VII. Tutorial 6: Oprule

The purpose of this tutorial is to provide instruction on the use of Operating Rule Language (ORL) statements to set gate operations and flows. With operating rules, expressions can be used to make the model operate gates on-the-fly; e.g., a gate can be directed to automatically close when stage conditions reach a certain threshold. The following steps will instruct you on how to add the ORL statements. We will apply operating rules to a new gate that we will create and to a source/sink inflow.

1. Adding a Second Gate Where Op Rule Will Be Applied

a. In the *Simulations Navigator*:
   1) Expand the *model: tutorial_hydro* folder.
   2) Expand the *Grid* folder.
   3) Double-click on *Gates.*

b. In the *Layer panel*, right-click and select *Set edit layer*.

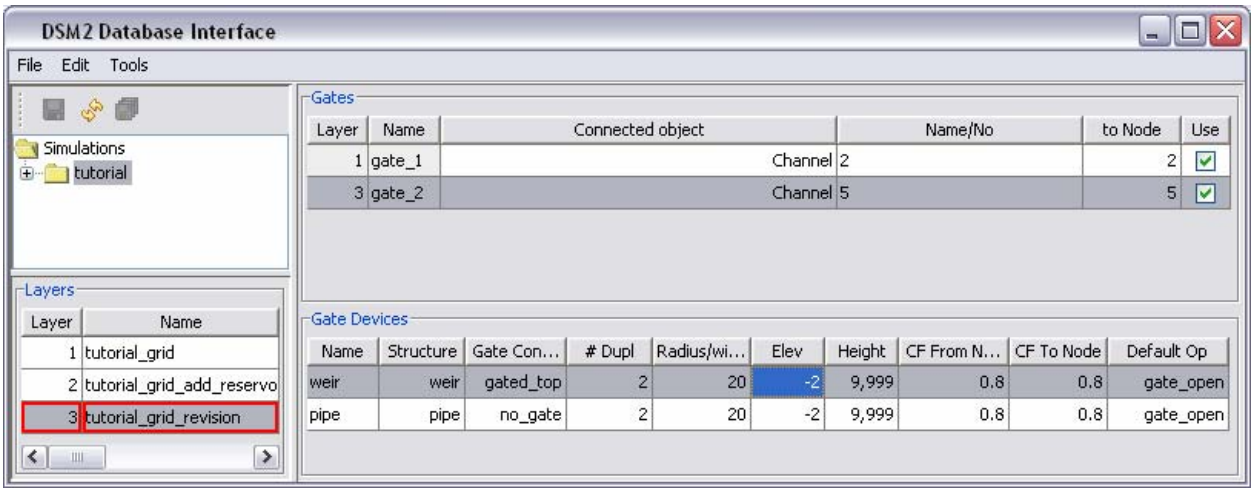
c. In the *Select Layers* window, double-click the *tutorial_grid_revision* layer.

d. In the *Gates* table:
   1) Right-click on the row with *gate_1* and select *Copy row to edit layer (with subtables)*.
   2) Click on the copied row and change the following fields:
      i) Name: *gate_2*
      ii) Name/No.: *5*
      iii) to Node: *5*

e. In the *Gate Devices table*:
   1) Click on each of the weir and pipe rows and change the following field:
      i) Elev: *-2*

f. Save the current settings.

g. At this point, the GUI should look as follows:



2. Adding Output for the Second Gate:

a. In the *Simulations Navigator*:
   1) Collapse the *Grid* folder [optional].
   2) Expand the *Output Time Series* folder.
   3) Double-click on *Gate Output.*

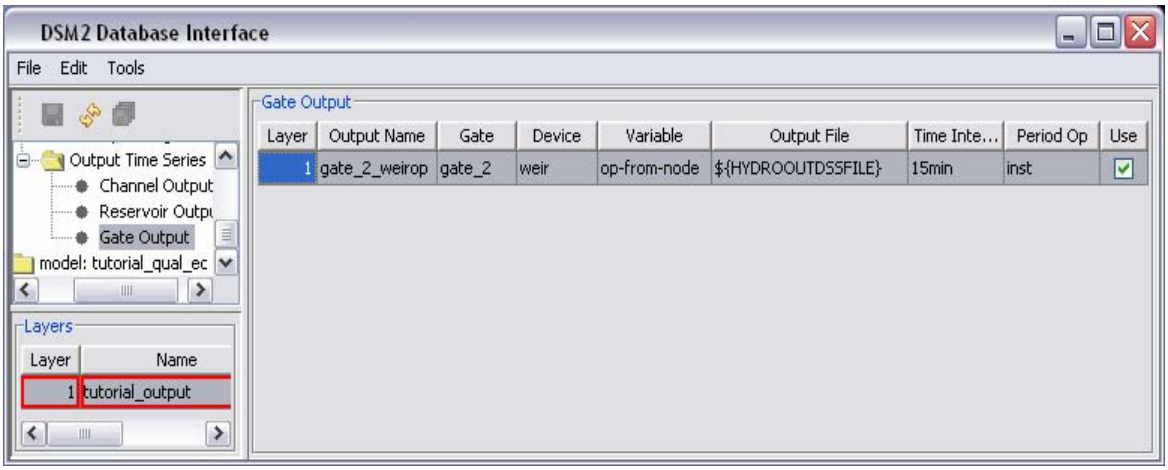
b. In the *Layer panel*, right-click and select *Set edit layer*.

c. In the *Select Layers* window, double-click the *tutorial_output* layer.

d. In the *Operating Rules* table:
   1) Right-click and select *Insert row*.
   2) Enter the following values into the appropriate fields:
      i) Output Name: *gate_2_weirop*
      ii) Gate: *gate_2*
      iii) Device: *weir*
      iv) Variable: *op-from-node*
      v) Output File: *${HYDROOUTDSSFILE}*
      vi) Time Interval: *15min*
      vii) Period Op: *inst*
      viii) Use: Make sure that the entry contains a checkmark.

e. Save the current settings.

f. At this point, the GUI should look as follows:



g. In Windows Explorer, navigate to the directory, *\{DSM2_home}\tutorial\simulations\simple\t6_oprule*.

h. Open the file, *hydro.inp*.

i. Add the following statements to the output paths section in order to view gate trigger locations:

```
trigger_loc  4    7500   stage  15min   inst  ${HYDROOUTDSSFILE}
ds_gate2     5    0      flow   15min   inst  ${HYDROOUTDSSFILE}
```

j. In the *Layers panel*, right-click and select *Unset edit layer* [optional].

3. Create an Operating Rule to Close the Weir when Stage is Low:

This operating rule closes the new gate we created during times where stage at a monitoring point is low. First we will define the rule in terms of an expression called *stage_critical* (the condition where stage violates a minimum) and *op_applies* (a seasonal condition that is True when we are controlling the gate for stage. In a later step we will define these variables.

a. In the *Simulations Navigator*:

1) Collapse the *Output Time Series* folder [optional].

2) Expand the *Operations* folder.

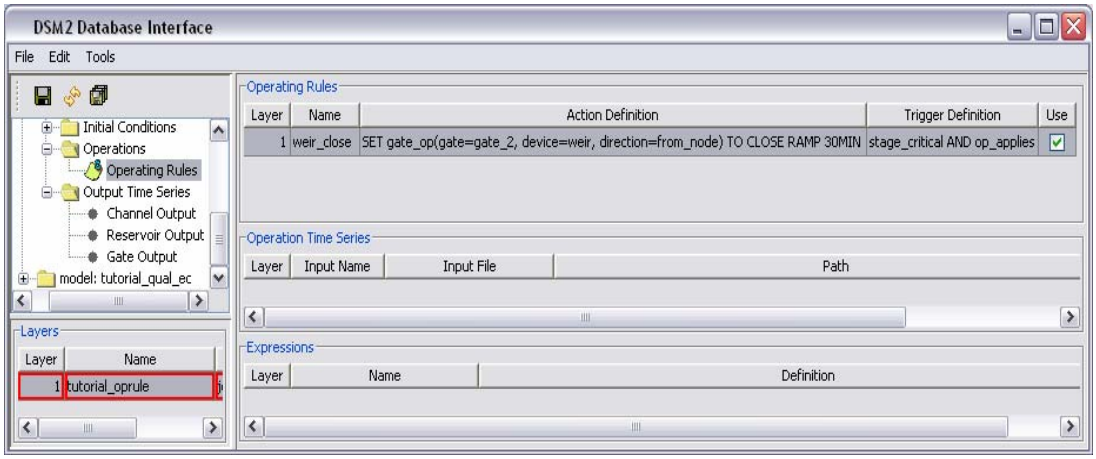
3) Double-click on *Operating Rules.*

b. Add a new Operating Rules Layer:

1) In the *Layer panel*, right-click and select *New layer*.

2) Select *Yes* to confirm the refresh.
3) Name the new layer, *tutorial_ oprule*, and add a description.
4) Enter *1* for the layer number.

c. In the *Layer panel*, right-click and select *Set edit layer*.
d. In the *Select Layers* window, double-click the *tutorial_oprule* layer.
e. In the *Operating Rules* table:
1) Right-click and select *Insert row*.
2) Enter the following values into the appropriate fields:
i) Name: *weir_close*
ii) Action Definition: *SET gate_op(gate=gate_2, device=weir, direction=from_node) TO CLOSE RAMP 30MIN*
iii) Trigger Definition: *stage_critical AND op_applies*
iv) Use: Make sure that the entry contains a checkmark.
f. Save the current settings.
g. At this point, the GUI should look as follows:



Note that the expressions stage_critical and op_applies will be created in a later step.

3. Create an Operating Rule to Open the Weir when Stage is High:

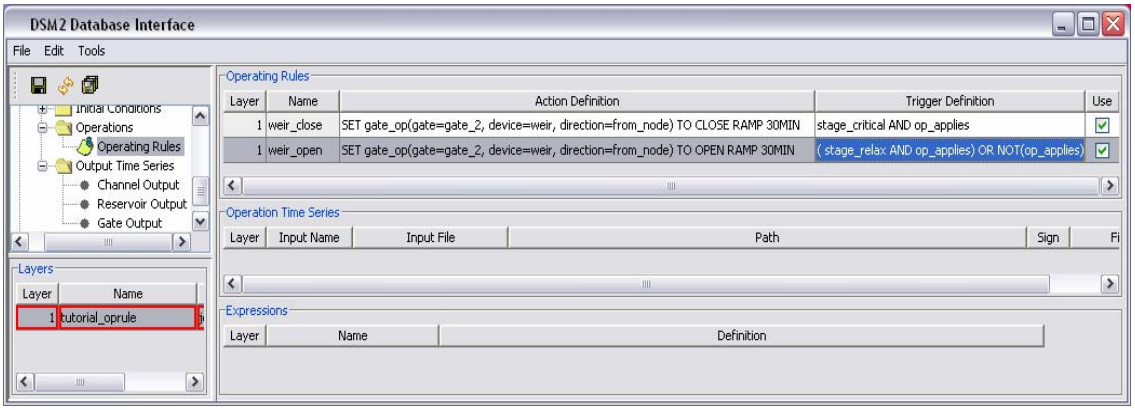
As before, we will enter the rule to open the weir first in terms of the expressions *stage_relax* (a condition where stage is safely above a threshold where we can open the gate) and *op_applies*. In the next step we will define these expressions.

a. In the *Operating Rules table*:
1) Right-click and select *Insert row*.

2) Enter the following values into the appropriate fields:
   i) Name: *weir_open*
   ii) Action Definition: *SET gate_op(gate=gate_2, device=weir, direction=from_node) TO OPEN RAMP 30MIN*
   iii) Trigger Definition: (stage_relax AND op_applies) OR NOT(op_applies)
   iv) Use: Make sure that the entry contains a checkmark.

b. Save the current settings.

c. At this point, the GUI should look as follows:



d. In the *hydro.inp* file, add the following environmental variables and values into the ENVVARS section:

STAGE_CRITICAL 1.4
STAGE_RELAX 1.6

4. Define Expressions used in the rule

a. In the *Expressions* table:
   1) Right-click and select *Insert row*.
   2) Enter the following values into the appropriate fields:
      i) Name: *op_applies*
      ii) Definition: *SEASON < 01FEB*
   3) Again, right-click and select *Insert row*.
   4) Enter the following values into the appropriate fields:
      i) Name: *stage_critical*
      ii) Definition: *chan_stage(channel=4, dist=7500) < ${STAGE_CRITICAL}*

5) Once again, right-click and select *Insert row*.

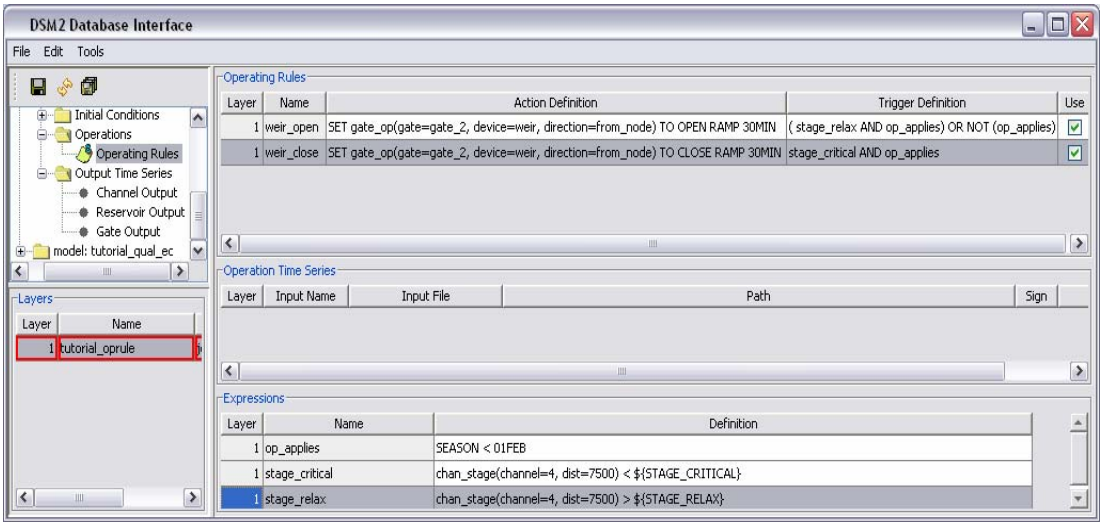
6) Enter the following values into the appropriate fields:

i) Name: *stage_relax*

ii) Definition: *chan_stage(channel=4, dist=7500) > ${STAGE_RELAX}*

b. Save the current settings.

c. At this point, the GUI should look as follows:



d. Now run HYDRO and QUAL:

1) Open a command window for the *t6_oprule* directory.

2) In the command window, type: *hydro hydro.inp*.

3) In the command window, type: *qual qual.inp*.

4) Open the *output.dss* file in the *t6_oprule* directory, and examine the results.

5. Add a Reduced Flow Operating Rule:

In our next operating rule, we will control the inflow to a node by having it toggle back and forth between a larger “full flow” and a reduced flow. First we will enter the rule and then we will define the full and reduced flows.

a. In the *Operating Rules table*:

1) Right-click and select *Insert row*.

2) Enter the following values into the appropriate fields:

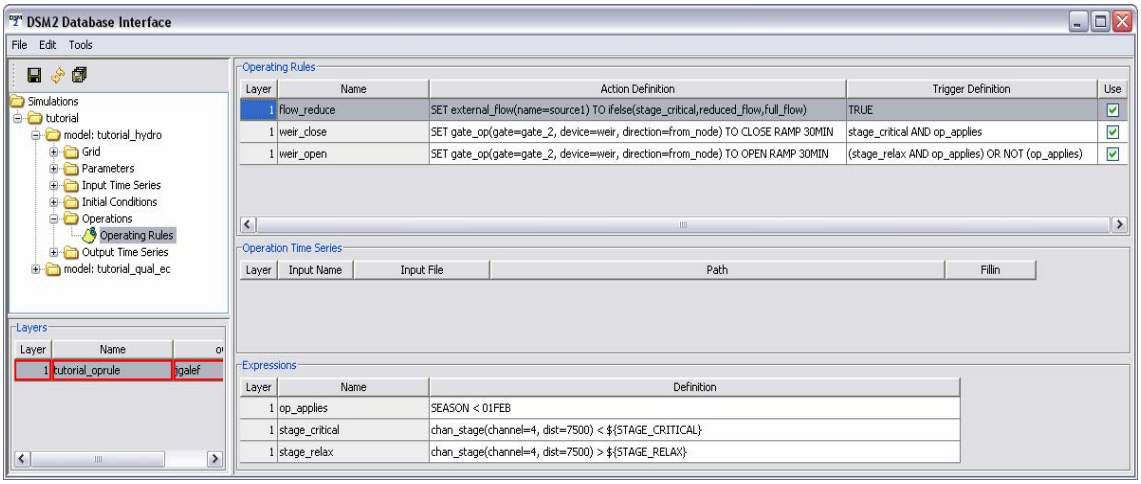
i) Name: *flow_reduce*

ii) Action Definiton: *SET external_flow(name=source1) TO ifelse(stage_critical,reduced_flow,full_flow)*

iii) Trigger Definition: *TRUE*

iv) Make sure the *Use* box is checked.

b. At this point, the GUI should look as follows:



c. Save the current settings.

d. Now create the expressions that define *full_flow* and *reduced_flow*. In the *Expressions* table:

1) Right-click and select *Insert row*.

2) Enter the following values into the appropriate fields that define *full_flow.* This will involve the time series *source_flow* which we will enter later:

i) Input Name: *full_flow*

ii) Definition: *ts(name=source_flow) [note: this is a reference to a time series we haven't defined yet].*

3) Do the same for *reduced_flow.* Note: we are defining *reduced_*flow in terms of the time series. There is no guarantee of what order expressions will be evaluated, so you cannot safely define *reduced_flow* in terms of another expression such as *full_flow*. Enter the following values into the appropriate fields:

i) Input Name: *reduced_flow*

ii) Definition: *0.5*ts(name=source_flow).*

e. Save the current settings.

1) Now we will define the *source_flow* time series upon which the *full_flow* and *reduced_flow* expressions are based.

f. In the *Layer panel*, right-click and select *Set edit layer*.

g. In the *Select Layers* window, double-click the *tutorial_oprule* layer.

h. In the *Operation Time Series* table:

1) Right-click and select *Insert row*.

2) Enter the following values into the appropriate fields:

i) Input Name: *source_flow*

ii) Input File: *${TUTORIALINPUT}*

iii) Path: */TUTORIAL/SOURCE/FLOW//15MIN/CONSTANT/ [Note: there are two forward slashes between 15MIN and CONSTANT]*

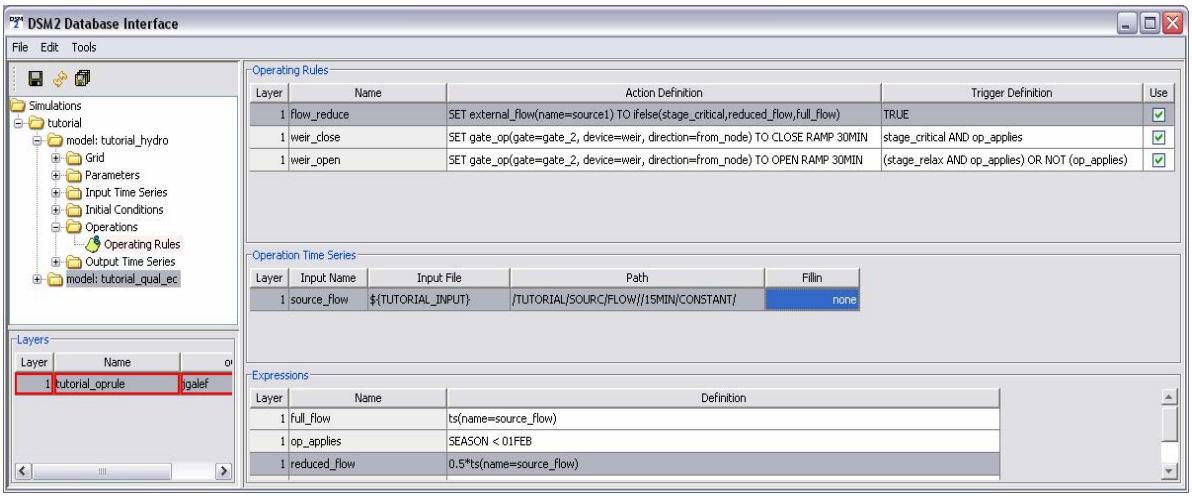
iv) Sign: *1*

v) Fillin: *none*

vi) Make sure the *Use* box is checked.

i. Save the current settings.

j. At this point, the GUI should look as follows:

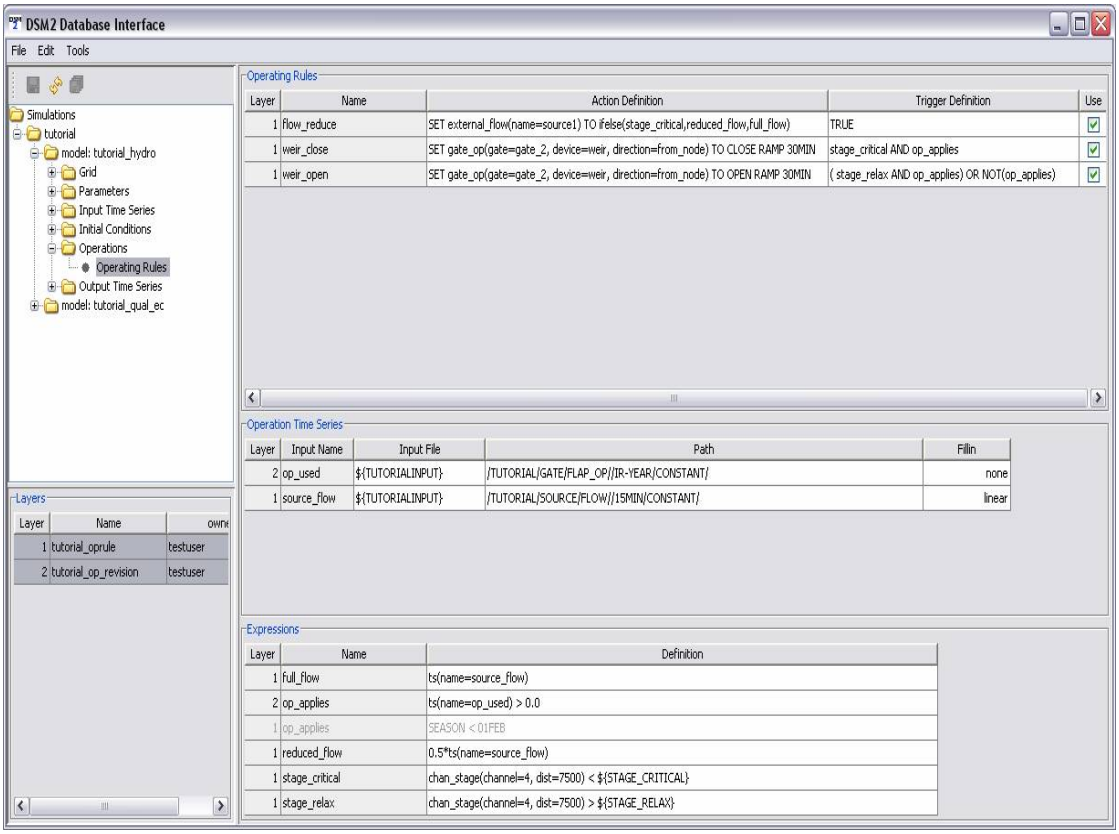


6. Override the Expression op_applies:

Recall that *op_applies* is used to determine when the weir is operated. Previously the definition of this expression was seasonal: the expression was SEASON < 01FEB.

The goal now is to make the same expression depend on a time series. Rather than change the expression, we will override it in a new layer.

a. Add a new Operating Rules Layer:
    1) In the *Layer panel*, right-click and select *New layer*.
    2) Select *Yes* to confirm the refresh.
    3) Name the new layer, *tutorial_ oprule_revision*, and add a description.
    4) Enter *2* for the layer number.
b. In the *Layer panel*, right-click and select *Set edit layer*.
c. In the *Select Layers* window, double-click the *tutorial_oprule_revision* layer.
d. Redefine the expressions that define *op_applies*. In the *Expressions* table:
    1) Right-click and select *Insert row*.
    2) Enter the following values into the appropriate fields:
        i) Input Name: *op_applies*
        ii) Definition: *ts(name=op_used) [note: this is a reference to a time series we will define in the next step].*
e. Define the time series *op_used* on which the *op_applies* expression depends. In the *Operation Time Series* table:
    1) Right-click and select *Insert row*.
    2) Enter the following values into the appropriate fields:
        i) Input Name: *op_used*
        ii) Input File: *${TUTORIALINPUT}*
        iii) Path: */TUTORIAL/GATE/FLAP_OP//IR-YEAR/CONSTANT/*
        iv) Sign: *1*
        v) Fillin: *none*
        vi) Make sure the *Use* box is checked.
f. At this point, the GUI should look as follows:



g. In the *Layers* panel, right-click and select *Unset edit layer* [optional].

h. Run HYDRO and QUAL and examine the results.