V.3.3-RES-SNGL SINGLE RESERVOIR REGULATION OPERATION

Identifier: RES-SNGL

Application: All programs

Description: This Operation provides capabilities for simulating the regulation of a single, independently operated reservoir allowing operating modes to change under varying hydrologic conditions.

A complete description of the Operation is in Chapter II.4.

The manner in which releases from the reservoir are made (the operating mode) is called a Scheme. Schemes calculate discharges, pool elevations and storage contents.

Data management aids that do not compute discharges but help in controlling the simulation are called Utilities.

Table 1 describes each Scheme and Utility.

The change from one operating mode to another is specified through a set of commands called the Reservoir Control Language (RCL).

Input Summary: The input for this Operation is in 3 sections:

- o GENERAL - specify the parameters, time series information and carryover values
- o SPECIFIC - specify input for each Scheme and Utility
- o RCL - specify the controlling statements

Each input section is opened with a section identifier and closed with an appropriate section trailer. The sections can be entered in any order but are processed in the order GENERAL, SPECIFIC and RCL.

The input uses the free format rules described in Chapter I.3-FREEFMT-UFIELD.

Abbreviations for any header, trailer or keyword are indicated by underscores beneath the letters comprising the abbreviation. For example the abbreviation for PARMS is P.

Optional keywords are indicated by brackets ([]). Default values are set for a keyword if it is not specified. The default values for optional keywords are provided with the keyword.

Standard units for input values are:

Input Value	English	Metric
Elevation	FT	M
Instantaneous discharge	CFS	CMS
Mean discharge	CFSD	CMSD
Storage contents	ACFT or TIMD	CMSD

Units of input are set in the general section using the UNITS keyword. ACFT stands for acre-feet and TIMD is time interval mean discharge. For example an Operation data time interval of 6 hours would lead to a TIMD of 1/4 CFSD and a time interval of 12 hours would need a TIMD of 1/2 CFSD.

Examples

Example 1

In this simple example the reservoir is specified to pass inflow only. No SPECIFIC input is needed to define the pass inflow (PASSFLOW) Scheme so the only sections needed for definition are GENERAL and RCL. Any keywords that can be defaulted (noted with an *) have been supplied with values. The only model results that are to be passed from this Operation are mean discharge. The Operation time interval is 6 hours as indicated by the two inflow time series time intervals.

```
  RES-SNGL    EXAMPLE1
  $
  GENERAL
*   UNITS ENGLISH ACFT
*   TITLE 'RES-SNGL EXAMPLE #1'
  $
  PARMS
    ELVSSTOR  150.0  160.0 162.5  165.0  167.5  170.0  &
               0.0   1000.0  1500.  2500.  3500.  4800.
* INTERP LINEAR
  ENDP
  $
  TS
    INSTQIN   EX1IN  QINE 6
    MEANQOUT  EX1IN  SQME 6
    MEANQOUT  EX1OUT SQME 6
  ENDT
  $
  CO
    INFLOW      600.
    Q-INST      600.
*   Q-MEAN      600.
*   POOL1       163.3
*   POOL0       163.3
*   STORAGE    2600.
  ENDCO
  ENDGENL
  $
  RCL
    DO PASSFLOW
  ENDRCL
  END
```

Example 2

In this example no regulation simulation is performed. The discharge values are provided by the operating agency and supplied through a time series.

All keywords that can be defaulted have been with the result that the input units are English (with acre-feet for storage values), the interpolation used with the elevation versus storage curve is linear, the title is left blank and the missing value option for the prescribed discharge Scheme (SETQ) is specified to pass inflow.

All model outputs are to be written to a time series except for the storage contents. The Operation data time interval is 6 hours as specified by the two inflow time series data time intervals.

```
RES-SNGL    EXAMPLE2
$
GENERAL
  PARMS
    ELVSSTOR   150.0  160.0  162.5  165.0  167.5  170.0 &
               0.0  1000.   1500.  2500.  3500.   4000.
  ENDP
  $
  TIME-SERIES
   INSTQIN    EX2IN   SQIN   6
   MEANQIN    EX2IN   SQME   6
   MEANQOUT   EX2OUT  SQME   6
   INSTQOUT   EX2OUT  SQIN   6
   POOL       EX2OUT  SPEL   6
  ENDTS
  $
  CARRYOVER
    INFLOW  600.
    Q-MEAN  550.
    POOL1  163.3
  ENDC
 ENDGENL
 $
 SPECIFIC
   SETQ
     PARMS
       QVALUE  TS
     ENDP
     $
     TS
     SQTS  EX2   RQME   6
    ENDT
  ENDSETQ
ENDSPEC
$
RCL
  DO SETQ
ENDRCL
END
```

Example 3

In this example the reservoir's regulation plan specifies to pass inflow unless either the instantaneous discharge exceeds 65000 CFS or the pool elevation surpasses 109.0 FT. With either threshold crossed, the gated spillway comes into play. The discharge and elevation checks need to be made at the beginning of each time period and after the pass inflow Scheme (PASSFLOW) if it has been executed.

Also in this example, the user wants to use observed mean discharges and observed pool elevations to adjust the model outputs. The adjusted instantaneous and mean discharges and the adjusted pool elevations are to be written to a time series. The ADJUST Utility is one of the Utilities that needs to be defined in the SPECIFIC section but needs no RCL statement to be executed.

The Operation time interval is 6 hours as set by the two inflow time series specified in the GENERAL time series section. All simulated model outputs are to be written to time series (the last 4 time series specifications in the GENERAL time series section).

```
       RES-SNGL     EXAMPLE3

       $
       GENERAL
         TITLE  'RES-SNGL EXAMPLE #3'
         UNITS  ENGLISH  TIMD
       $
       PARMS
         ELVSSTOR          75.0  100.0  109.0  110.0  115.0 &
                   118.0  120.0  122.0  125.0  &
                     0.0  7500.  22750.  26250.  &
                  57500.  88750.  115000  145750.  200000.
         INTERP  LOG
       ENDP
       $
       TIME-SERIES
         INSTQIN   EX3IN   QINE  6
         MEANQIN   EX3IN   SQME  6
         MEANQOUT  EX3OUT  SQME  6
         INSTQOUT  EX3OUT  SQIN  6
         POOL      EX3OUT  SPEL  6
         STORAGE   EX3OUT  SRSO  6
       ENDT
       $
       CARRYOVER
         INFLOW  37000.
         Q-INST  38000.
         POOL1    109.0
       ENDC
   ENDGENL
   $
   SPECIFIC
     SPILLWAY
       PARMS
           TYPE  GATED
```

```
        REPLQ  50000.
        CREST  75.0
        ELVSQ   0.00    84.0  100.0   105.0   108.0  &
               109.0   110.0  115.0   118.0   122.0  &
                 0.0   20000.  38000.  50000.  60000.  &
               65000.  68000.  95000.  125000.  210000.
        PASSEL  109.0
      ENDP
      $
        CO
          OLDQ 0.0
        ENDC
      ENDSPWY
      $
      ADJUST
        TIME-SERIES
         OBSQOM    ADJOBSQ   RQME  6
         ADJQOM    ADJMEAN   SQME  6
         ADJQO     ADJINST   QINE  6
         OBSH      ADJOBSH   PELV  6
         ADJH      ADJELV    PELE  6
      ENDT
    ENDADJ
  ENDSPEC
  $
  RCL
    IF (Q0.GT.65000.0.OR.POOL.GT.109.) THEN DO SPILLWAY
       ELSE DO PASSFLOW.
         IF (QO.GT.65000.0.OR.POOL.GT.109) THEN DO SPILLWAY
    ENDIF
  ENDRCL
  END
```

Example 4

In this example the selection of minimum outputs Utility (SETMIN) is used for the non-flood periods to ensure that the mean discharge from the reservoir does not exceed allowed limits. For non-flood periods, two Schemes, prescribed discharge (SETQ) and downstream stage and pool controlled discharge (STPOOLQ), are used, with the limiting discharge relations of STPOOLQ controlling the model outputs.

The occurrence of a flood situation is detected by the entry into surcharge (ENTERISC) Utility with the discharge in these flood periods determined by the induced surcharge (INDSRCHGE) Scheme.

Also in this example, the 'observed' inflow is to be back-computed using observed mean daily discharges and observed pool elevations in the BACKFLOW Utility, the model outputs are to be adjusted using observed period mean discharges and observed pool elevations in the ADJUST Utility and, since a rule curve is used in INDSRCHGE, the rule curve adjustment (RULEADJ) Utility is used to determine and apply the difference between the specified rule elevation and the elevation maintained by the operator.

The referback feature of curve definition has been used in the RULEADJ Utility definition. The rule curve is originally defined in the INDSRCHGE Scheme.

Once again the time interval is 6 hours as specified by the inflow time series in the GENERAL section.

For brevity, only subsets of the complete elevation vs storage, induced surcharge and gate rating curves will be provided in the example.

```
RES-SNGL    EXAMPLE4
$
GENERAL
  TITLE  'RES-SNGL EXAMPLE #4'
  UNITS  ENGLISH ACFT
  PARMS
    ELVSSTOR   560.    610.   625.     630.   635      640.  &
                0.0  168000. 365000.  463000  579000.  715000.
    INTERP LINEAR
  ENDP
  $
  TIME-SERIES
    INSTQIN   EX4IN   SQIN   6
    MEANQIN   EX4IN   SQME   6
    MEANQOUT  EX4OUT  SQME   6
    INSTQOUT  EX4OUT  SQIN   6
    POOL      EX4OUT  SPEL   6
  ENDT
  $
  CARRYOVER
    INFLOW  2900.
    Q-MEAN   675.
    POOL1    630.
  ENDC
ENDGENL
$
SPECIFIC
  SETQ
    PARMS
      QVALUE  TS
      OPTION  4
    ENDP
    $
    TS
      SQTS  EX4  RQME  6
    ENDT
    $
    CO
      OLDQ   675.   675.   675.   675.
    ENDCO
  ENDSETQ
  $
  BACKFLOW
    TS
      OBSH   EX4    PELV  6
      OBSQ   EX4    RQME  24
    ENDTS
  ENDBACK
  $
  ADJUST
```

```
  TS
    OBSQOM   EX4  RQME  6
    ADJQOM   EX4  RQMP  6
    ADJQO    EX4  QINE  6
    OBSH     EX4  PELV  6
    ADJH     EX4  PELE  6
  ENDT
ENDADJ
$
INDSRCHGE
  PARMS
    HUPPER  635.
    HCHECK RULE
    HLOWER RULE
    COMPINQ  3
    IOPTND   1
    SCQI   20000.  80000.  16000.  300000.
    SCEL   625.5   633.2    635.    641.
    SCQO   18000.  18000.  18000.  26000.   &
           18000.  18000.  26000.  26000.   &
           18000.  31500.  40000.  265000.  &
           43000.  72000.  89000.  280000.
    DTYPE   3
    DTABLE      600.0   5  &
                635.0   7
    HTARGET1      635.0
    REDUCE       2000.
    QTARGET2    18000.
    DIFFQI3      5000.
    GATEOPEN       0.  4.    10.    16.
    GATEL     620.   628.   633.   641.
    GATEQ    19000. 19000. 19000.  19000.  &
             42260. 46230. 48430.  51260.  &
            110640. 130880. 141850. 157610.  &
            293950. 293950. 293950. 330720.
    GATESET   1
    CURVE   1   106   136   305   335   366   &
               625.  625.  635.  635.  625.  625.
    RULETIME  6
  ENDP
ENDINDS
$
RULEADJ
  PARMS
    CURVE INDSRCHGE
    PERIODS 4
    ELEVDIFF  2.0
    MAXQI  40000.
  ENDP
  $
  TS
    ELEV  EX4  PELV  6
  ENDTS
ENDRADJ
$
STPOOLQ
```

```
  PARMS
    GAGE1
      LAG  3
      RATING  EX4
      CONTROL1   6.8    8.0     9.1     10.4     12.2   &
                20000. 17000.  14000.   10000.   4000.
      CONTROL2   8.0   10.3    12.0     15.5    17.0  17.5  18.5  &
                20000. 17000.  14000.   10000.   4000. 2000. 675.
      RISING      560.   1
      FALLING     560.  -999. 635.001    &
                     1    2        1
      CURVE INDSRCHGE
LAG/K
RES-SNGL
  17.
   3.
   0
      ENDP
      $
      TS
        LOCAL1   EX4LOCAL   SQIN6
       ENDT
ENDSTPQ
   $
   SETMIN
      PARMS
        TYPE MEANQ
      ENDP
   ENDSMIN
ENDSPEC
$
RCL
 DO ENTERISC
 IF (SURCHARGE) THEN DO INDSRCHGE
    ELSE  DO  SETQ
          DO  STPOOLQ
          DO  SETMIN
  ENDIF
ENDRCL
END
```

Table 1. Operation RES-SNGL Schemes and Utilities

Name	Type	Description
ADJUST	Utility	Output adjustment: Modify simulated values using observed values to create an adjusted value.
BACKFLOW	Utility	Inflow adjustment: Utilize observed pool elevations and discharges to adjust simulated inflow.
ENTERISC	Utility	Entry into induced surcharge Scheme: Check to see if induced surcharge Scheme is to be used.
FILLSPILL	Scheme	Fill and spill: No discharge occurs until the pool elevation reaches a specified level. The inflow is passed until maximum discharge is reached. Routing occurs at that point.
FLASHBDS	Scheme	Flash board control: A type of uncontrolled gated spillway. Flash boards provide additional storage until elevation tops the boards and the boards flip. Requires new routing regulations as additional boards flip.
GOFLASH	Utility	Entry into flash board Scheme: Check to see if flash board Scheme is to be used.
INDSRCHGE	Scheme	Induced surcharge: Provide additional storage above normal top of pool level when used during flood situations.
MAXQ	Utility	Maximum outflow: Determine maximum possible discharge at a given pool elevation.
MINQ	Scheme	Discharge minimization: A release is determined to try to prevent flooding at a downstream location by using forecasted inflows (non-iterative solution).
PASSFLOW	Scheme	Pass inflow: None of the inflow volume is retained thereby maintaining the pool elevation.
POOLQ	Scheme	Pool elevation controlled discharge: Release is controlled only by the pool elevation.

Name	Type	Description
POWERGEN	Scheme	Power generation: The generation (turbine) discharge is computed as influenced by various conditions including inflow, rule curve, minimum discharge requirement, diurnal and weekly fluctuations in generation schedules and maximum generation discharge, among others. Not to be accounted for are forecasted weather conditions and power pool activities.
RAINEVAP	Utility	Direct rainfall and/or evaporation: Add influence of meteorological inputs to changes in pool elevations.
RULEADJ	Utility	Rule curve adjustment: Determine the amount of deviation the operator keeps the pool from elevation specified by the rule curve.
RULECURVE	Scheme	Rule curve: The pool elevation is specified by a table of elevations for each day of the year and discharge is computed based on the designated elevation.
SETH	Scheme	Prescribed elevation: The elevation for the time period is specified and the discharge is computed.
SETMAX	Utility	Select maximum element: Use maximum value of already computed outputs.
SETMIN	Utility	Select minimum element: Use minimum value of already computed outputs.
SETQ	Scheme	Prescribed discharge: The discharge from the reservoir for the time period is known beforehand and the pool elevation is the only computed quantity.
SPILLWAY	Scheme	Uncontrolled spillway: No discharge occurs until the pool elevation reaches a specified level. All spilled inflow is then routed.
STPOOLQ	Scheme	Downstream stage and pool elevation controlled discharge: The reservoir release is controlled by the stage at a downstream point and the current pool elevation.

Name	Type	Description
SUMINF	Utility	Inflow summation: Sum inflows over a specified time interval. Used in power generation and minimize discharge Schemes.