVAP JOINT RESERVOIR REGULATION OPERATION METHOD RAINEVAP

Description

Method RAINEVAP computes the change in reservoir storage due to precipitation and evaporation over the lake surface.

Input

Keyword	Definition
RAINEVAP	Keyword indicating the start of parameters for the RAINEVAP Method. Must be followed by: - component identifier - Method identifier
[TSINPUT]	Keyword indicating an input time series. Must be followed by: - 'OBSERVEDPRECIP' or 'OBSERVEDEVAP' - time series alias The values in the timeseries are taken to be the total over the time step. Also note that if you provide an 'OBSERVEDPRECIP' timeseries, it is recommended that you input a PRECIP – ENDPRECIP section (see below). Similarly, if you provide an 'OBSERVEDEVAP' timeseries, it is recommended that you input a EVAP - ENDEVAP section (see below). Failure to do so, will result in use of a default value of 0, whenever the observed timeseries value is missing.
[PRECIP]	Keyword indicating that average precipitation values will be specified.
[VALUES]	Keyword indicating the start of a list of average daily total precipitation values. Must be followed by a list of date/precipitation pairs. A date/precipitation pair may be followed by a diurnal distribution. The table will be interpolated in time to determine the value for application for a given timestep. 1/
[ENDVALUES]	Keyword indicating the end of the list.
[ENDPRECIP]	Keyword indicating the end of the PRECIP input.
[EVAP]	Keyword indicating that average evaporation values will be specified.
[VALUES]	Keyword indicating the start of a list of average daily total evaporation values. Must be followed by

Keyword	Definition
	a list of date/evaporation pairs. A date/evaporation pair may be followed by a diurnal distribution. The table will be interpolated in time to determine the value for application for a given timestep. 1/
[ENDVALUES]	Keyword indicating the end of the list.
[ENDEVAP]	Keyword indicating the end of the EVAP input.
ENDRAINEVAP	Keyword indicating the end of the RAINEVAP parameters.

1/ Diurnal distributions are specified using 24/dt values that sum to 1.0.

Example

```
RAINEVAP ReservoirName MethodName
   TSINPUT ObservedPrecip alias    #Observed MAP time series
   # Note: Absence of a PRECIP section will result in use of 0.0
   # precip anytime the timeseries is missing.

   TSINPUT ObservedEvap alias      #Observed evaporation time
                                   #series

   EVAP                            #Beginning of Evaporation data
   VALUES                          #evaporation values
      01/01    .25 0.3 0.3 0.25 0.15
      02/01    .08
      03/01    .09
      10/13    0.25
      10/28    0.23
      11/15    0.21
      ENDVALUES
   ENDEVAP                         #End of evaporation
ENDRAINEVAP
```

V.3.3-RES-J-SETELEVATION JOINT RESERVOIR REGULATION OPERATION METHOD SETELEVATION

Description

Method SETELEVATION prescribes a reservoir release calculated to achieve a target reservoir pool elevation.

The target elevation is based on an observed value or according to user-specified date/elevations pairs; the pairs are only used when observed values are not available. The parametric syntax for SETELEVATION is described below. For a full explanation of how the date/pool elevation pairs are used and the decision algorithm for blending see II.4-RES-J-SETELEVATION.

Input

Keyword	Definition
SETELEVATION	Indicates the start of parametric information for the SETELEVATION Method. 'SETELEVATION' must be followed by: - a reservoir-type component identifier as defined in the TOPOLOGY section - an identifier for this Method
[TSINPUT]	Indicates the existence of an observed pool elevation time series. 'TSINPUT' must be followed by: - time series keyword 'OBSERVEDPOOL' - an input time series alias defined in the TIMESERIES definition section
VALUES	Indicates the start of the date/elevation pair list. Beginning on the next line after 'VALUES', list any number of date/elevation pairs, one pair per line. Each date should be unique. It is recommended that the list of pairs begin with 1/1_00:00 (midnight on the morning of January 1) and end with 12/31_23:00 (11:00 p.m. on December 31). Doing so will facilitate lookup procedures on the list and aid the user in ensuring that the transition over year's end will function as desired. 1/ 2/
ENDVALUES	Indicates the end of the list
[INTERPOLATE]	Indicates that elevations between list-defined dates will be linearly interpolated.
[BLENDTS]	Causes blending to occur from the last non-missing value in the observed pool elevation time series to

Keyword	Definition
	a value in the date/elevation pair list, over a given number of time steps. 'BLENDTS' must be followed by: - an integer number of time steps over which to blend. 2/ - an optional integer number representing the time step number since the current time series blending sequence began. This also corresponds to the time step number since the last non-missing value in the release time series. Defaults to the time series blend value + 1 (representing a complete blend). This value is used to initialize carryover.
[BLENDTBL]	Causes blending of the elevation table. Blending occurs across an elevation explicitly defined on the date/elevation pair list, over a given number of time steps. 'BLENDTBL' must be followed by: - an integer number of time steps over which to blend. 2/ - an optional integer number representing the time step number since the current list blending sequence began. Defaults to 1. This value is used to initialize carryover. List blending is intended to smooth the transition from one list-prescribed release to another. Therefore, use of 'INTERPOLATE' will nullify 'BLENDTBL' functionality. For example, if the current time step and the previous time step straddle a list-defined date, blending from the previous elevation to the new elevation would occur. If however, 'INTERPOLATE' has been defined, blending would be nullified as the transition across the date would have already been smoothed by interpolation.
ENDSETELEVATION	Indicates the end of parameters for the SETELEVATION Method.

1/ Dates are specified using one of the formats:
'2-digit_month'/'2-digit_day'
'2-digit_month'/'2-digit_day'_'2-digit_hour'
'2-digit_month'/'2-digit_day'_'2-digit_hour':'2-digit_minute'

2/ For a full explanation of how the date/elevation pair list is used and the decision algorithm for blending see II.4-RES-J-SETELEVATION.

Example

```
SETELEVATION ReservoirName MethodName
```

```
TSINPUT ObservedPool alias      #Observed time series -
                                #optional.
   VALUES                       #If observed time series
                                #specified, these values
                                #are only used
                                #if time series value is
                                #missing. If no observed
                                #time series is entered,
                                #then these values are
                                #used exclusively.
   01/01_00:00 135.0
   01/01_06:00 136.0
   01/01_12:00 134.0
   01/01_18:00 135.0
   01/02_00:00 136.0
   01/02_06:00 134.0
   01/02_12:00 134.0
   01/02_18:00 135.0
   01/03_00:00 136.0
   02/01 133.5
   10/13 124
   10/28 125
   11/15 120.3
   ENDVALUES
INTERPOLATE                     #Optional
BLENDTS      3                  #BlendTS and Blend values are
BLENDTBL      2                 #optional for this method.  Note
                                #also that BLENDTBL value of 2
                                #would attempt to arrive at a
                                #new value in 2*6 hours which is
                                #more that the 6 hour period for
                                #which we have defined some
                                #elevations.  In these cases the
                                #blend algorithm would not
                                #finish prior to beginning
                                #another blend routine.
ENDSETELEVATION
```

V.3.3-RES-J-SETMAX JOINT RESERVOIR REGULATION OPERATION METHOD SETMAX

Description

Method SETMAX determines the maximum computed output variable of all of the Methods it acts upon.

All of the Methods specified must be of the same type, e.g. release or withdrawal.

Input

Keyword	Definition
SETMAX	Keyword indicating the start of parametric information for the SETMAX Method. Must be followed by: - component identifier - Method identifier - list of Method keywords, component identifiers, Method identifiers 1/
ENDSETMAX	Keyword indicating the end of the parametric information for the SETMAX Method.

1/ Valid Method keywords are:
- BALANCE
- MAXDECREASE
- MAXINCREASE
- MAXSTAGE
- SETELEVATION
- SETMAX
- SETMIN
- SETRELEASE
- SETSUM
- SETWITHDRAW

Example

```
SETMAX ComponentName MethodName
   #Will determine the maximum release value as computed by these
   #two methods:
   SETRELEASE ComponentName SetReleaseName
   SETELEVATION ComponentName SetElevationName
   ENDSETMAX
```

V.3.3-RES-J-SETMIN JOINT RESERVOIR REGULATION OPERATION METHOD SETMIN

Description

Method SETMIN determines the minimum computed output variable of all of the Methods it acts upon.

All of the Methods specified must be of the same type, e.g. release or withdrawal.

Input

Keyword	Definition
SETMIN	Keyword indicating the start of parametric information for the SETMIN Method. Must be followed by: - component identifier - Method identifier - list of Method keywords, component identifiers, Method identifiers 1/
ENDSETMIN	Keyword indicating the end of the parametric information for the SETMIN Method.

1/ Valid Method keywords are:
- BALANCE
- MAXDECREASE
- MAXINCREASE
- MAXSTAGE
- SETELEVATION
- SETMAX
- SETMIN
- SETRELEASE
- SETSUM
- SETWITHDRAW

Example

```
SETMIN ComponentName MethodName
   #Will determine the minimum release value as computed by these
   #two methods:
   SETRELEASE ComponentName SetReleaseName
   SETELEVATION ComponentName SetElevationName
   ENDSETMIN
```

V.3.3-RES-J-SETRELEASE JOINT RESERVOIR REGULATION OPERATION METHOD SETRELEASE

Description

Method SETRELEASE determines a reservoir release based on an observed value or a release table.

The release table allows releases to be expressed as a function of date and pool elevation. The release table is only used when observed values are not available. The parametric syntax for SETRELEASE is described below. For a full explanation of how the release table is used and the decision algorithm for blending see II.4-RES-J-SETRELEASE.

Input

Keyword	Definition
SETRELEASE	Indicates the start of parametric information for the SETRELEASE Method. 'SETRELEASE' must be followed by: - a reservoir-type component identifier as defined in the TOPOLOGY definition section - an identifier for this Method
[TSINPUT]	Indicates the existence of an observed release time series. 'TSINPUT' must be followed by: - time series keyword 'OBSERVEDRELEASE' - an input time series alias defined in the TIMESERIES definition section.
VALUES	Indicates the start of the release table.
ELEV	Indicates the start of the column header row defining pool elevations for which releases will be specified. 'ELEV' must be followed by: - a list of elevation values in ASCENDING order - companion keyword 'ENDELEV', signifying the end of the column header row. RES-J must see all elevation data on the same line as the keyword. If many data points are used and more than one line is desired to input this header row, force a line continuation by ending the input line with ' \' (a blank space followed by a backslash). Beginning on the next line after 'ENDELEV', create a table by listing a date, release values (as many releases as defined elevations) and an optional diurnal distribution. You may have any number of rows in this table, each beginning with a unique date. It is recommended, however, that the table begin with 1/1_00:00 (midnight on the morning of

Keyword	Definition
	January 1) and end with 12/31_23:00 (11:00 p.m. on December 31). Doing so will facilitate lookup procedures on the table and aid the user in ensuring that the transition over year's end will function as desired. 1/ 2/ 3/
ENDVALUES	Indicates the end of the release table.
[INTERPOLATE]	Indicates that releases between table-defined dates and/or elevations will be linearly interpolated. 'INTERPOLATE' can be followed by the following keywords: - 'TIME' indicates interpolation only between table dates. Constant release will be used between elevations. - 'ELEV' indicates interpolation only between table elevations - 'ALL' or 'BOTH' indicates interpolation between both table dates and elevations If INTERPOLATE is omitted or entered with no keyword the default is 'INTERPOLATE TIME'.
[BLENDTS]	Causes blending of observed time series. Blending occurs from the last non-missing value in the release time series to a value in the release table, over a given number of time steps. 'BLENDTS' must be followed by: - an integer number of time steps over which to blend 3/ - an optional integer number representing the time step number since the current time series blending sequence began. This also corresponds to the time step number since the last non-missing value in the release time series. Defaults to the time series blend value + 1 (representing a complete blend). This value is used to initialize carryover.
[BLENDTBL]	Causes blending on the release table. Blending occurs across a release explicitly defined on the release table, over a given number of time steps. 'BLENDTBL' must be followed by: - an integer number of time steps over which to blend 3/ - an optional integer number representing the time step number since the current table blending sequence began. Defaults to 1. This value is used to initialize carryover. Table blending is intended to smooth the transition from one table-prescribed release to another. Therefore, use of 'INTERPOLATE' may nullify

Keyword	Definition
	'BLENDTBL' functionality. For example, if pool elevation crosses over a table-defined elevation from one time step to the next, blending would occur. If however, 'INTERPOLATE ELEV' or 'INTERPOLATE ALL' has been defined, blending would be nullified as the transition across the elevation point would have already been smoothed by interpolation.
ENDSETRELEASE	Indicates the end of parameters for the SETRELEASE Method.

1/ Dates are specified using one of the following the formats:
'2-digit_month'/'2-digit_day'
'2-digit_month'/'2-digit_day'_'2-digit_hour'
'2-digit_month'/'2-digit_day'_'2-digit_hour':'2-digit_minute'

2/ Date release values may be followed with a diurnal distribution. The diurnal distribution is expressed as a list of 24/dt values which sum to 1.0.

3/ For a full explanation of how the release table is used and the decision algorithm for blending see II.4-RES-J-SETRELEASE.

Example

```
SETRELEASE ReservoirName MethodName
   TSINPUT ObservedRelease alias  #Observed time series - optional
      VALUES                      #If observed time series
                                  #specified, these values are
                                  #only used if time series value
                                  #is missing. If no observed
                                  #time series, then these values
                                  #are used exclusively.
      #Example of setting multiple release values (one for each
      #elevation value) with the ability to specify a
      #distribution as applied to that date for all three
      #values.
      ELEV   129.0  145.0  165.0  ENDELEV
      01/01  200  265  384  0.2 0.3 0.3 0.2
      02/01  300  320  340
      03/01  367  380  500
      08/01  235  270  382
      11/15  300  325  550
   ENDVALUES
   INTERPOLATE TIME          #Refers to how table values data are
                             #interpreted.
   BLENDTS       3           #Both BLENDTBL and BLENDTS are
                             #optional
   BLENDTBL 2
   ENDSETRELEASE
```

V.3.3-RES-J-SETSUM JOINT RESERVOIR REGULATION OPERATION METHOD SETSUM

Description

Method SETSUM sums the computed output variable of all of the Methods it acts upon.

All of the Methods specified must be of the same type, e.g. release or withdrawal.

Input

Keyword	Definition
SETSUM	Keyword indicating the start of parametric information for the SETSUM Method. Must be followed by: - component identifier - Method identifier - list of Method keywords, component identifiers, Method identifiers 1/
ENDSETSUM	Keyword indicating the end of the parametric information for the SETSUM Method.

1/ Valid Method keywords are:
- SETMAX
- SETMIN
- SETRELEASE
- SETWITHDRAW

Example

```
SETSUM ComponentName MethodName
   #Will determine the summation of the release values
   #computed by these two methods:
   SETRELEASE ComponentName SetreleaseName_1
   SETRELEASE ComponentName SetreleaseName_2
   ENDSETSUM
```

V.3.3-RES-J-SETWITHDRAW JOINT RESERVOIR REGULATION OPERATION METHOD SETWITHDRAW

Description

Method SETWITHDRAW determines a reservoir withdrawal based on an observed value or a withdrawal table.

The withdrawal table allows withdrawals to be expressed as a function of date and pool elevation. The withdrawal table is only used when observed values are not available. Optionally, the withdrawal can be applied as inflow to another component in the system. The parametric syntax for SETWITHDRAW is described below. For a full explanation of how the withdrawal table is used and the decision algorithm for blending see II.4-RES-J-SETWITHDRAW.

Input

Keyword	Definition
SETWITHDRAW	Indicates the start of parametric information for the SETWITHDRAW Method. 'SETWITHDRAW' must be followed by: - a reservoir-type component identifier as defined in the TOPOLOGY definition section. - an identifier for this Method
[TSINPUT]	Indicates the existence of an observed release time series. 'TSINPUT' must be followed by: - time series keyword 'OBSERVEDWITHDRAW' - an input time series alias defined in the TIMESERIES definition section
VALUES	Indicates the start of the withdrawal table.
ELEV	Indicates the start of the column header row defining pool elevations for which withdrawals will be specified. 'ELEV' must be followed by: - a list of elevation values in ASCENDING order - companion keyword 'ENDELEV', signifying the end of the column header row. RES-J must see all elevation data on the same line as the keyword. If many data points are used and more than one line is desired to input this header row, force a line continuation by ending the input line with ' \' (a blank space followed by a backslash). Beginning on the next line after 'ENDELEV', create a table by listing a date, withdrawal values (as many as withdrawals as defined elevations) and an optional diurnal distribution. You may have any number of rows in this table, each beginning with a

Keyword	Definition
	unique date. It is recommended, however, that the table begin with 1/1_00:00 (midnight on the morning of January 1) and end with 12/31_23:00 (11:00 p.m. on December 31). Doing so will facilitate lookup procedures on the table and aid the user in ensuring that the transition over year's end will function as desired. 1/ 2/ 3/
ENDVALUES	Indicates the end of the withdrawal table.
[INTERPOLATE]	Indicates that withdrawals between table-defined dates and/or elevations will be interpolated. 'INTERPOLATE' can be followed by: - an interpolation keyword: 'TIME' indicates interpolation only between table dates; 'ELEV' indicates interpolation only between table elevations; 'ALL' or 'BOTH' indicates interpolation between both table dates and elevations. The default is 'TIME'.
[BLENDTS]	Causes blending to occur from the last non-missing value in the withdrawal time series to a value in the withdrawal table, over a given number of time steps. 'BLENDTS' must be followed by: - an integer number of time steps over which to blend. 3/ - an optional integer number representing the time step number since the current time series blending sequence began. This also corresponds to the time step number since the last non-missing value in the release time series. Defaults to the time series blend value + 1 (representing a complete blend). This value is used to initialize carryover.
[BLENDTBL]	Causes blending to occur across a withdrawal explicitly defined in the withdrawal table, over a given number of time steps. 'BLENDTBL' must be followed by: - an integer number of time steps over which to blend. 3/ - an optional integer number representing the time step number since the current table blending sequence began. Defaults to 1. This value is used to initialize carryover. Table blending is intended to smooth the transition from one table-prescribed withdrawal to another. Therefore, use of 'INTERPOLATE' may nullify 'BLENDTBL' functionality. For example, if pool elevation crosses over a table-defined elevation from one time step to the next, blending would

Keyword	Definition
	occur. If however, 'INTERPOLATE ELEV' or 'INTERPOLATE ALL' has been defined, blending would be nullified as the transition across the elevation point would have already been smoothed by interpolation.
[TOCOMP]	Indicates that withdrawals will be applied as inflows to another component. 'TOCOMP' must be followed by: - a component ID that will receive the withdrawal. 4/ - a transfer mode keyword: 'INSTANTANEOUS' indicates that the withdrawal should be applied to the component this timestep, to be used in that component's solution. RESJ verifies that the component receiving the transferred withdrawal will be solved after the reservoir owning this SetWithdraw Method. If it will solve before the owning reservoir, 'INSTANTANEOUS' parameterization is not allowed. 'NEXTSTEP' indicates that the withdrawal should be applied to the component for use in its solution at the next timestep.
[INITIALTRANSFER]	Indicates the value of the withdrawal transferred as a result of last timestep's solution. If the TOCOMP mode is set to NEXTSTEP, this keyword MUST be included in the parameterization. The INITIALTRANSFER value is applied to the receiving component at the beginning of the first solution timestep. 'INITIALTRANSFER' may be followed by: - the initial transfer to the component. Defaults to 0.
ENDSETWITHDRAW	Indicates the end of parameters for the SETWITHDRAW Method.

Carryover Transfer

Carryover values saved are BLENDTS, BLENDTBL and INITIALTRANSFER values. No transfer of the blend paramters is made. Transfer of INITIALTRANSFER is direct, without transformation:

INITIALTRANSFER(NEW) = INITIALTRANSFER(OLD)

1/ Dates are specified using one of the following formats:
'2-digit_month'/'2-digit_day'
'2-digit_month'/'2-digit_day'_'2-digit_hour'
'2-digit_month'/'2-digit_day'_'2-digit_hour':'2-digit_minute'

2/ Date withdrawal values may be followed with a diurnal distribution. The diurnal distribution is expressed as a list of 24/dt values which sum to 1.0.

3/ For a full explanation of how the withdrawal table is used and the decision algorithm for blending see II.4-RES-J-SETWITHDRAW.

4/ The locations of the owner of this SETWITHDRAW Method and the receiving component must be consistent with the transfer mode in terms of the order of system solution. That is, the withdrawal solved by reservoir A cannot transfer to any component that has previously solved its Methods for the current timestep. Also, the user must ensure that if the receiving component belongs to a MAXSTAGE subtree, the owner of this SETWITHDRAW Method also belongs to the subtree. If the receiving component expects to receive a transfer from a reservoir that does not exist in the subtree, the MAXSTAGE Method will not operate correctly.

Example

```
SETWITHDRAW ReservoirName MethodName
   TSINPUT ObservedWithdraw alias
                              #Observed time series - optional
   VALUES                     #If observed time series
                              #specified, these values are
                              #only used if time series value
                              #is missing. If no observed time
                              #series, then these values used
                              #exclusively.
      #Example of setting multiple withdrawal values (one for
      #each elevation value) with the ability to specify a
      #distribution as applied to that date for all three
      #values.
      ELEV  129.0  145.0  165.0  ENDELEV
      01/01  200  265  384  0.2 0.3 0.3 0.2
      02/01  300  320  340
      03/01  367  380  500
      08/01      235  270  382
      11/15      300  325  550
      ENDVALUES
   INTERPOLATE TIME         #Refers to how table values are
                            #interpreted.
   BLENDTBL      2          #Both BLENDTBL and BLENDTS are
                            #optional
   BLENDTS       3
   TOCOMP NODE_A NEXTSTEP   #The withdrawal will become inflow to
                            #NODE_A, next timestep.  NODE_A may be
                            #anywhere within the system, so long
                            #as any MAXSTAGE method containing
                            #NODE_A also contains the owner of
                            #this method.
   INITIALTRANSFER 45.0
   ENDWITHDRAW
```

V.3.3-RES-J-SPILLWAY JOINT RESERVOIR REGULATION OPERATION METHOD SPILLWAY

Description

Method SPILLWAY augments a reservoir release determined by previous release Methods according to the pseudo-implicit solution of the water balance including an uncontrolled spillway.

Pseudo-implicit solution is accomplished by breaking the simulation time step into a user defined number of intervals. The reservoir storage (and hence pool elevation) at the beginning of each interval determines the spill for that interval. A table matching pool elevation with spill determines the spill over the crest for the given time interval. If spill occurred during any of the intervals, SPILLWAY redefines the reservoir's pool elevation according to the state at the end of the intervals and prevents any further mass balance solution of the reservoir this time step. The reservoir's release is revised to be the sum of the release determined by previous release Methods and the spill associated with the final state of the reservoir. The parametric syntax for SPILLWAY is described below. For a full explanation of how the pseudo-implicit solution see II.4-RES-J-SPILLWAY.

Input

Keyword	Definition
SPILLWAY	Indicates the start of parametric information for the SPILLWAY Method. 'SPILLWAY' must be followed by: - a reservoir-type component identifier as defined in the TOPOLOGY definition section. - an identifier for this Method
TABLE	Keyword indicating start of the elevation-storage table. 'TABLE' must be followed by: - table keyword 'ELEV_SPILL' signifying the table's use as an elevation-spill table on the same line. Subsequent lines must contain the table data: -One elevation and its corresponding spill value pair, per line.
ENDTABLE	Indicates the end of the elevation-spill table.
INTERVALS	Indicates the number of intervals the simulation time step should be sub-divided into to enable pseudo-implicit solution of the water balance, including the spill term. 'INTERVALS' must be followed by: - an integer value

Keyword	Definition
[INITIALSPILL]	Indicates the spill associated with the total discharge (release) from the reservoir at the beginning of the simulation period. This value will be subtracted from the Reservoir's INITIALRELEASE to separate the effects of the SPILLWAY Method from the other release; a value must follow. If INITIALSPILL is not defined it will default to 0.0.
ENDSPILLWAY	Indicates the end of parameters for the SPILLWAY Method.

Carryover Transfer

The carryover saved consists of the INITIALSPILL only. Transfer of the carryover is direct, without transformation:

INITIALSPILL(NEW) = INITIALSPILL(OLD)

Example

```
SPILLWAY ReservoirName MethodName
   TABLE ELEV_SPILL
      100 0
      101 0.1
      102 0.3
      103 0.6
      104 1.0
      105 1.5
      106 2.1
      107 2.8
      109 4.4
      110 5.4
   ENDTABLE
   INTERVALS 12
   INITIALSPILL 2.1
ENDSPILLWAY
```