Workshop 4 – Multiple Rules Operation

Introduction

This workshop will demonstrate how to create downstream control function reservoir operation rules in HEC-ResSim and how to combine and analyze multiple operation rules in the same zone. The workshop will build off the Water Control Plan operation set created at the end of Workshop 3. Students will create different types of downstream control function rules and investigate how rule priorities in zones affect the release decision logic.

Problem Statement

The goals of this workshop are to:
- Create downstream control function reservoir operation rules in HEC-ResSim to represent several of the flow objectives listed for downstream locations in the Crazy Mountain Reservoir Regulation Manual,
- Assign operation rules to the appropriate zone and correctly prioritize rules within zones, and
- Identify the effects of operations on simulation results.

The rules we will explore are (from the Water Control Plan in Section III of the Crazy Mountain Reservoir Regulation Manual):

1. At-Site water control plan operations (already created from Workshop 3).
2. Water Supply Requirements – minimum flows at Rockville and Greenfield.
3. Normal Flood Control Operation – channel capacity restrictions at River Point and Greenfield.
4. (extra credit) Conjunctive-use for water supply at Greenfield. Supplement groundwater pumping with surface water from the river to maintain a conjunctive water supply of 3,500 cfs.

As in Workshop 3, rules will be added to a new operation set which will then be used by a new alternative. An outline of the operation sets and the associated alternatives is given in the table below. Please review the Water Control Plan, Crazy Mountain Regulation Manual, Section III, for detailed information on the rules before proceeding.

The rules, operation sets, and alternatives that you will be creating:

Task #	Network	New Rule	Operation Set	Alternative
1	01 Standard		At-Site Rules	Alt 02
2	01 Standard	Min Flow- Rockville	DSops-Rock	WCP-Rock
3	01 Standard	Max Flow- River Pointe	DSops-Rock&River	WCP-RR
4	01 Standard	Min Flow-Greenfield; Max Flow-Greenfield	Water Control Plan	WCP-RRG
5	WithLoopy		Water Control Plan	WCP-Loopy

Tasks

1. <u>Review starting watershed</u>: Open the **WS4** simulation in the starting watershed for the Workshop 4, **WS4_Start**. Run the simulation and use standard plots and reports to analyze the results for alternative **Alt02** and answer the following questions.

> *Tip*
>
> This simulation contains one alternative with simulation results generated using the At-Site Rules operation set. This operation set contains all the at-site operation rules created in Workshop 4. In addition, the simulation time window has been extended by 3 days (flows during the extended portion of the time window are assumed to stay constant through 1July); local flows at Rockville, Villanova, and Bethesda are multiplied by factors of 2, 2, and 2.204 respectively (instead of 1); and the starting reservoir elevation is 682 feet rather than 680 feet.

Questions

      I)   Which rules are active and when?

      II)   When are the water control plans flow criteria violated? Use the table below to note times when the criteria are violated.

Location Violation	Rockville	Greenfield	River Pointe
Flow < 2,500 cfs			
Flow < 3,500 cfs			
Flow > 12,000 cfs			
Flow > 40,000 cfs			

2. Add Minimum flow limit at Rockville
    o   Open the Reservoir Network Module and the network **01 Standard**.
    o   In the Reservoir Editor, duplicate the **At-Site Rules** operation set and call it **DSops-Rock**.
    o   In the new operation set, create an operation rule from **Crazy Mountain** that does not allow flow at Rockville to fall below the minimums as described in Table 3-2 of the Reg. Manual. Once added, this rule should be the lowest priority rule in the zone.

> *Tip*
>
> When creating a downstream control rule, once you click **OK** in the New Rule window, it will not be possible to change the location (control point). The Downstream Control Function Rule Editor looks almost identical to the Release Function rule editor except for two additional fields: **Downstream Location** (which is shaded gray, thus not able to be changed), and **Parameter** (which, by default, is set to **Flow**).

Questions

III)   How did you define the function for this rule (or, what is this rule defined to be a function of)? How many entries are in your function table? What is the interpolation type?

IV)   To which zone did you add the new rule? Why? To what other zone(s) should you also add the rule?

3. Add Maximum flow limit at River Pointe

   o   Make a copy of the **DSops-Rock** operation set and call it **DSops-Rock&River**.
   o   Add an operation rule that does not allow flow at River Pointe to exceed the seasonally varying maximums as described in Schedule A of the Reg. Manual. Once added, this rule should be the lowest priority rule in the zone.

Questions

   V)   What is the "growing season"? What is this rule a function of? What is the interpolation type?

   VI)   To which zone did you add the new rule? Why? To what other zone(s) should you also add the rule?

4. Add flow limits at Greenfield
   o   Make a copy of the **DSops-Rock&River** operation set and call it **Water Control Plan**.
   o   Add an operation rule that does not allow flow at Greenfield to exceed the seasonally varying maximums as described in Schedule A of the Reg. Manual.
   o   Next, add an operation rule that will provide the minimum flows described in Table 3-3 of the Reg. Manual.
   o   Add the rules so that the minimum flow rules have higher priority than the maximum flow rules and the priorities of the downstream locations are in the following order: Rockville, Greenfield, and River Pointe.
   o   Close the reservoir editor and save the network.

Questions
   o   In what ways did these rules differ from those you created in tasks 2 & 3?

VIII) To which zone did you add the new rule? Why? To what other zone(s) should you also add the rule?

5. Create an alternative for each new operation set
    o   Use SaveAs of Alt 02 then change the operation set.
    o   Name the new alternatives **WCP-Rock**, **WCP-RR**, and **WCP-RRG** and assign each an Operation Set as noted in the table on page 1.
    o   Verify that the Time Step is hourly and the Flow Computation Method is Instantaneous for each alternative.

6. Add the new alternatives to the WS4 simulation
    o   Open the simulation module.
    o   Edit the simulation (right-click on the simulation in the Simulation Control Tree or go to the **Simulation** menu and select **Edit**) and add the three new alternatives that you have created.

7. Analyze Rockville Operations
    o   Set the **WCP-Rock** alternative active.
    o   Compute.
    o   Examine results at the reservoir and the Rockville junction.
    o   Compare results to Alt 02 (using the At-Site Rules operation set).

Question
   IX) How do reservoir releases for the WCP-Rock differ from Alt-02 (the At-Site Rules operations)? When do they start? Why do they start? When do they end? Why do they end at that time? Do the WCP-Rock results meet the Rockville minimum flow objective? Why or why not?

8. Change rule priority
   o Give the Rockville minimum flow rule a higher priority in the conservation zone and re-compute the simulation.

> *Tip* If you want to compare simulation results for different rule priorities, make a trial. Once the trial is active, open the reservoir editor and change the priority of a rule by right-clicking on it in the rule tree and selecting one of the "move" options (increase priority, decrease priority, move to top, and move to bottom). Compute the trial and compare its results to the original alternative.

Question
   X) How does changing the priority change the simulated operations? Why? What changes do you observe if you give the rule other priorities?

9. Analyze the maximum flow limit at River Point
   o Set the **WCP-RR** alternative active. Compute.

Question
   XI) How do reservoir releases now differ from WCP-Rock alternative? When do the differences begin? Why do they start? When do they end? Do the results meet the River Point channel capacity? Why or why not?

10. Change the rule priorities to allow the reservoir to operate for River Pointe. [HINT, use another trial.]

Questions

    XII) What is the new rule order? How do reservoir releases and downstream flows at River Pointe now differ? Do the results meet the constraint you are trying to model (flow at Rockville must be at least 2500 cfs)? Why or why not?

    XIII) Which rule priority scenario is preferable?

11. Analyze the Flow limits at Greenfield
   - Set the **WCP-RRG** alternative active. Compute.

Questions

    XIV) How do the results now differ from WCP-RR alternative? When do they start? Why do they start? When do they end? Why do they end at that time? Do the results meet the Greenfield flow constraints? Why or why not?

XV)   Can you change rule priority for the Max Flow-Greenfield rule to show an operational influence? Do the results meet the objective you are trying to model? Why or why not?

XVI)   Which scenario of rule priorities is preferable?

12. Analyze the Influence of routing on downstream operations

- ○ Create a new trial of the **WCP-RRG** alternative.
- ○ Right click on the downstream-most reach, **VENT Oak River to River Pointe**, and select **Edit Reach Properties**.
- ○ Modify both the Muskingum K and Subreaches from 1 to 8.
- ○ Apply the changes, compute the trial, and compare the results to the original alternative.

XVII)   What is the difference at River Pointe? Why? How/why is this an improvement?

XVIII)   How does the release decision at Crazy Mountain differ?

In reality, the new values are actually closer to the true values for the routing reach.

13. Analyze the Influence of a diversion on downstream operations

- ○ Return to the Network Module.
- ○ Use **Network**, **SaveAs** to Make a copy of the **01 Standard** network and call it **WithLoopy**. Verify that the **WithLoopy** network is the current network.
- ○ Select the diversion tool and draw in the **Loopy** diversion, which removes flow from Rockville and returns it to the network at Bethesda.
- ○ Enter the diversion function and routing as described in Appendix B of the Reg. Manual.

- o   Modify the Muskingum Routing values of VENT Oak River to River Pointe to those of the trial in the previous exercise.
- o   Save the network.

Create a NEW alternative
- o   Using the **WithLoopy** network, create a new alternative. Name it **WCP-Loopy**.
- o   Select the **Water Control Plan** operation set.
- o   Set the Time Step to 1 Hour and the Flow Computation Method to Instantaneous.
- o   Set the initial conditions and time-series selections to the same as those for the **WCP-RRG** alternative.
- o   The initial condition of the diversion should be set to 0.

> **Tip**
> To copy the time series selection from one alternative to another, select the entire set of rows in the original alternative, then press ctrl-C or select copy from the right-click menu. Then select the first (grey, not white) cell of the time series table for the new alternative. Use Ctrl-V (**not** right-click, paste) to paste the copied cells into the new table.

- o   Switch back to the simulation module. Edit the simulation and add the **WithLoopy** alternative. Compute. Compare the results to those of **WCP-RRG**.

Question
XVII)   What effect does the diversion have on the reservoir and its operations? Were any of the three control points affected? If so, which ones and in what way?