

Workshop 3 – Creating At-Site Operating Rules

Introduction

This workshop will demonstrate how to create at-site reservoir operation rules in HEC-ResSim, insert operating rules into appropriate zones, and verify that the rules produce desired operations. New operations sets and alternatives will be created for each rule type entered. Operations sets will be based on the basic guide curve operations set created in Workshop 3. Release Function and Flow Rate of Change operation rules will be investigated. Students will simulate alternatives for each rule type, identify the effects of rule operation, and verify that the effects match expected behavior.

Problem Statement

The goal of this workshop is to:

- Create reservoir operation rules in HEC-ResSim for several of the operations described in the *Crazy Mountain Reservoir Regulation Manual*,
- Determine the appropriate zone(s) to assign operation rules, and
- Identify the effects of the operation on simulation results

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

1. Guide curve operation (already created from Workshop 2),
2. Do not release less than 700 cfs,
3. Do not release more than 6,000 cfs during the growing season, or more than 10,000 cfs during the non-growing season,
4. Releases should not increase by more than 1,000 cfs per hour,
5. Maximum allowable release is a function of reservoir elevation and season as described by Schedule B, and
6. Specified irrigation diversion schedule is a function of season as described in Table 3-4.

You will create a new operation set and alternative for each operating rule mentioned above. This will enable us to learn how each rule impacts the operation independently.

- As a final task, you will enter all at-site reservoir rules into their appropriate zone(s) within a single operation set.

Please review the Water Control Plan for background information on the rules and operations before proceeding. Also, please refer to your lecture material for guidance on Implementing Release Rules.

The following summary table lists the associated Network, Operation Set, and rule(s) for each alternative you will be creating and analyzing in this workshop.

Alternative	Network	Operation Set	Rule type to create and apply
Alt01 GC	01 Standard	Basic GC	None, basic guide curve operation
Alt02 Min	01 Standard	Min Required Release	Minimum release function of date
Alt03 Max	01 Standard	Max Allowable Release	Maximum release function of date
Alt04 ROC	01 Standard	Max-Inc-Flow-ROC	Maximum increasing flow rate of change
Alt05 SchB	01 Standard	Schedule B	Maximum release function of pool elevation Maximum decreasing flow rate of change, <u>and</u> Maximum release function of date
Alt06 Div	02 With Nutty	Diverted Outlet	Specified release function of pool elevation, <u>and</u> Maximum release function of date
Alt07 ALL	02 With Nutty	At-Site Rules	All rules created in this workshop

General Instructions for all alternatives

Create a new Operation Set

- From the **Edit** Menu, select **Reservoirs...** to open the **Reservoir Editor** then select the **Operations** tab.
- Select the Basic GC operation set from the **Operation Set** dropdown list.
- From the **Operations** menu, select **Duplicate** to make a copy of the Basic GC operation set and name the copy (as instructed for each alternative below).

Create a new Rule

- From the **Zone-Rules** tree
 - Select a zone
- From the **Rule** menu
 - Select **New...**
- In the **New Operating Rule** dialog
 - Select the release element for **Operate Releases From**. This is often the reservoir or the dam.
 - Select the **Rule Type**
 - **Name** the Rule
- In the **Reservoir Editor** Rule Panel
 - See specific instructions for each rule/alternative below...
 - Click **Apply** to apply/save your changes to the operation set and keep the Reservoir Editor open.

Create a new Alternative

- From the **Alternative** Menu, select **Edit** to open the **Alternative Editor**.
- Select the alternative Alt01 GC created for the Basic Guide Curve Operations. From the **Alternative** menu, select **Save As...** to make a copy of the alternative:
 - Name the copy (as instructed for each alternative below).
 - Enter a description.
- Revise your copy (as instructed for each alternative below):
 - On the **Operations** tab - Select the correct operation set for your new alternative
 - On the **Run Control** tab - Verify that the **Time Step** is set to 1 Hour and the Flow Computation Method is set to Instantaneous
 - From the **Alternative** menu - **Save** your new alternative.

➤ **Part A – Create the new Rules and Operation Sets**

1. Open the starting watershed for the Workshop 3: **WS3_Start**
2. From the **Reservoir Network Module**, open the network named **01 Standard**

Alt02 Min

• **Create a second Operation Set and a new Minimum Required Release Rule**

3. Open the Reservoir Editor and select the Operations tab.
4. Duplicate the **Basic GC** operation set and name the copy **Min Required Release**.
5. Refer to Section III of the *Regulation Manual*. Interpret the at-site requirement “Do not release less than 700 cfs” and add a new rule to the **Conservation** zone:

In the New Operating Rule Dialog

- Name the Rule **Min Rel at Dam – Normal Condition**.
- The rule must Operate Releases from the Crazy Mountain-Dam.
- The rule type must be Release Function.

In the Reservoir Editor Rule Panel

- Define the rule as a Function of Date.
- Select the appropriate Limit Type (i.e., Maximum, Minimum, or Specified?) and Interpolation Type (i.e., Linear, Cubic, or Step?).
- Enter the Release criteria in the Date-Release table according to the *Regulation Manual*.
- Click **Apply** to apply/save your changes to the operation set and keep the Reservoir Editor open.

Alt03 Max

• **Create a third Operation Set and a new Maximum Allowable Release Rule**

6. Duplicate the **Basic GC** operation set and name the copy **Max Allowable Release**.
7. Refer to Section III of the *Regulation Manual*. Interpret the at-site requirement “Do not release more than 10,000 cfs during the non-growing season and do not release more than 6,000 cfs during the growing season.” Create a new rule called **Max Rel at Dam** that reflects this requirement, and apply the rule to the appropriate zone(s).

Questions

- l) How did you handle the time-date aspects of the rule between the growing and non-growing seasons?

II) What option did you choose for *Interpolation* type? Why?

III) To what zone(s) did you assign your rule? Why?

Tip

To assign a rule to a second zone, highlight the second zone. Right click on the zone and select **Use Existing Rule**. In the popup window, select the previously defined rule to add to that zone.

Alt04 ROC

- **Create a fourth Operation Set and a new Maximum Increasing Flow Rate of Change Rule**
 8. Duplicate the **Basic GC** operation set and name the copy **Max-Inc-Flow-ROC**.
 9. Refer to Section III of the *Regulation Manual*. Interpret the at-site requirement “releases should not increase by more than 1,000 cfs per hour.” Create a new rule called **Max-Inc-Flow-ROC** that reflects this requirement at Crazy Mountain- Dam, and apply the rule to the appropriate zones.

Question

IV) To what zone(s) did you assign your rule? Why?

Alt05 SchB**• Create a fifth Operation Set and a new Maximum Release Function of Pool Elevation Rule**

10. Unlike what you have done for the previous Alternatives (where you duplicated the Basic GC operation set), this time Duplicate the **Max Allowable Release** operation set and name the copy **Schedule B**.

11. Refer to Section III of the *Regulation Manual*. Interpret the at-site requirement “Follow Release Schedule B in the Major Flood Control Pool for Rising Inflow Condition as well as Falling or Constant Inflow Condition” and create two new rules:

Create the *first rule* for the Rising Inflow Condition

- Add a new rule to the **Major Flood Control Pool**.

In the New Operating Rule Dialog

- Name the rule **Schedule B – Rising Inflow**.
- The rule must Operate Releases from the Crazy Mountain-Dam.
- The rule type must be Release Function.

In the Reservoir Editor Rule Panel

- Define the rule as a Function of Model Variable: “Crazy Mountain-Pool Reservoir Elevation.” (Click the Define Button and set Release as a Function of: Model Variable. Filter through the Independent Variable Definition Editor to find the correct Model Variable. Highlight the variable and press Select so that the Time-Series name appears in the box at the bottom of the editor. For the Time Series Options, set Function: **Previous Value**. Press OK to close the Independent Variable Definition Editor.)
- Select the appropriate Limit Type (**Maximum**) and Interpolation Type (**Linear**)
- Enter elevations and releases in the table for the non-growing season.

Question

- V) How did you enter values that accommodate both step (707 – 711 ft) and linear (711 – 712 ft) interpolation in one table?

VI) Enter elevations and releases for the **other seasons**.

HINT: Click the **Edit...** button next to **Seasonal Variation**.. In the popup window, select **Step** from the dropdown list labeled **Interpolation Type**, and enter the additional **Dates**.

- At this point, do not enter the rising inflow condition associated with the operation. Leave the checkbox **Rising/Falling Condition** unchecked.
- Press Apply to save changes to this rule and keep the Reservoir Editor open.

Create the *second rule* for the Falling-or-Constant Inflow Condition of Schedule B...

- Add this new rule to the **Major Flood Control Pool**

In the New Operating Rule Dialog

- Name the rule **Max dec. flow ROC=0**.
- The rule must Operate Releases from the Crazy Mountain-Dam.
- The rule type must be Flow Rate of Change Limit.

In the Reservoir Editor Rule Panel

- Define the rule as Function of: **Constant**.
- Select the rate of change Type according to the *Regulation Manual* (Decreasing).
- Enter **Zero** for the Max Rate of Change.
- Press Apply to save changes to this rule and keep the Reservoir Editor open.

12. In this Schedule B Operation Set, which is a duplicate of the Max Allowable Release Operation Set, there will be an existing **Max Rel at Dam** Rule that you should add to the Normal Flood and Conservation zones. This action will ensure that releases transition properly as the pool level rises. However, since this operation set was built as a duplicate of the Max Allowable Release Operation Set, those rules should already be in the appropriate zones. If they were not, these are the steps you could take to add them:

- Highlight the zone, right-mouse-click, and select **Use Existing**.
- Select the **Max Rel at Dam**.
- Click **OK** to apply your changes and close the Reservoir Editor.
- From the **Network** Menu, **Save** your changes to the Network.

Alt06 Div**• Create a sixth Operation Set, a new Specified Required Release Rule**

13. From Network Menu in the Reservoir Network Module, open the network named **02 With Nutty**.
14. From the Reservoir Editor, duplicate the **Basic GC** operation set and name the copy **Diverted Outlet**.
15. Refer to Section III of the *Regulation Manual*. Interpret the at-site requirement “Water is diverted directly from the Crazy Mountain pool through the Nutty Canal for irrigation in fields located south of the reservoir” and add a new rule to the **Conservation** zone.

In the New Operating Rule Dialog

- Name the rule **Req Flow – Nutty Canal**.
- The rule must Operate Releases from the Crazy Mountain-Nutty Canal.
- The rule type must be Release Function.

In the Reservoir Editor Rule Panel

- Define the rule as a Function of Date
- Select the appropriate Limit Type (**Minimum**) and Interpolation Type (**Step**).

Enter the Date and Release data in the table according to the *Regulation Manual* for the monthly required diversion schedule through Nutty Canal

Question

VII) How did you handle the time-date aspects of the rule for the seasonally varying monthly diversion schedule?

- Click **Apply** to apply/save your changes to the operation set.

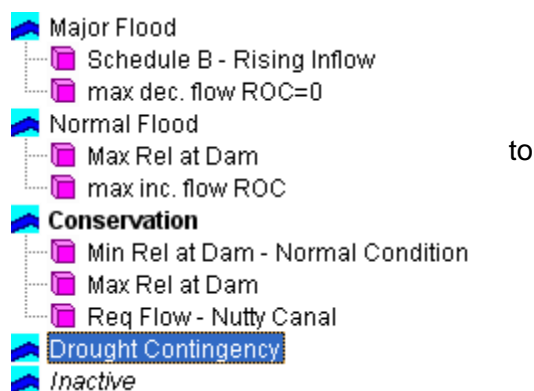
Alt07 ALL

- **Create a seventh and final Operation Set, use ALL Existing Rules created for previous operation sets, and create a seventh and final Alternative**

16. Add ALL Existing Rules available to this Operation Set, and place the existing rules accordingly in their appropriate zone.

17. From the **Network** Menu, **Save** your changes to the Network.

18. From the **File** Menu, **Save** your watershed.



➤ **Part B – Create the new Alternatives**

Alt02 Min

19. From the **Alternative** Menu, select **Edit** to open the Alternative Editor.

20. Highlight the Alternative **Alt01 GC** created for the Basic Guide Curve Operations. Select the **Save As...** option from the Alternative Menu to make a copy of this alternative:

- Name the new copy **Alt02 Min**
- Provide a description “Minimum Required Release Operation”

21. Edit the **Alt02 Min** Alternative to use the “**Min Required Release**” Operation Set:

- Verify that the Time Step is set to 1 Hour and the Flow Computation Method to Instantaneous under the **Run Control** tab.
- From the Operations tab, select the new Operation Set “**Min Required Release.**”
- Save the **Alt02 Min** alternative.

Alt03 Max

22. Make a copy of **Alt01 GC** and edit the **Alt03 Max** alternative to use the “**Max Allowable Release**” Operation Set.

Alt04 ROC

23. Make a copy of **Alt01 GC** and edit the **Alt04 ROC** alternative to use the “**Max-Inc-Flow-ROC**” Operation Set.

Alt05 SchB

24. Make a copy of **Alt01 GC** and configure the new alternative:

- From the Operations tab, select the new Operation Set **Schedule B**.
- Change the lookback elevation to start the Crazy Mountain reservoir level at 707.2 ft.

Alt06 Div

25. Make a copy of the alternative **Nutty** which is equivalent to **Alt01 GC** except it uses the **02 With Nutty** network.

- Name the new copy **Alt06 Div**.
- Provide a description “Reservoir Water Diversion for Irrigation.”

26. Edit the **Alt06 Div** Alternative to use the **Diverted Outlet** Operation Set.

Alt07 ALL

27. Make a copy of **Alt06 Div** and edit **Alt07 ALL** to use the **At-Site Rules** Operation set.

➤ Part C - Simulation Module – Analyze Results

28. Switch to the Simulation Module. Open and Edit the simulation “1997.06.19-0200.”

- In addition to **Alt 01 GC** and **Nutty**, add to this simulation Alternatives 02 through 07 (i.e., **Alt02 Min**, **Alt03 Max**, etc.).
- Check the box for Performing a New Extract.
- Press OK to close the Simulation Editor.

29. Compute each of the new alternatives.

Tip

To compute an alternative without first making it active, right click on the alternative in the Simulation Control Panel (the tree at the right of the main window) and select **Compute** from the context menu.

Alt02 Min

30. In the Simulation Control Panel, check the boxes next to **Alt02 Min** and **Alt01 GC**. This will allow you to compare the results of Minimum Required Release Operation against Basic Guide Curve Operation in the plots and summary reports.

31. Analyze Reservoir Plots and Release Decision Reports.

Tip

To view a plot, right-click on an element and select one of the plot options. Data will be plotted from all of the computed alternatives that have been checked in the Simulation Control Panel. Release Decision Reports can be accessed by either right-clicking on a reservoir, or from the Reports menu. The Release Decision Report will provide results only from the active (bold) alternative.

➤ **Questions**

VIII) How do the releases for the new Alt02 Min alternative differ from the basic Guide Curve operation? When do the differences start? Why do they start? When do they end? Why do they end at that time? Do the results correspond to the operation you are trying to model (release must be at least 700 cfs)? How do you know that the rule is determining the release?

IX) What happens if you add the Min rule to the Normal flood pool instead of the conservation pool? Why?

X) In which zone(s) should you enter the rule to correctly simulate the desired operation?

XI) Why, or how did you determine that?

- If necessary, reassign the rule to the correct zone(s). Re-compute the simulation.

Alt03 Max

32. Set As Active **Alt03 Max**.

33. Use Reservoir Plots and Release Decision Reports for **Alt03 Max** and **Alt01 GC** to compare the results of Maximum Allowable Release Operation against Basic Guide Curve Operation.

Questions

XII) How do the releases for the Alt03 Max alternative differ from the basic Guide Curve operation? When do the differences start? Why do they start? When do they end? Why do they end at that time? How do you know that the rule is determining the release?

XIII) What happens if you assign the rule to only the flood pool? To only the conservation pool? Why?

- If necessary, reassign the rule to the correct zone(s). Re-compute the simulation.

Alt04 ROC

34. Use Reservoir Plots and Release Decision Reports for **Alt04 ROC** and **Alt01 GC** to compare the results of Maximum Increasing Flow Rate of Change Operation against Basic Guide Curve Operation.

Questions

XIV) How do the releases for the Alt04 ROC alternative differ from the basic Guide Curve operation? When do the differences start? Why do they start? When do they end? Why do they end at that time?

- XV) What happens if you assign the rule to both the Conservation and Normal Flood pools? Why?

Alt05 SchB

35. Use Reservoir Plots and Release Decision Reports for **Alt05 SchB** and **Alt01 GC** to compare the results of Schedule B Operation against Basic Guide Curve Operation

Question

- XVI) How do the releases for the Alt05 SchB alternative differ from the basic Guide Curve operation? When did the differences start? When did they end? Why?

36. Now enter the **Rising/Falling Condition** information associated with the Schedule B operation (The rising inflow condition is defined by a three-hour average increase of 500 cfs).

- In the simulation module, open the reservoir editor and select the operations tab.
- Highlight the "Schedule B – Rising Inflow" operation rule.
- Check the **Rising/Falling Condition** box. Click the **Edit...** button.
- Enter Rising/Falling criteria in the popup window. Click **OK**. Click **OK** again to close the reservoir editor. (Rule applies when **Inflow** is **Rising** by at least **500 cfs** over **3 hours**.)
- Re-simulate the alternative.

Question

XVII) How do releases change? What determines releases in the first few hours after the lookback period ends? Why?

37. Save all changes made in the simulation module for the **Alt05 SchB** alternative back to the network module:
- Right-mouse-click on the **Alt05 SchB** alternative in the control panel. Select **Save to Base Directory**.
 - Check the **Copy Data** box in the **Save...to Base** window and click **OK**.

Alt06 Div

38. Use Reservoir Plots and Release Decision Reports for **Alt06 Div** and **Nutty** to compare the results of Diversion Operation against Basic Guide Curve Operation.

Question

XVIII) How do the releases for the Alt06 Div alternative differ from the basic Guide Curve operation? What releases did the Dam make? What releases did Nutty Canal Diversion make?

Alt07 ALL

39. Use Reservoir Plots and Release Decision Reports for “**Alt07 ALL**” and **Nutty** to compare the results of all At-Site Rule Operation against Basic Guide Curve Operation

Question

XIX) How do the releases for the Alt07 ALL alternative differ from the basic Guide Curve operation? What releases did the Dam make? What releases did Nutty Canal Diversion make?