SSARR Reservoir Regulation (SSARRESV) Model

1. Description of Algorithm

The SSARR Reservoir Regulation model routes streamflows from upstream to downstream points through lake storage and reservoirs under free flow or controlled-flow modes of operation.

This operation is based on the Streamflow Synthesis and Reservoir Regulation System developed by US Army Corps of Engineers and Northwest River Forecast Center of National Weather Service. Flows may be routed as a function of multi-variable relationships involving backwater effects from a downstream reservoir. For further information see:

https://vlab.ncep.noaa.gov/documents/207461/1893022/24ssarresv.pdf

2. Model Parameters

SSARRES uses the existing NWSRFS operation definition for defining model parameters. The NWSRFS operation definition is enclosed within a single parameter element named "OPERATION_CONTENTS". An example is shown below. For further information see:

https://vlab.ncep.noaa.gov/documents/207461/1893022/533ssarresv.pdf

Below is an example of SSARRESV parameters input file (Single Reservoir):

```
SSARRESV
TITLE  'DWORSHAK RESERVOIR N'
UNITS  ENGLISH
INFLOW
TIME-SERIES
INSTQI2   DWRI1I    QINE   6
ENDTS
CARRYOVER
Q-INST       1241.
ENDCO
ENDINFLW
SAR
PARMS
ELVSSTOR    1150.00   1200.00   1250.00   1300.00   1350.00   1400.00  &
          1420.00   1440.00   1445.00   1450.00   1460.00   1470.00  &
          1480.00   1490.00   1500.00   1510.00   1520.00   1530.00  &
          1540.00   1550.00   1560.00   1570.00   1580.00   1590.00  &
          1600.00   1600.50   1605.00                          &
             0.   193000.   328000.   520000.   765000.  1098000.  &
         1252000.  1410000.  1414000.  1498000.  1586000.  1681000.  &
         1782000.  1887000.  1998000.  2115000.  2238000.  2367000.  &
         2502000.  2644000.  2794000.  2950000.  3115000.  3287000.  &
         3468000.  3478000.  3562000.
```

```
MAXEL    1600.00
MINEL    1445.00
MINQREL      1000.
ENDP
TIME-SERIES
INSTQO1   DWRI1     SQIB   6
INSTQO2   DWRI1     QINE   6
POOL      DWRI1     SPEL   6
STORAGE   DWRI1     RSTE   6
OBSQO     DWRI1MRG  RQOT   6
OBSH      DWRI1     FBEL   6
ENDTS
CARRYOVER
Q-INST       1500.
POOL       1517.12
STORAGE   2202576.
ENDCO
ENDSAR
END
```

3. Model States

SSARRESV model states are defined in a property file format. An example is shown below. The model state property names are:

For one Reservoir:

Property Name	Description
UNIT	Units for State Variables (default is ENGLISH)
DOWNSTREAM_RESERVOIR_ELEVATION	Elevation for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_INST_INFLOW	Instantaneous inflow for at start of run
DOWNSTREAM_RESERVOIR_INST_OUTLOW	Instantaneous outflow for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_NOT_USED	Retain for programming convenience, not used in actual computation
DOWNSTREAM_RESERVOIR_STORAGE	Storage for the downstream reservoir a start of run

Single Reservoir States File Sample:

```
DOWNSTREAM_RESERVOIR_ELEVATION=1517.63
DOWNSTREAM_RESERVOIR_INST_INFLOW=1558.6
DOWNSTREAM_RESERVOIR_INST_OUTLOW=1500.0
DOWNSTREAM_RESERVOIR_NOT_USED=0.0
DOWNSTREAM_RESERVOIR_STORAGE=2208849.0
UNIT=ENGLISH
```

For backwater reservoir for in a two-reservoir system:

Property Name	Description
UNIT	Units for State Variables (default is ENGLISH)
DOWNSTREAM_RESERVOIR_ ELEVATION	Elevation for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_ INST_INFLOW	Instantaneous inflow for at start of run
DOWNSTREAM_RESERVOIR_ INST_OUTLOW	Instantaneous outflow for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_ NOT_USED	Retain for programming convenience, not used in actual computation
DOWNSTREAM_RESERVOIR_ STORAGE	Storage for the downstream reservoir a start of run
UPSTREAM_RESERVOIR_ OUTLOW	Instantaneous outflow for the upstream reservoir at the start of run
UPSTREAM_RESERVOIR_ ELEVATION	Elevation for the upstream reservoir at start of run
UPSTREAM_RESERVOIR_ STORAGE	Storage for the upstream reservoir at start of run
TRIB_FLOW_INTO_DOWNST REAM_RESERVOIR	Tributary flow into the downstream reservoir at start of run

For a backwater station with backwater effect from a downstream reservoir in a two-reservoir system:

Property Name	Description
UNIT	Units for State Variables (default is ENGLISH)
DOWNSTREAM_RESERVOIR_ELEVATION	Elevation for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_INST_INFLOW	Instantaneous inflow for at start of run
DOWNSTREAM_RESERVOIR_INST_OUTLOW	Instantaneous outflow for the downstream reservoir at start of run
DOWNSTREAM_RESERVOIR_NOT_USED	Retain for programming convenience, not used in actual computation
DOWNSTREAM_RESERVOIR_STORAGE	Storage for the downstream reservoir a start of run
UPSTREAM_RESERVOIR_OUTLOW	Instantaneous outflow for the upstream reservoir at the start of run
DOWNSTREAM_RESERVOIR_NOT_USED	Retain for programming convenience, not used in actual computation
DOWNSTREAM_RESERVOIR_NOT_USED	Retain for programming convenience, not used in actual computation
TRIB_FLOW_INTO_DOWNSTREAM_RESERVOIR	Tributary flow into the downstream reservoir at start of run

Two-Reservoir States File Sample:

DOWNSTREAM_RESERVOIR_ELEVATION=1734.37
DOWNSTREAM_RESERVOIR_INST_INFLOW=18649.3
DOWNSTREAM_RESERVOIR_INST_OUTLOW=16025.4
DOWNSTREAM_RESERVOIR_NOT_USED=0.0
DOWNSTREAM_RESERVOIR_STORAGE=892.00
UPSTREAM_RESERVOIR_OUTLOW=16200.7
DOWNSTREAM_RESERVOIR_NOT_USED=0.0
DOWNSTREAM_RESERVOIR_NOT_USED=0.0
TRIB_FLOW_INTO_DOWNSTREAM_RESERVOIR=0.00
UNIT=ENGLISH

4. Model Time Series

INPUT TIME SERIES:

Time Series Type	Internal Model Units	Time Step	Missing Values Allowed	Required [Yes or No]
Instantaneous Inflow at period Start (INSTQI1)	CMS	any	No	No
Instantaneous Inflow at period End (INSTQI2)	CMS	any	Yes	No
Observed Instantaneous Outflow (OBSQO)	CMS	any	No	Yes
Observed Mean Outflow (OBSQOM)	CMSD	any	No	Yes
Observed Pool Elevation (OBSH)	M	any	No	Yes
Instantaneous Inflow at period Start for all tributary and local Inflow (TRIBQL1)	CMS	any	No	No
Instantaneous Inflow at period End for all tributary and local Inflow (TRIBQL2)	CMS	any	No	No

OUTPUT TIMESERIES:

Time Series Type	Internal Model Units	Time Step	Missing Values Allowed	Required [Yes or No]
Instantaneous Outflow at period Start (INSTQO1)	CMS	any	No	No
Instantaneous Outflow at period End (INSTQO2)	CMS	any	Yes	No
Simulated Mean Outflow (MEANQOUT)	CMSD	any	Yes	No
Simulated Pool Elevation (POOL)	M	any	Yes	No
Simulated Storage Contents (STORAGE)	CMSD	any	Yes	No
Inflow at period End Back-computed from Observed Pool Elevation and Discharged (BACKQI1)	CMS	any	Yes	No
Inflow at period Start Back-computed from Observed Pool Elevation and Discharged (BACKQI2)	CMS	any	Yes	No
Mean Inflow Back-computed from Observed Pool Elevation and Discharged (BACKQIM)	CMSD	any	Yes	No

5. Modifications (Mods)

The SSARRESV model has seven mods it accounts for.

Parameter Id	Internal Model Units	Time Step	Description
FREEFLOW		any[2]	Free flow (lake routing) DEFAULT
SETQ	CFS	any[2]	Outflow specified
SETH	FT	any[2]	Reservoir elevation specified
SETS	ACFT	any[2]	Reservoir storage specified
SETDQ	CFSD[1]	any[2]	Changes in storage specified
SETDH	FT[1]	any[2]	Daily change of elevation specified
SETDS	ACFT[1]		Daily change of storage specified

[1] daily values (per Day)
[2] an equidistant time series; the date and time must coincide with a model time step
SSARRESV uses the existing NWSRFS operation definition for defining model mods. For further information see:

https://vlab.ncep.noaa.gov/documents/207461/1893022/653c_fcm_ssarreg.pdf

SSARREG mod files will be converted from an xml to text file format.

Sample of SSARREG mods xml file:

```
<?xml version="1.0" encoding="UTF-8"?>
<TimeSeries
   xsi:schemaLocation="http://www.wldelft.nl/fews/PI
http://fews.wldelft.nl/schemas/version1.0/pi-schemas/pi_timeseries.xsd"
   version="1.2" xmlns="http://www.wldelft.nl/fews/PI"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
   <timeZone>0.0</timeZone>
   <series>
      <header>
         <type>instantaneous</type>
         <locationId>SELWE</locationId>
         <parameterId>SETDH</parameterId>
         <qualifierId>DS</qualifierId>
         <timeStep unit="nonequidistant"/>
         <startDate date="1993-04-03" time="00:00:00"/>
         <endDate date="1993-04-06" time="00:00:00"/>
         <missVal>-999.0</missVal>
         <stationName>SELWE</stationName>
         <units>FT</units>
      </header>
      <event date="1993-04-03" time="00:00:00" value="0.40" flag="2"/>
      <event date="1993-04-06" time="00:00:00" value="-0.40" flag="2"/>
   </series>
   <series>
      <header>
         <type>accumulative</type>
         <locationId>SELWE</locationId>
         <parameterId>SETDQ</parameterId>
         <qualifierId>DS</qualifierId>
         <timeStep unit="nonequidistant"/>
         <startDate date="1993-04-03" time="06:00:00"/>
         <endDate date="1993-04-07" time="00:00:00"/>
         <missVal>-999.0</missVal>
         <stationName>SELWE</stationName>
         <units>CFSD</units>
```

```
      </header>
      <event date="1993-04-03" time="06:00:00" value="1500.0" flag="2"/>
      <event date="1993-04-04" time="00:00:00" value="2000.0" flag="2"/>
      <event date="1993-04-07" time="00:00:00" value="-300.0" flag="2"/>
   </series>
   <series>
      <header>
         <type>instantaneous</type>
         <locationId>SELWE</locationId>
         <parameterId>SETH</parameterId>
         <qualifierId>DS</qualifierId>
         <timeStep unit="nonequidistant"/>
         <startDate date="1993-04-04" time="06:00:00"/>
         <endDate date="1993-04-05" time="06:00:00"/>
         <missVal>-999.0</missVal>
         <stationName>SELWE</stationName>
         <units>FT</units>
      </header>
      <event date="1993-04-04" time="06:00:00" value="1983.3" flag="2"/>
      <event date="1993-04-05" time="00:00:00" value="1983.9" flag="2"/>
   </series>
   <series>
      <header>
         <type>instantaneous</type>
         <locationId>SELWE</locationId>
         <parameterId>SETDS</parameterId>
         <qualifierId>DS</qualifierId>
         <timeStep unit="nonequidistant"/>
         <startDate date="1993-04-05" time="06:00:00"/>
         <endDate date="1993-04-05" time="06:00:00"/>
         <missVal>-999.0</missVal>
         <stationName>SELWE</stationName>
         <units>acft</units>
      </header>
      <event date="1993-04-05" time="06:00:00" value="-900.0" flag="2"/>
   </series>
</TimeSeries>
```

Sample Text Format

```
2 949872
SSARREG_DS_2_949872=1733.0
SSARREG_US_1_949873=27800.0
SSARREG_US_1_951307=99000.0
SSARREG_US_2_951811=1744.5
SSARREG_US_2_952121=1744.5
SSARREG_US_2_952555=1743.6
```

6. Notes about configuring Model in FEWS workflow

Examples:

Module Configuration File
ModuleConfigFiles\SSARRESV_MCDW1_MCDW1_Forecast.xml

Module Parameter File
ModuleParFiles\SSARRESV_MCDW1_MCDW1_UpdateStates.xml

7. FEWS Adapter Used

The SSARRESV model uses the OHDFewsadapter to communicate. Information about this adapter can be found at OHDFewsadapter.