

Boundary and Initial Conditions for 1D Modeling

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Objectives

- Know requirements and options for *boundary conditions*
- Review sources of data
- Know *initial condition* options
- Additional Tips and Tricks



Unsteady Flow Data

- External Boundaries - **Required**
 - Upstream end of the river
 - Downstream end of the river
- Internal Boundaries – **Required/Optional**
 - Define gate operation (required for all gates)
 - Add flow within the river system (optional)
- Initial Conditions – **Optional**
 - Establish flow and stage at all nodes at the start of simulation

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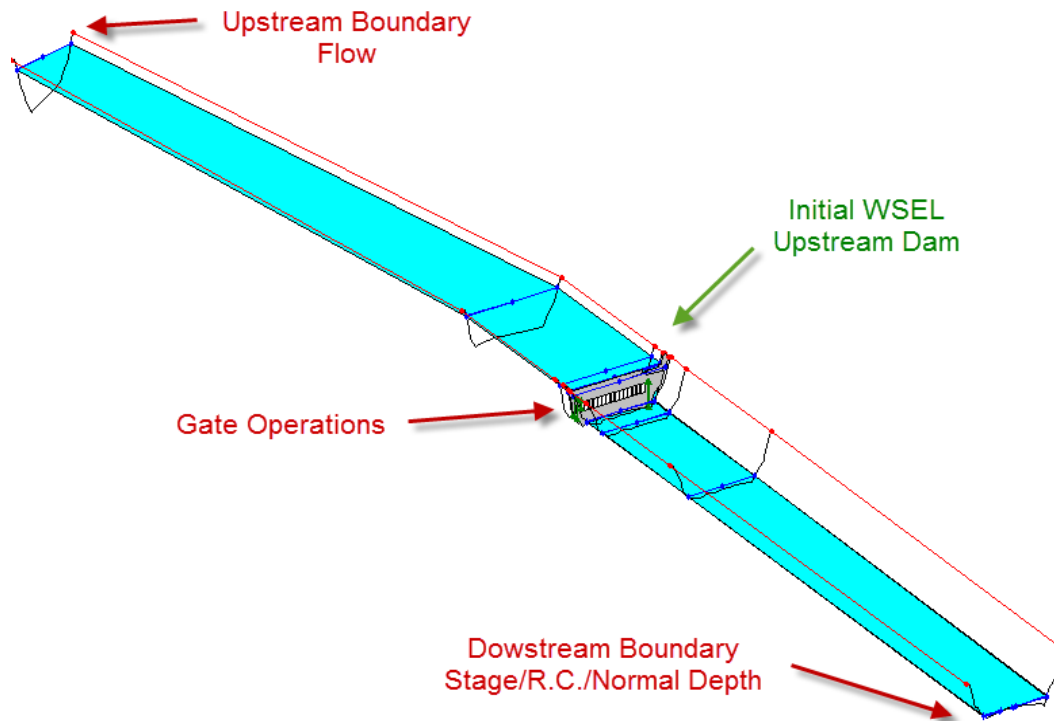
As with steady-flow applications, the Unsteady Flow data define flow and starting conditions for the simulation. The model simulates a dynamic hydraulic process on a segment of a river system network. To perform the hydraulic calculations within the segment, the time-varying “Boundary Conditions” must be defined for the “External Boundaries.”

The Unsteady Flow editor provides the options to define:

- External boundary type and data
- Add internal boundary data
- Set the initial conditions for the start of the simulation



Boundary Overview



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A flow boundary (flow hydrograph) is usually specified at the upstream end of the river. The downstream end is usually a water surface type boundary. Either, it is a stage hydrograph, or it is a type of boundary where RAS can compute the water surface based on the flow (rating curve or normal depth).

Boundary conditions must be specified for all gates.

Additional options: specifying an internal, initial water surface (for example at a dam) and specifying additional inflows/outflows such as lateral inflows and groundwater (not shown in above example).



Unsteady Flow Data Editor

Project: Beaver Cr. - SA and SA Connection
 Plan: Storage Areas and LS with Gates
 Geometry: Beaver Cr. with Storage Areas with Gates
 Steady Flow:
 Unsteady Flow: Unsteady Flow with Gates Openings
 Description:

Unsteady Flow Data - Unsteady Flow with Gates Openings

Boundary Condition Types

Boundary Condition Types			
Stage Hydrograph	Flow Hydrograph	Stage/Flow Hydr.	Rating Curve
Normal Depth	Lateral Inflow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
T.S. Gate Openings	Elev Controlled Gates	Navigation Dams	IB Stage/Flow
Rules	Precipitation		

Add Boundary Condition Location

Add RS ... Add SA/ZD Flow Area ... Add Conn ... Add Pump Sta ... Add Pipe Node ...

Select Location in table then select Boundary Condition Type

River	Reach	RS	Boundary Condition
1 Beaver Creek	Kentwood	5.99	Flow Hydrograph
2 Beaver Creek	Kentwood	5.570 LS	T.S. Gate Openings
3 Beaver Creek	Kentwood	5.0	Rating Curve

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Once the geometric data is entered, the modeler can then enter all of the required (and optional) unsteady flow data. To bring up the unsteady flow data editor, select **Unsteady Flow Data** from the **Edit** menu on the HEC-RAS main window. The Unsteady flow data editor should appear as shown above.

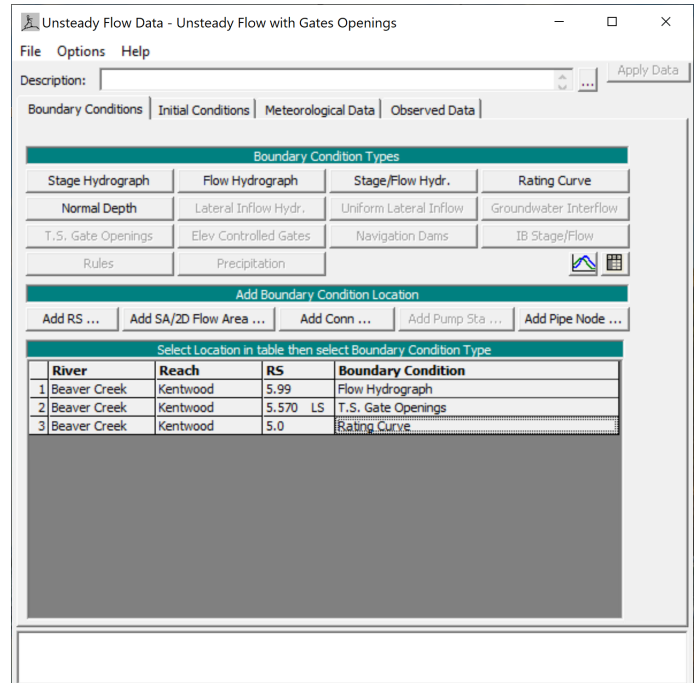
The user is required to enter boundary conditions at all of the external boundaries of the system and any gates as well as any other desired internal locations, and optional initial flows and storage area conditions in the system at the beginning of the simulation period.



Boundary Conditions: Upstream



- Editor shows required external boundaries
- Boundary Type shows available options
- Upstream options:
 - Stage Hydrograph
 - Flow Hydrograph
 - Stage & Flow Hydrograph
(Recommended)



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Boundary conditions are entered by first selecting the **Boundary Conditions** tab from the Unsteady Flow Data Editor. River, Reach, and River Station locations of the external bounds of the system will automatically be entered into the table.

Boundary conditions are entered by first selecting a cell in the table for a particular location, then selecting the boundary condition type that is desired at that location. Not all boundary condition types are available for use at all locations. The program will automatically gray-out the boundary condition types that are not relevant when the user highlights a particular location in the table.

Users can also add locations for entering internal boundary conditions. To add an additional boundary condition location, select the desired River, Reach, and River Station, then press the **Add a Boundary Condition Location** button.



Flow Hydrograph



- Read from DSS
 - Select DSS file
 - Select Pathname
- Enter in Table
 - Select time interval
 - Select start date/time
 - Enter flow data - or cut & paste
 - Add more Ordinates (if needed)

Flow Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.99

Read from DSS before simulation Select DSS file and Path

File: C:\HEC\Ras30\Unsteady\beaver.dss
 Path: /BEAVER CREEK KENTWOOD/5.99/FLOW/01FEB1999/1HOUR/10 YEAR EVNT/

Enter Table Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 22MAY 1974 Time: 0000
 Fixed Start Time: Date: Time:

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data		
No. Ordinate	Date	Flow (cfs)
1	21May 1974 2400	500
2	22May 1974 0100	730
3	22May 1974 0200	1404.33
4	22May 1974 0300	2477.03
5	22May 1974 0400	3875
6	22May 1974 0500	5502.97
7	22May 1974 0600	7250
8	22May 1974 0700	8997.03
9	22May 1974 0800	10625
10	22May 1974 0900	12022.97
11	22May 1974 1000	13095.67
12	22May 1974 1100	13770
13	22May 1974 1200	14000
14	22May 1974 1300	13770
15	22May 1974 1400	13095.67

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step
 Max Change in Flow (without changing time step):

Min Flow: Multiplier: EG Slope for distributing flow along BC Line: TW Check

Plot Data OK Cancel

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A flow hydrograph can be used as either an upstream boundary or downstream boundary condition but is most commonly used as an upstream boundary condition. When the flow hydrograph button is pressed, the window shown above will appear. As shown, the user can either read the data from a HEC-DSS (HEC Data Storage System) file, or they can enter the hydrograph ordinates into a table.

If the user selects the option to read the data from DSS, they must press the **Select DSS File and Path** button. When this button is pressed a DSS file and pathname selection screen will appear as shown on the next page. The user first selects the desired DSS file by using the browser button at the top. Once a DSS file is selected, a list of all of the DSS pathnames within that file will show up in the table. The user can use the pathname filters to reduce the number of pathnames shown in the table. The last step is to select the desired DSS Pathname and to close the window.



Select DSS File and Path

River: Beaver Creek Reach: Kentwood RS: 5.99: Flow

File Options Help

File Count: 1 Time Window: 21May1974 2400 - 25May1974 2400

Use File Name File Date

C:\HEC\HEC-RAS\Classes\2022\1D-Unstead 5/2/2022 3:53:09 PM

Time Window: Plan Time

General Filter: Apply

Last Applied Filter: Path Count: 8 / 1064

Row #	File Name	Type	Part A	Part B	Part C	Part D	Part E	Part F	Data Type	Data Units	x,y
1018	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW	01MAY1974	1HOUR	EXIST COND	INST-VAL	cfs	
1019	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW	01MAY1974	1HOUR	SA AND LS	INST-VAL	cfs	
1020	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW	01MAY1974	1HOUR	SA AND LS WITH GATES	INST-VAL	cfs	
1021	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW	01MAY1974	1HOUR	TASK 1	INST-VAL	CFS	
1022	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW	01MAY1974	1HOUR	TASK 2	INST-VAL	CFS	
1023	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW-CUM	01MAY1974	1HOUR	EXIST COND	INST-CUM	acre-ft	
1024	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW-CUM	01MAY1974	1HOUR	SA AND LS	INST-CUM	acre-ft	
1025	BeaverSA	RegularTimeSeries	BEAVER CREEK KENTWOOD	5.99	FLOW-CUM	01MAY1974	1HOUR	SA AND LS WITH GATES	INST-CUM	acre-ft	

Show Plot

Selected Path: /BEAVER CREEK KENTWOOD/5.99/FLOW/01MAY1974/1HOUR/EXIST COND/

OK Cancel

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When the **Select DSS File and Path** button is pressed a DSS file and pathname selection screen will appear as shown above. First select the desired DSS file by using the browser button at the top. Once a DSS file is selected, a list of all of the DSS pathnames within that file will show up in the table. The user can use the pathname filters to reduce the number of pathnames shown in the table. The last step is to select the desired DSS Pathname and to close the window.

Note:

The desired path must be added to the window at the bottom by double clicking the desired selection. Click on the **Clear List** button to remove a selection.



Flow Hydrograph Table



- Select radio button “Enter Table”
- Select time interval
- Select start date/time
- Enter flow data or cut & paste
- Add more Ordinates (if needed)

Flow Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.99

Read from DSS before simulation

File: C:\HEC\Ras30\Unsteady\beaver.dss
 Path: \BEAVER CREEK KENTWOOD\5.99\FLOW\0\FEB 1999\1 HOUR\10 YEAR EVNT/

Enter Table Read from DSS before simulation Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 22MAY1974 Time: 0000
 Fixed Start Time: Date: Time:

Hydrograph Data		
No.	Date	Flow (cfs)
1	21May1974 2400	500
2	22May1974 0100	730
3	22May1974 0200	1404.33
4	22May1974 0300	2477.03
5	22May1974 0400	3875
6	22May1974 0500	5502.97
7	22May1974 0600	7250
8	22May1974 0700	8997.03
9	22May1974 0800	10625
10	22May1974 0900	12022.97
11	22May1974 1000	13095.67
12	22May1974 1100	13770
13	22May1974 1200	14000
14	22May1974 1300	13770
15	22May1974 1400	13095.67

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step
 Max Change in Flow (without changing time step):

Min Flow: Multiplier: EG Slope for distributing flow along BC Line: TW Check

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The user also has the option of entering a flow hydrograph directly into a table, as shown above. The first step is to enter a **Data time interval**. Currently the program only supports regular interval time series data. A list of allowable time intervals is shown in the dropdown window of the data interval list box. To enter data into the table, the user is required to select either **Use Simulation Time** or **Fixed Start Time**.

If the user selects **Use Simulation Time**, then the entered hydrograph will always start at the beginning of the simulation time window. The simulation starting date and time is shown next to this box, but is grayed out.

If the user selects **Fixed Start Time** then the hydrograph is entered starting at a user specified time and date. Once a starting date and time is selected, the user can then begin entering the data.



Starting Time



Flow Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.99

Read from DSS before simulation

File: C:\Users\q0hecsp\Documents\RAS Data\Beaver.dss
Path: /BEAVER CREEK KENTWOOD/5.99/FLOW/01FEB1990/1HOUR/100 Y1 EVNT/

Enter Table

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 10FEB1990 Time: 0000

Fixed Start Time: Date: Time:

Hydrograph Data

	Date	Simulation Time	
		(hours)	
		00:00	317.58
1	09Feb1990 2400		
2	10Feb1990 0100	01:00	429.91
3	10Feb1990 0200	02:00	615.75
4	10Feb1990 0300	03:00	873.08
5	10Feb1990 0400	04:00	1199.07

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step

Max Change in Flow (without changing time step): 100

Min Flow: 1000 Multiplier:

Unsteady Flow Analysis

Plan: Unsteady with 100 yr event Short ID: 100 Y1 Evt

Geometry File: Beaver Cr. - bridge

Unsteady Flow File: Unsteady flow data - Smaller Event

Plan Description:

Programs to Run

Geometry Preprocessor

Unsteady Flow Simulation

Sediment

Post Processor

Floodplain Mapping

Simulation Time Window

Starting Date: 10FEB1990 Starting Time: 0000

Ending Date: 12FEB1990 Ending Time: 2400

Computation Settings

Computation Interval: 2 Minute Hydrograph Output Interval:

Mapping Output Interval: 1 Hour Detailed Output Interval:

Computation Level Output

DSS Output Filename: C:\Users\q0hecsp\Documents\RAS Data\Beaver.dss

Mixed Flow Regime (see menu: "Options/Mixed Flow Options ...") debug par

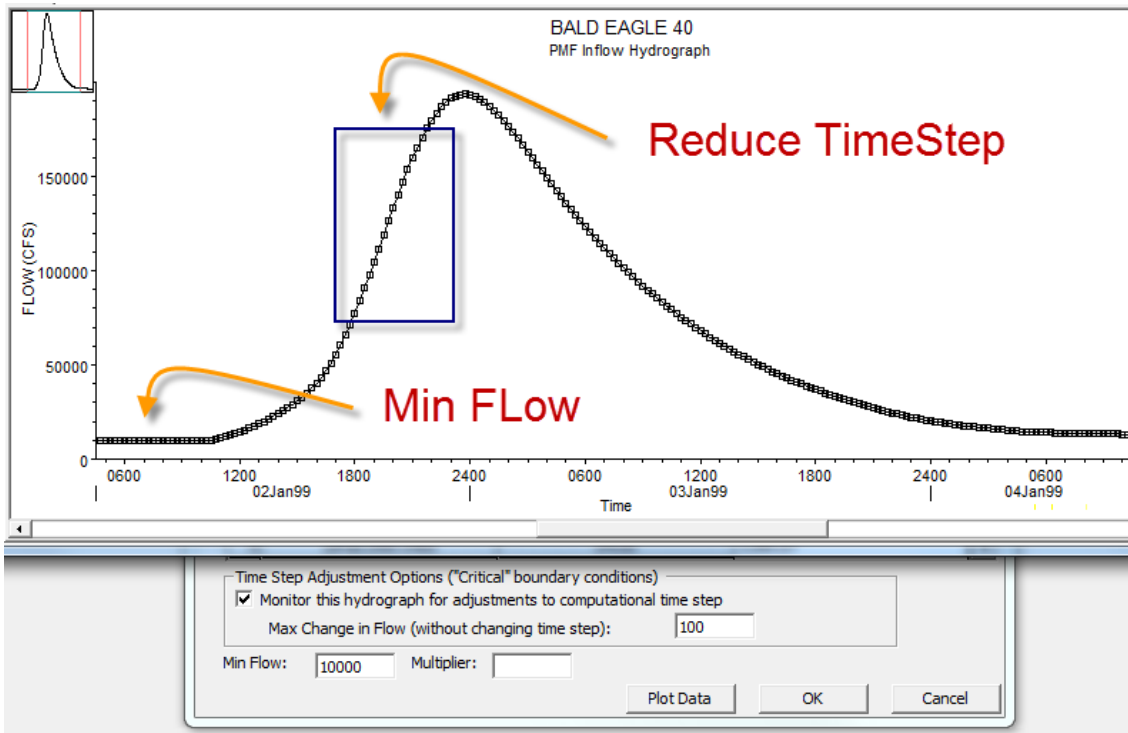
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If the first value in the table should always be the first flow, then the **Use Simulation Time** is recommended. In this case for instance, if the user changed the starting date on the **Unsteady Flow Analysis** compute window to 0400 the first flow would still be 317.58 cfs. The user does not need to enter a date on the **Flow Hydrograph** editor because the date is always the same as the date on the compute window.

If the values in the table have actual dates, for instance they are historical flows, then the **Fixed Start Time** is recommended. The user then has to enter the Date and Time (the blank fields shown above). In this situation, RAS will know to match the correct flow to the correct time. So, for instance, if the Fixed Time was entered as 0000, but the starting time on the compute window was changed to 0400, RAS would know to use 1199.07 cfs as the first flow in the simulation.



Min Flow and Time Step Flow Monitor



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- An additional option listed on the flow hydrograph boundary condition is: **Monitor this hydrograph for adjustments to computational time step**
- When you select this option, the program will monitor the inflow hydrograph to see if a change in flow rate from one time step to the next is exceeded. If the change in flow rate does exceed the user entered maximum, the program will automatically cut the time step in half until the change in flow rate does not exceed the user specified max. Large changes in flow can cause instabilities.
- The use of this feature can help to keep the solution of the program stable.
- Also, the flow hydrograph for model boundaries can be monitored to ensure that the flow values do not drop below an input minimum value. If the value is less than the minimum, the value is set to the minimum.
- If the study is only concerned with the high flow/high stage results, a flow minimum might be useful to prevent instability at low flows.

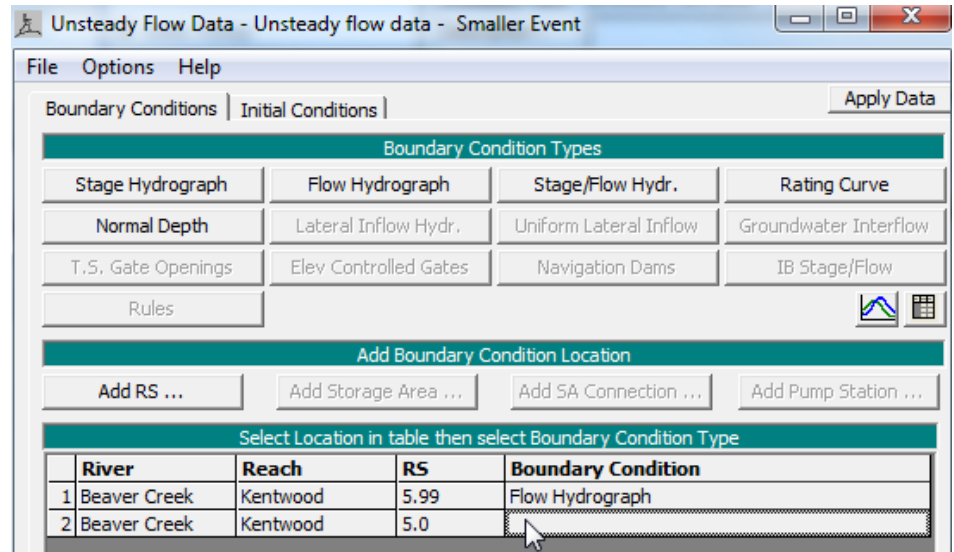
Additionally, the flow hydrograph for model boundaries can be easily modified by a constant ratio. This allows easy testing of model sensitivity to input flow values, or an analysis of model results with larger flood events.

These features appear on most flow input editors.



Downstream Boundary Conditions

- Stage hydrograph
- Flow hydrograph
(not recommended)
- Rating Curve
- Normal Depth



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Downstream boundary can be:

- Stage Hydrograph - e.g., gage data on the stream
- Flow Hydrograph - e.g., gage data converted to flow
- Stage & Flow - e.g., combined observed stage and forecasted flow
- Rating Curve - e.g., rating at a gauged location, or steady-flow rating
- Normal Depth - e.g., average slope of stream to estimate energy slope



Stage Hydrograph



- Read from DSS
 - Select DSS file
 - Select Pathname
- Enter in Table
 - Select time interval
 - Select start date/time
 - Simulation time
 - Fixed starting time
 - Enter stage data or cut & paste

Stage Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.0

Read from DSS before simulation Select DSS file and Path

File: _____

Path: _____

Enter Table Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 10FEB1999 Time: 0000

Fixed Start Time: Date: _____ Time: _____

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data			
	Date	Simulation Time (hours)	Stage (ft)
1	09Feb1999 2400	00:00	204.14
2	10Feb1999 0100	01:00	206.09
3	10Feb1999 0200	02:00	207.26
4	10Feb1999 0300	03:00	208.47
5	10Feb1999 0400	04:00	209.3
6	10Feb1999 0500	05:00	209.83
7	10Feb1999 0600	06:00	210.25
8	10Feb1999 0700	07:00	210.68
9	10Feb1999 0800	08:00	210.99
10	10Feb1999 0900	09:00	211.27
11	10Feb1999 1000	10:00	211.53
12	10Feb1999 1100	11:00	211.78
13	10Feb1999 1200	12:00	212.02
14	10Feb1999 1300	13:00	212.25
15	10Feb1999 1400	14:00	212.47
16	10Feb1999 1500	15:00	212.68
17	10Feb1999 1600	16:00	213.
18	10Feb1999 1700	17:00	214.

Plot Data OK Cancel

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A stage hydrograph can be used as either an upstream or downstream boundary condition. The editor for a stage hydrograph is similar to the flow hydrograph editor shown above. The user has the choice of either attaching a HEC-DSS file and pathname or entering the data directly into a table.



Rating Curve



- Single value rating
- Downstream boundary
- Read from DSS
 - Select DSS file
 - Select Pathname
- Enter in Table
 - Enter stage- flow data - or
 - Cut & paste

Rating Curve

River: Beaver Creek Reach: Kentwood RS: 5.0

Read from DSS before simulation Select DSS file and Path

File: _____

Path: _____

Enter Table

Del Row Ins Row

	Stage (ft)	Flow (cfs)
1	204.14	200.
2	206.09	500.
3	207.26	1000.
4	208.47	2000.
5	209.3	3000.
6	209.83	4000.
7	210.25	5000.
8	210.68	6000.
9	210.99	7000.
10	211.27	8000.
11	211.53	9000.
12	211.78	10000.
13	212.02	11000.
14	212.25	12000.
15	212.47	13000.
16	212.68	14000.
17	213.	16000.
18	214.	21000.
19	215.	26000.
20	216.	30000.
21		
22		
23		

Plot Data OK Cancel

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The rating curve option can be used as a downstream boundary condition. The user can either read the rating curve from HEC-DSS or enter it by hand into the editor.

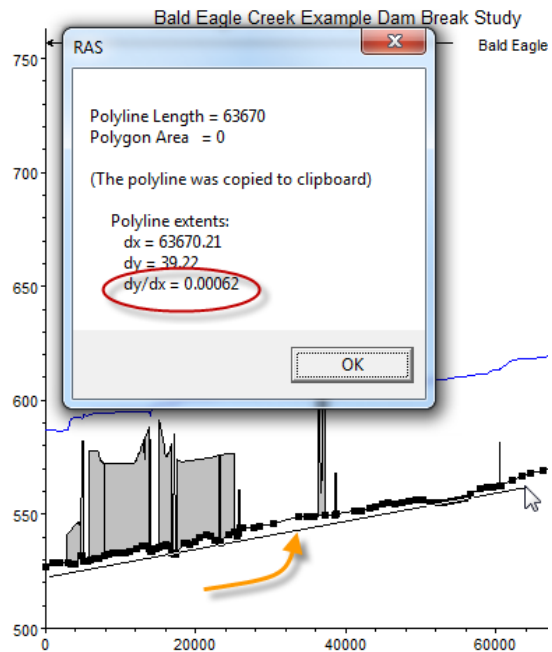
The downstream rating curve is a single valued relationship, and does not reflect a loop in the rating, which may occur during an event. This assumption may cause errors in the vicinity of the rating curve. The errors become a problem for streams with mild gradients where the slope of the water surface is not steep enough to dampen the errors over a relatively short distance. When using a rating curve, make sure that the rating curve is a sufficient distance downstream of the study area, such that any errors introduced by the rating curve do not affect the study reach.



Normal Depth



- Enter Friction (energy) Slope
- Program uses Manning's equation to compute stage
- Provides "Normal Depth" DS boundary



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The normal depth option will use Manning's equation to compute a downstream stage. The friction slope must be entered by the user.

As a first approximation, the average bed slope (at the downstream end) can be used as an estimate for the friction slope. On the profile plot (as well as most other plots), the user can draw a line (or polygon) and RAS will provide information. Position the mouse pointer at the start of the line, hold down the Ctrl key, press the left mouse button, draw the line and release the Ctrl key.

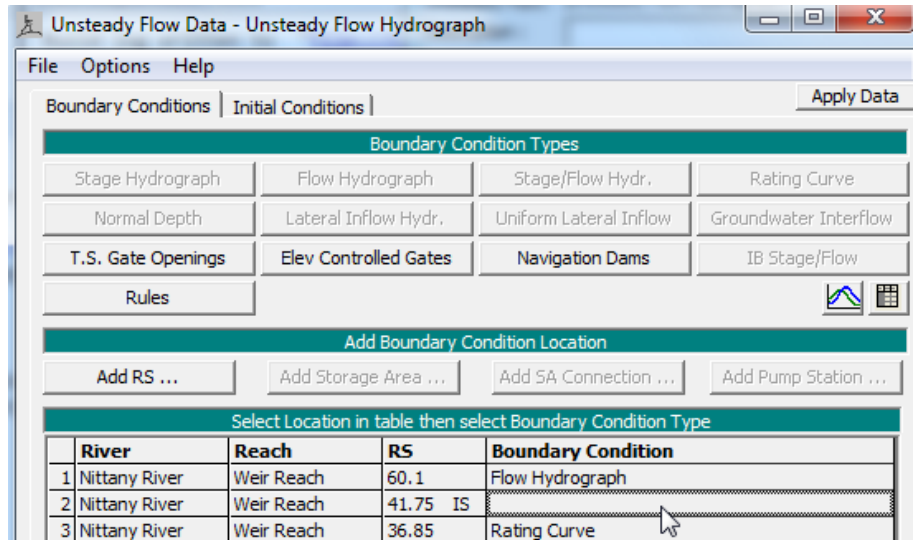
To draw multiple line segments (or a polygon), release and then relick the left mouse button.



Gates



- Time-series of gate openings
- Navigation Dams
- Elevation Controlled
- Rules



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Time Series of Gate Openings

This option allows the user to enter a time series of gate openings for an inline gated spillway, lateral gated spillway, or a spillway connecting two storage areas.

Elevation Controlled Gate

Define the opening and closing of gates based on the elevation of the water surface elevation upstream from the structure.

Navigation Dams

Simulate the gate operations for navigation dams attempting to maintain navigation depths.

Rules

This option allows the user to control gate openings (and other hydraulic structure functions) using sophisticated If/Then tests and advanced math operations.

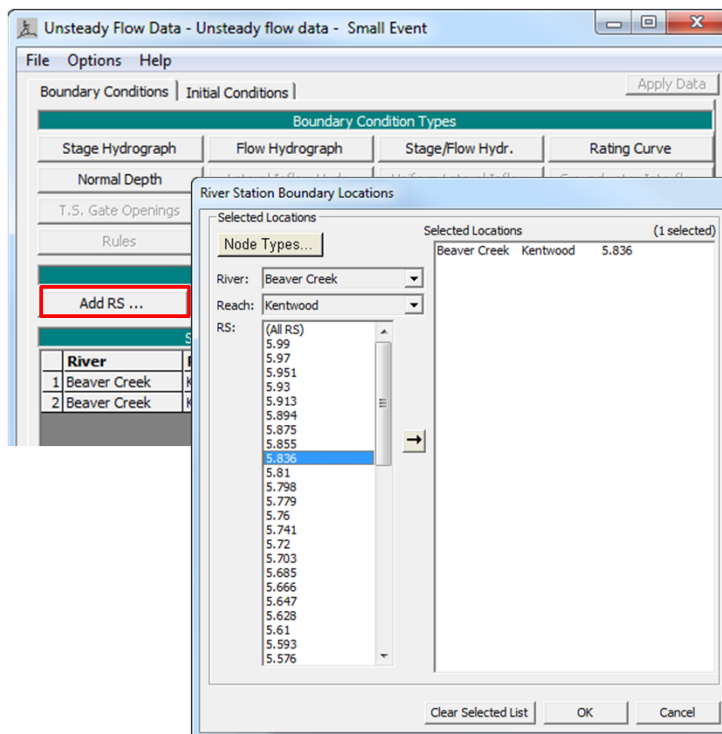
Not covered in this lecture.



Adding an Internal Boundary



- Select
 - River
 - Reach
 - River Station
- Add a Boundary Condition Location
- Location added to the list of Boundary Conditions



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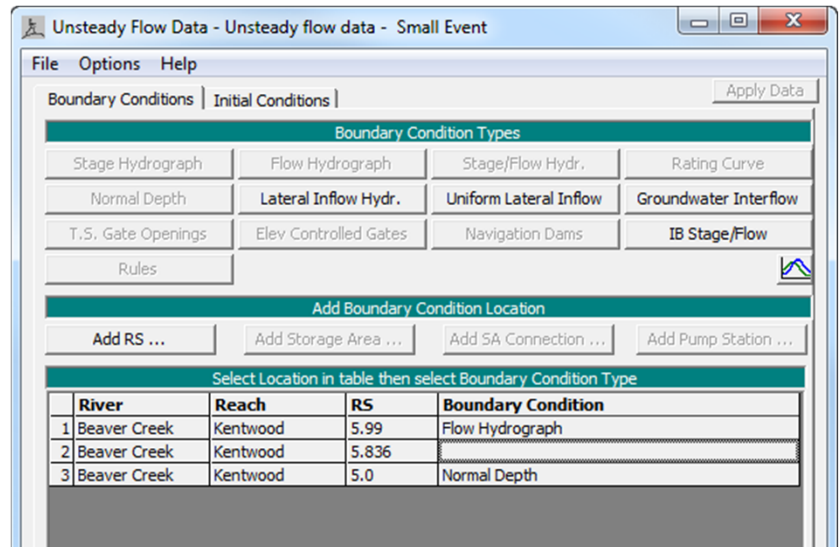
The Unsteady Flow Data editor automatically has the external boundaries defined, based on the geometric data model. The user can add internal boundary locations to define additional lateral flow. Also, when weirs with gates are added, the gate operation will be defined as an internal boundary.

Select the River, Reach and River Station where the data will be added. Then press **Add a Boundary Condition Location**. The location is added to the boundary condition table.



Internal Boundary Conditions

- Lateral Inflow Hydrograph (e.g. small streams)
- Uniform Lateral Inflow (e.g. rainfall/runoff)
- Groundwater Interflow



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Lateral Inflow Hydrograph: This internal boundary condition allows the user to bring in flow at a specific point along the river.

Uniform Lateral Inflow Hydrograph: This internal boundary condition allows the user to bring in a flow hydrograph and distribute it uniformly along the river reach between two specified cross sections.

Groundwater Interflow: This option allows the user to identify a reach that will exchange water with a groundwater reservoir.



Lateral Inflow Hydrograph



- Lateral flow downstream from a Cross Section
- Read from DSS
 - Select DSS file
 - Select Pathname
- Enter in Table
 - Select time interval
 - Select start date/time
 - Enter flow data - or cut & paste

Lateral Inflow Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.836

Read from DSS before simulation Select DSS file and Path

File: _____
Path: _____

Enter Table Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 10FEB1999 Time: 0000
 Fixed Start Time: Date: _____ Time: _____

No. Ordinates Interpolate Missing Values Del Row Ins Row

Hydrograph Data		
No.	Date	Lateral Inflow (cfs)
	Simulation Time (hours)	
1	09Feb 1999 2400	0
2	10Feb 1999 0100	9.73
3	10Feb 1999 0200	357.48
4	10Feb 1999 0300	801.96
5	10Feb 1999 0400	1410.38
6	10Feb 1999 0500	1869.34
7	10Feb 1999 0600	2328.30
8	10Feb 1999 0700	2787.27
9	10Feb 1999 0800	3246.23
10	10Feb 1999 0900	3705.19
11	10Feb 1999 1000	4164.15
12	10Feb 1999 1100	4623.11
13	10Feb 1999 1200	5082.08

Time Step Adjustment Options ("Critical" boundary conditions)
 Monitor this hydrograph for adjustments to computational time step
 Max Change in Flow (without changing time step): _____

Min Flow: _____ Multiplier: _____

Plot Data OK Cancel

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Lateral Inflow Hydrograph: This internal boundary condition allows the user to bring in flow at a specific point along the stream. The user attaches this boundary condition to the river station of the cross section just upstream of where the lateral inflow will come in. The actual change in flow will not show up until the next cross section downstream from this inflow hydrograph. The user can either read the hydrograph from DSS or enter it by hand.

A lateral diversion/outflow can be specified by entering negative numbers.



Uniform Lateral Flow Hydrograph

- Uniform Lateral flow to a reach element
- Add Internal Location at Upstream River RS
- Set Downstream RS
- Read from DSS
- Enter in Table

Uniform Lateral Inflow Hydrograph

River: Beaver Creek Reach: Kentwood RS: 5.836

Inflow will be evenly distributed from RS: "5.836" to RS:

Read from DSS before simulation Select DSS file and Path

File: 5.685
5.666
5.647
5.628
5.61
5.593
5.576
5.559

Path:

Enter Table Data time interval:

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: Time:

Fixed Start Time: Date: Time:

No. Ordinates

Hydrograph Data			
	Date	Simulation Time	Lateral Inflow
		(hours)	(cfs)
1	09Feb1999 2400	00:00	0
2	10Feb1999 0100	01:00	9.73
3	10Feb1999 0200	02:00	357.48
4	10Feb1999 0300	03:00	801.96
5	10Feb1999 0400	04:00	1410.38
6	10Feb1999 0500	05:00	1869.34
7	10Feb1999 0600	06:00	2328.30
8	10Feb1999 0700	07:00	2787.27
9	10Feb1999 0800	08:00	3246.23
10	10Feb1999 0900	09:00	3705.19
11	10Feb1999 1000	10:00	4164.15

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step

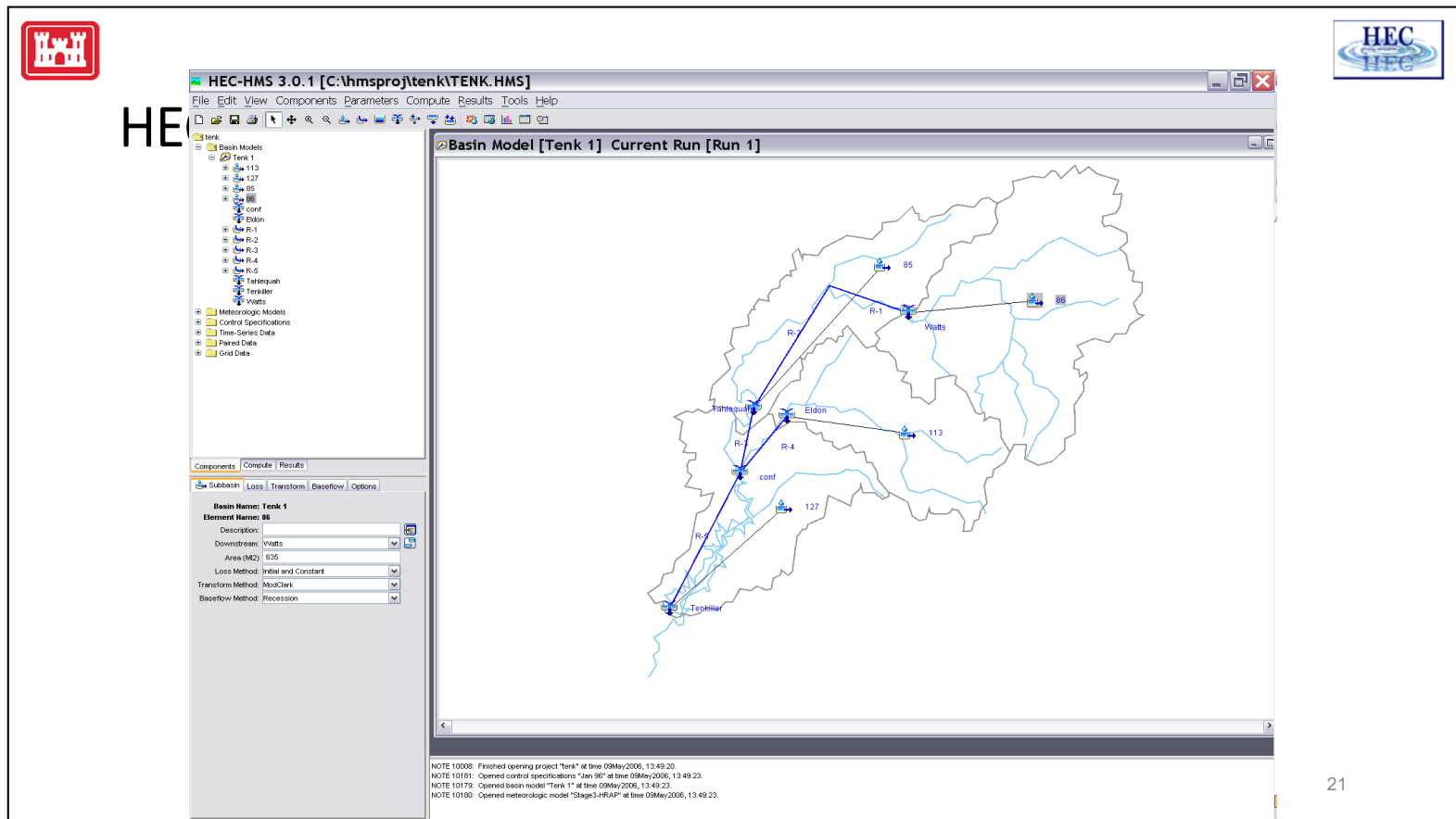
Max Change in Flow (without changing time step):

Min Flow: Multiplier:

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Uniform Lateral Inflow Hydrograph: This internal boundary condition allows the user to bring in a flow hydrograph and distribute it uniformly along the river reach between two specified cross sections. The hydrograph for this boundary condition type can be either read from DSS, or entered into a table.

Boundary & Initial Conditions



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HMS provides individual watershed flows locations. If a reach flows through a watershed the hydrograph can be distributed along the reach with the distributed flow boundary condition.

NOTE:

By default, HEC-HMS will automatically route the local run-off to the downstream end of the subbasin. If you use hydrographs developed by HMS, that have been calibrated in HMS, then you will need to incorporate these into HEC-RAS as point Lateral Inflows at the downstream end of the subbasin where they were computed. Alternatively, one could develop an HEC-HMS model in which local flows (i.e. Unit Hydrograph parameters) were developed in such a way as to represent only getting the flow to the main stream (and not also routing it down the main stream to the outlet). If flows were developed in this manner in HEC-HMS, then when using them in HEC-RAS you should use the Uniform Lateral Inflow option, which distributes the flows along the entire length of the main channel. Then HEC-RAS will route them down the main channel, along with the flows from upstream.



Groundwater Flow



- Add Internal Location at Upstream River RS
- Set Downstream RS
- Input Groundwater Stage
 - Read from DSS
 - Enter in Table
- Groundwater Interflow K
 - Hydraulic Conductivity
- Distance between stages of river & groundwater

Groundwater Interflow

River: Beaver Creek Reach: Kentwood RS: 5.836

Interflow will be between RS:5.836 to RS:

Read from DSS before simulation

File:
Path:

Enter Table Select/Enter the Data's Starting Time Reference

Data time interval:

Use Simulation Time: Date: Time:
 Fixed Start Time: Date: Time:

No. Ordinates

Hydrograph Data		
	Date	Groundwater Stage (ft)
	Simulation Time (hours)	
1	09Feb 1999 2400	00:00
2	10Feb 1999 0100	01:00
3	10Feb 1999 0200	02:00
4	10Feb 1999 0300	03:00
5	10Feb 1999 0400	04:00
6	10Feb 1999 0500	05:00
7	10Feb 1999 0600	06:00
8	10Feb 1999 0700	07:00
9	10Feb 1999 0800	08:00
10	10Feb 1999 0900	09:00
11	10Feb 1999 1000	10:00

Ground Water Interflow Parameters

Groundwater Interflow K (ft/day):

Thickness (or length) of GW Interflow (ft):

Min Flow: Multiplier:

22

Groundwater Interflow: This option allows the user to identify a reach that will exchange water with a groundwater reservoir. The stage of the groundwater reservoir is assumed to be independent of the interflow from the river, and must be entered manually or read from DSS. The groundwater interflow is similar to a uniform lateral inflow in that the user enters an upstream and a downstream river station, in which the flow passes back and forth. The computed flow is proportional to the head between the river and the groundwater reservoir. The computation of the interflow is based on Darcy's equation. The user is required to enter Darcy's groundwater loss coefficient (hydraulic conductivity), as well as a time series of stages for the groundwater aquifer.

If the groundwater time-series represents the stage immediately at the cross section, then the user should enter the "K of the streambed sediment" and the "Thickness of the streambed sediments."

If the groundwater time-series is the stage some distance from the cross section (such as a monitoring well), then the user should enter an "Average K of the Groundwater Basin" and the "Distance between the river and the groundwater stage monitoring location."



Darcy's Law

$$Q = V A$$

Q = Flow (L³/T)

A = Area, perpendicular to the flow (L²)

- Top width x length, if groundwater below channel
- Valley width x length plus channel depth x length, if groundwater is above channel invert

$$V = K S$$

V = Velocity (L/T)

K = Hydraulic Conductivity (L/T)

S = Slope (L/L) = Stage difference / Distance

23

Darcy's Law (1856) applied the principles of fluid flow to the flow of water in a permeable media. The velocity of flow equals the product of a coefficient times the hydraulic gradient. The flow equals the velocity times the effective area = gross area times porosity of the media. (*Hydrology for Engineers, by LKP*)

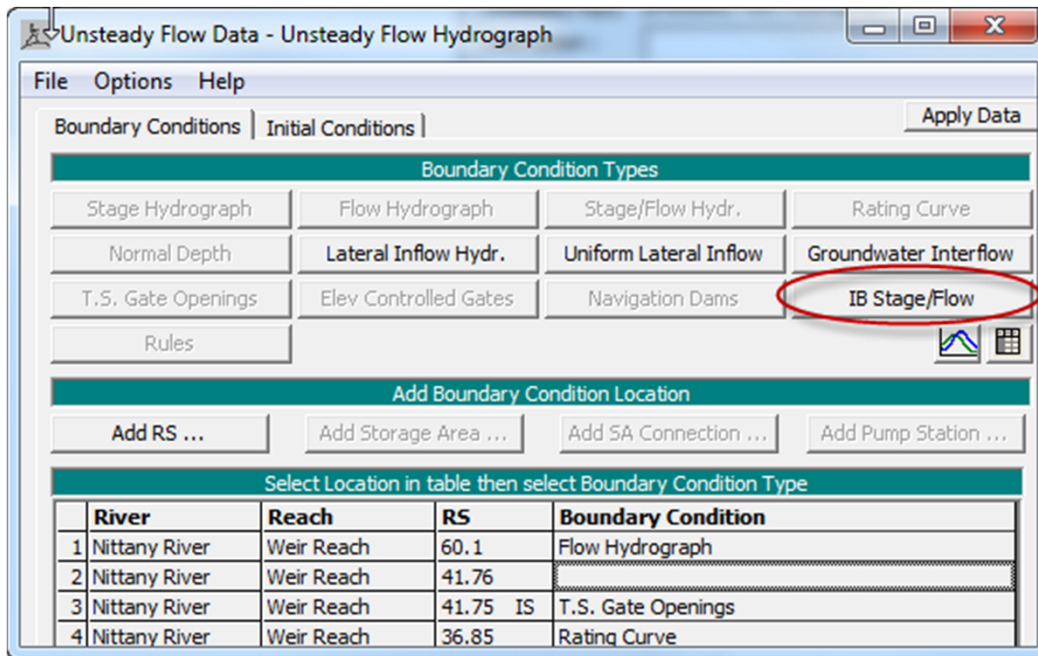
- In RAS, the slope is computed by the difference between the water elevation at the cross section and the input groundwater elevation, divided by the input Distance.
- The area is length times the flow width.
- The length is the channel length for the reach element (between upstream and downstream River Stations).
- The flow width depends on the groundwater level.

If the groundwater level is below the invert of the channel, the flow is down from the channel and the width is the average top width.

If the groundwater level is above the invert, the width is the overbank width plus the channel depth, estimated by the average channel water elevation minus the groundwater elevation.



IB Stage/Flow Upstream Inline Structure



24

IB Stage and Flow Hydrograph:

This option will act as a stage boundary for as long as there is stage data. If there is no stage data (or the stage data runs out), it will act as a flow boundary (for as long as there is flow data).

The IB boundary can force a known WSEL (or flow) at an internal cross section. The program will compute the resulting flow (or WSEL) in order to conserve mass. For instance, this can create a “wall of water” (a virtual dam) if less flow is allowed to leave the IB cross section than comes in from upstream.

If the IB stage/flow is located at a cross section immediately upstream of an inline structure, then the IB stage/flow boundary will override the inline structure computations as long as the IB boundary has data. When the IB boundary has run out of data, the normal inline structure computations will resume.

Using the IB boundary to override the inline structure operation at the beginning of a forecast model is the most common use for the IB boundary. When the IB boundary runs out, and the program switches to the inline structure computations, the flow computed from the inline hydraulics may be different than the last value computed by the IB boundary. This discontinuity can cause a “shock” that may cause instabilities. The user should use care with this option.



Stage and Flow Hydrograph



- Upstream Mixed
 - Stage used while defined
 - Flow used next
 - Inline Hyd. after
- Purpose:
 - Real-time use
 - Mix observed stage with
 - Forecasted flow

Internal Boundary Stage and Flow Hydrograph

River: Nittany River Reach: Weir Reach RS: 41.76

Read from DSS before simulation Select DSS file and Path

File:

Stage

Flow

Enter Table Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 08APR 1999 Time: 0000

Fixed Start Time: Date: Time:

No. Ordinates

Hydrograph Data				
	Date	Simulation Time (hours)	Stage (ft)	Flow (cfs)
1	07Apr 1999 2400	00:00	15.3	567.11
2	08Apr 1999 0100	01:00	15.4	897.76
3	08Apr 1999 0200	02:00		1228.42
4	08Apr 1999 0300	03:00		1559.07
5	08Apr 1999 0400	04:00		
6	08Apr 1999 0500	05:00		
7	08Apr 1999 0600	06:00		

Time Step Adjustment Options ("Critical" boundary conditions)

Monitor this hydrograph for adjustments to computational time step

Max Change in Flow (without changing time step):

25

In the above example, the stage will start at 15.3 feet at time zero and rise to 15.4 feet over the first hour. During this period, the program will compute the flow in order to maintain mass continuity. After exactly one hour, the program will switch to flow. It will initially force a flow of 897.76 cfs. If this flow is significantly different than the flow that was computed from the stage boundary, it could cause an instability.

The flow leaving the cross section will be increased until it reaches 1559.07 cfs at the end of the third hour. At this point (since this cross section is immediately upstream of an inline structure) the flow computations will switch to the inline structure. This inline structure has time-series gate openings. So the flow will be based on the gate openings that are specified at time 03:00. Again, a sudden change in flow might cause instability.

This option is convenient for a real-time forecast model. The initial stage in the reservoir can be entered (only a single stage at time zero is really needed) and the known releases can be entered up until the time of the forecast.



Precipitation Boundary Condition

- Single time-series for a SA/2D Flow Area
- Period cumulative
- Steps
 1. Add SA/2D Area
 2. Select Precipitation BC
 3. Enter time-series data

Precipitation Hydrograph

SA: 2D Area

Read from DSS before simulation Select DSS file and Path

File:

Path:

Enter Table Data time interval: 1 Hour

Select/Enter the Data's Starting Time Reference

Use Simulation Time: Date: 01OCT2013 Time: 0000

Fixed Start Time: Date: Time:

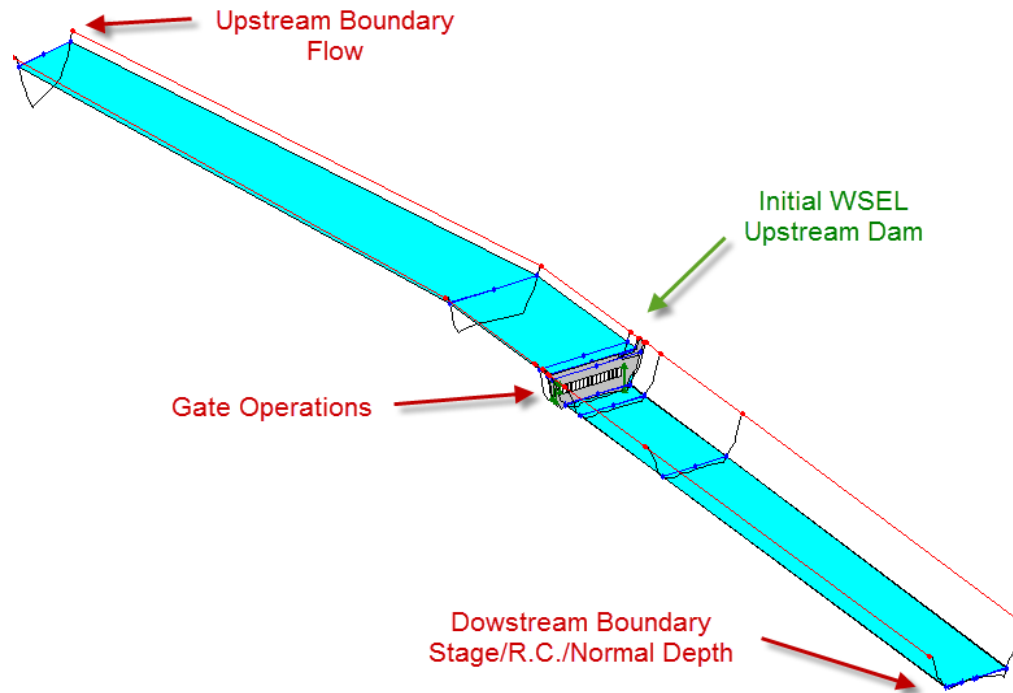
No. Ordinates

Hydrograph Data			
	Date	Simulation Time (hours)	Precipitation (mm)
1	30Sep2013 2400	00:00	0.0
2	01Oct2013 0100	01:00	0.2
3	01Oct2013 0200	02:00	0.2
4	01Oct2013 0300	03:00	0.3
5	01Oct2013 0400	04:00	0.6
6	01Oct2013 0500	05:00	0.2
7	01Oct2013 0600	06:00	0.1
8	01Oct2013 0700	07:00	0.0
9	01Oct2013 0800	08:00	.00
10	01Oct2013 0900	09:00	.00
11	01Oct2013 1000	10:00	.00
12	01Oct2013 1100	11:00	.00
13	01Oct2013 1200	12:00	.00
14	01Oct2013 1300	13:00	.00
15	01Oct2013 1400	14:00	.00
16	01Oct2013 1500	15:00	.00
17	01Oct2013 1600	16:00	.00
18	01Oct2013 1700	17:00	.00
19	01Oct2013 1800	18:00	.00
20	01Oct2013 1900	19:00	.00

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Downstream Boundary

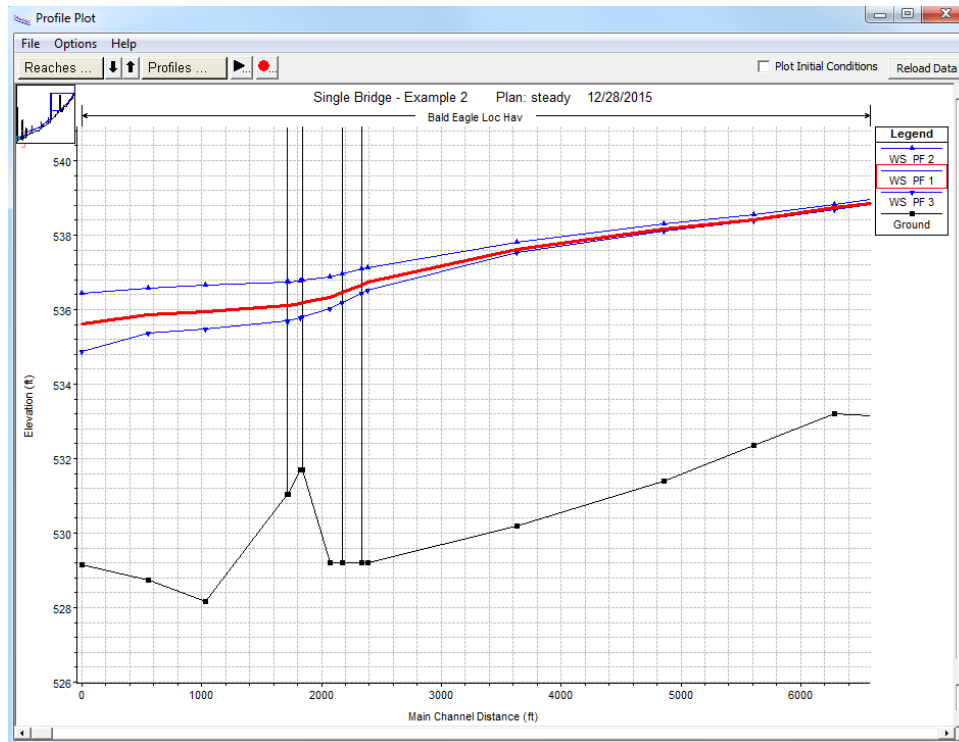


27

- A stage boundary is frequently located where there is a physical gage or perhaps where the river ends at a tidal location. But otherwise, there is usually some discretion in the location of the downstream boundary.
- The downstream boundary should be located far enough downstream so that any errors associated with the boundary do not propagate all the way upstream to the study area. This is more important on mild streams than on steep streams. If in doubt, the downstream boundary can be adjusted (for instance by changing the normal depth slope) to see how far upstream effects propagate.



Downstream Sensitivity



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The above example shows a steady flow profile from the RAS sample data set BaldEagle. Three different normal depths (using same upstream flow) were selected: 0.0003, 0.0006, and 0.0012. There is around 1.6 feet of difference between the highest and lowest profile at the downstream end. 6000 feet upstream, the difference between the highest and the lowest is 0.14 feet.

Assume for the moment that the actual water surface is the middle profile shown in red. At the downstream end, it is approximately half-way between the higher and the lower profile. Note that the lower profile converges more quickly (going upstream) than the higher profile does. This is typically the case.



Sources of Time-Series Data

- Historic Records (USGS)
 - Stage Hydrographs
 - Flow Hydrographs
- Computed Synthetic Floods
- Peak Discharge with assumed time distribution
- Rainfall-runoff modeling

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Unsteady-flow modeling provides a dynamic solution for stage and flow throughout the river network. The primary boundary data are time-series flow, typically for a flood event. Where do you get that flow data?

For most situations, the simulation will route an upstream flow hydrograph, using a downstream rating curve or normal depth. The upstream hydrograph can be:

- Historic, like those obtained from the US Geologic Service.
- Synthetic, often, prior studies have computed and published synthetic floods like the Corps' Standard Project (SPF) or the Probable Maximum Flood (PMF).
- Modeling, using rainfall-runoff models like the Corps' Hydrologic Modeling System (HEC-HMS).
- Peak Discharge, and a time to peak estimate, can be used to provide a crude hydrograph using the HEC-RAS interpolation routine (Triangle hydrograph). If a Unit Hydrograph is available, that distribution can be used to develop a flow hydrograph.



Boundary Condition Plot and Table

The screenshot displays the HEC-RAS software interface. The main window is titled 'Unsteady Flow Data - Mississippi Ohio'. It features a menu bar (File, Options, Help) and a toolbar with 'Boundary Conditions' and 'Initial Conditions' tabs. Below this is a section for 'Boundary Condition Types' with various options like 'Stage Hydrograph', 'Flow Hydrograph', etc. A circled button with a plot icon is highlighted. An 'Inflow summary' dialog box is open, showing a table of boundary condition locations and their minimum, maximum, and volume values. To the right, a 'Flow Boundaries' plot shows flow (cfs) over time from Dec 2004 to Feb 2005.

River	Reach	RS	Boundary Condition	
1	Mississippi	Upper Miss	110.4	Flow Hydrograph
2	Mississippi	Upper Miss	75.65	Lateral Inflow Hydr.
3	Mississippi	Upper Miss	60.11	Lateral Inflow Hydr.
4	Mississippi	Lower Miss.	940	Lateral Inflow Hydr.
5	Mississippi	Lower Miss.	900	Lateral Inflow Hydr.
6	Mississippi	Lower Miss.	846	Rating Curve
7	Ohio River	OHS	622.22	Flow Hydrograph
8	Ohio River	OHS		
9	Ohio River	OHS		
10	Ohio River	OHS		

Boundary Condition Location	Minimum (cfs)	Maximum (cfs)	Volume(acre-ft)	Comments
1 Beaver Creek Kentwood: 5.99	500	14000	14380.17	
2 Beaver Creek Kentwood: 5.29	25	250	272.73	

By clicking the circled button shown above, the user can quickly see a plot of the boundary hydrographs.



Initial Conditions



- Automatically computed (leave blank)
- Enter [some/all] Initial flow distribution
- Use system status from previous simulation (Restart)

River	Reach	RS	Initial Flow
1 Bryon Creek	Bryon Creek	639.	1200
2 Spruce Creek	Upper River	1278.	3000
3 Spruce Creek	Middle River	978.	1800
4 Spruce Creek	Lower River	480.	3000

Storage Area/2D Flow Area	Initial Elevation
1 Sto #1	68

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HEC-RAS unsteady flow requires a water surface and flow at every cross section at the start of the simulation. Unless the Restart option is used, RAS will automatically perform a steady-state backwater computation to provide the starting conditions for the unsteady flow model.

If the initial conditions are left blank, RAS will automatically compute the starting conditions. It will use the initial value in all of the incoming flow hydrographs (upstream and lateral) to determine the starting flows. This is the recommended option for most RAS data sets.

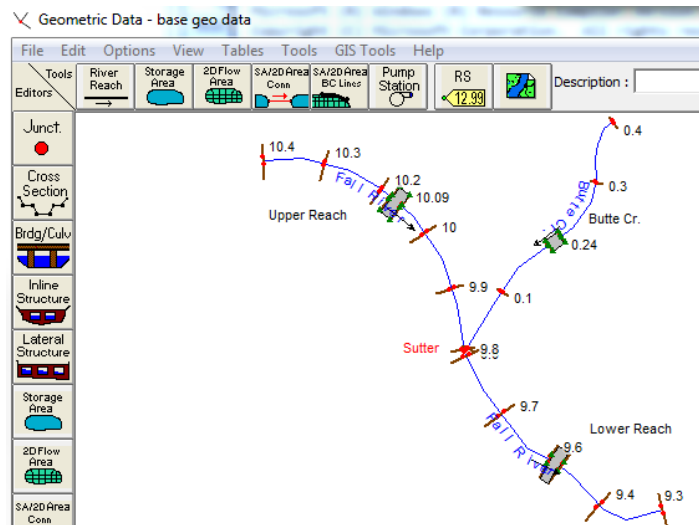
However, for some models the automated backwater may produce poor results leading to instabilities at the start of the unsteady flow run. Or, the steady flow results may be “good/stable”, but the assumptions of static-steady flow may not be correct. So in order to better represent the actual system at time zero, the user may want to enter the initial conditions. In either case, some or all of the flows may be specified.

Finally, the results that were written out from a previous unsteady flow simulation can be used as the starting condition. In this case, RAS will not need to compute a steady backwater solution.



Initial Conditions (Simple)

- Most dendritic systems (no looped networks) with or without lateral inflows are OK



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For simple situations, the automated option can normally be used, but if not:

For most applications, the initial condition is a steady-flow water surface profile throughout the river system. If a constant flow is defined for each river reach, that flow should represent a condition when flows are fairly stable, i.e., a period prior to the start of the flood. The initial value should usually be the starting flow in the inflow hydrograph. You do not want a large change in flow between the initial flow and the first inflow value.

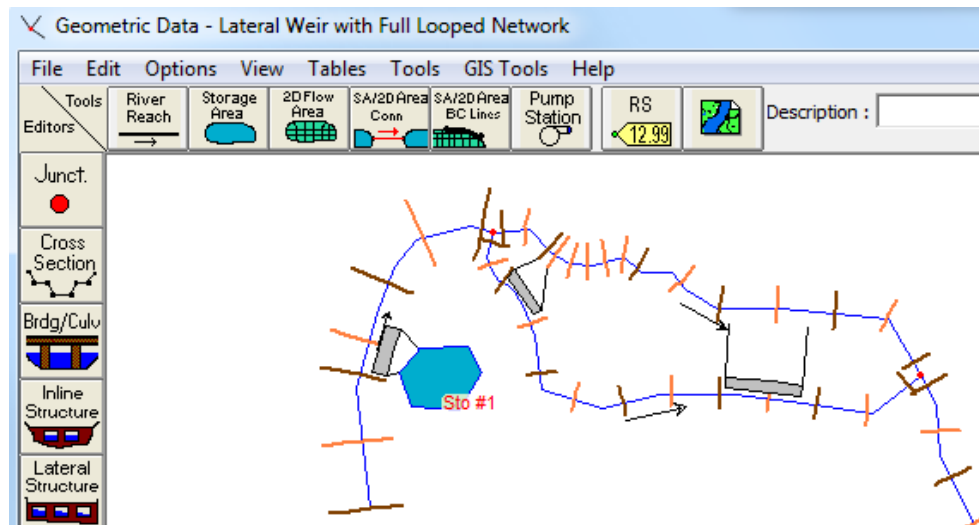
The flows in the river system should be consistent. For a complex river network, it may help to resolve the flow distribution using a steady-flow analysis model. The option for optimizing the flow distribution could be used to help develop a consistent flow set.

If flow is not steady at the start of simulation, you can use hydrologic routing to estimate the flows through the river system. Flow changes can be input in the initial condition, just like steady flow data. An HMS model could be used for this purpose. Remember, the initial flow in the hydrologic model is steady flow.



Initial Conditions (Complex)

- Looped networks and lateral structures (that have initial flows) are more difficult



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There are at least three reasons why you may want to input Initial Flows manually:

- 1) The transition between the steady flow profile computed for $t=0$ and the unsteady flow profile computed for the first time step is sometimes a difficult one. Since different equations are being used, there can be a discontinuity between these two profiles that leads to an instability. Specifying initial conditions allows you to 'tweak' them to increase the stability of this transition.
- 2) There are certain hydraulic configurations (e.g. looped networks) that RAS may struggle with.
- 3) Flows (and stages) may need to be specified for lateral structures (and inline structures).



Initial Condition: Loops & Lateral Structures

- Enter flows, if known, or...
- Steady Flow Optimization for Junctions
- Low flow for Lat Struct. and/or many warmup time steps

River	Reach	RS	Initial Flow
1 Bryon Creek	Bryon Creek	639.	
2 Spruce Creek	Upper River	1278.	
3 Spruce Creek	Middle River	978.	
4 Spruce Creek	Lower River	480.	

Storage Area/2D Flow Area	Initial Elevation
1 Sto #1	68

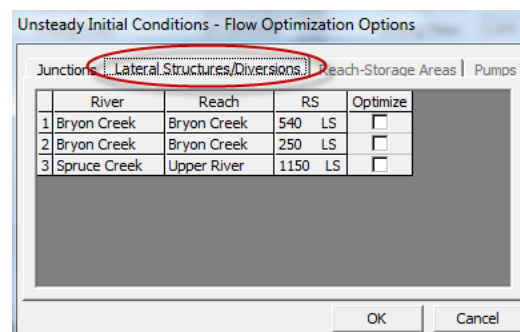
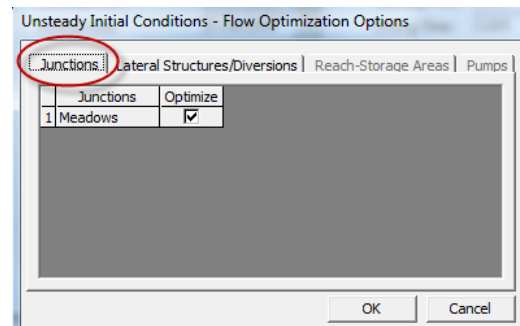
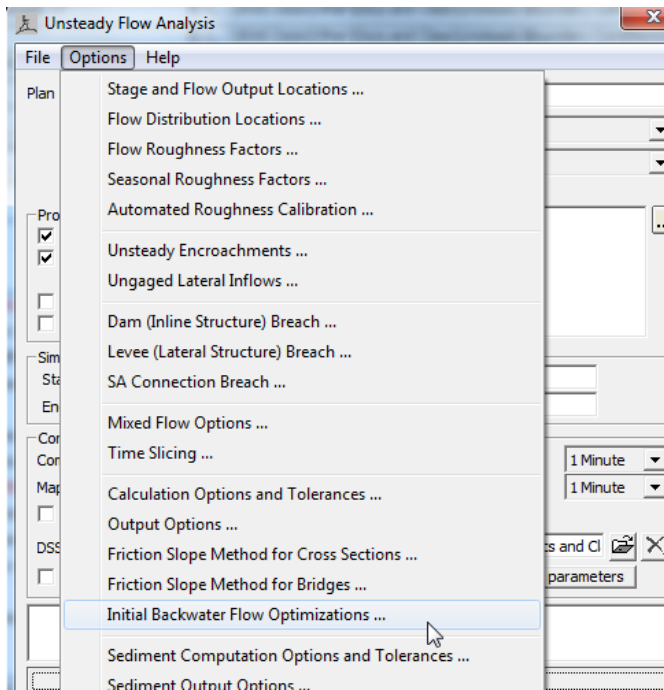
34

The initial backwater (steady flow) can attempt to solve the "split flow" problem that is caused by loops and flow diversions (e.g., lateral structures). This option (which is off by default) is available from the unsteady compute window. The optimization at junctions is usually good enough (to not have stability problems). The optimization for lateral structures is less robust. A single lateral structure will usually optimize, but the behavior of three or more is usually erratic and may give results that are worse than not attempting optimization in the first place.

It may be possible to avoid problems by choosing a low starting flow so that the lateral structures do not start with flow diversions. Alternately, the optimization for the lateral structures can be left off and the situation handled by a large number of warmup time steps. (The flow optimization at the junction would normally still be recommended.)



Initial Backwater



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Example:

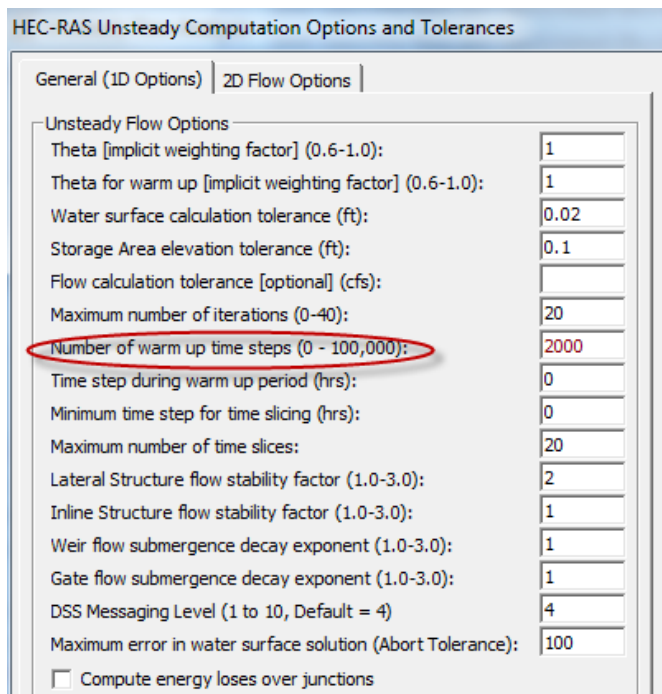
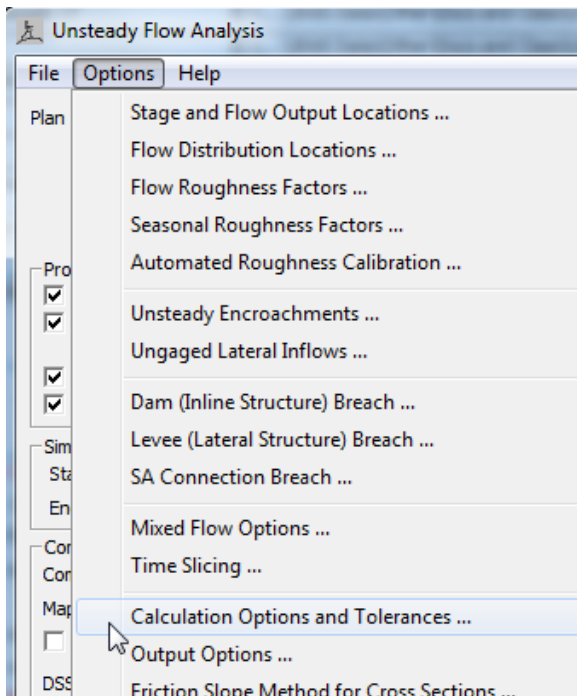
Assume that the RAS model shown has an upstream flow of 3000 cfs and that for a hydraulically-correct, steady state solution the upstream lateral structure (the one connected to the storage area) will divert 1000 cfs. The water surfaces downstream of this LS should be based on a flow of 2000 cfs. However, with the LS optimization off, the backwater will be based on the full 3000 cfs. The downstream reach will have 3000 cfs and the two middle (looped) reaches will also have a combined 3000 cfs. This extra flow will cause the water surfaces to be too high. Based on these computed water surfaces, the upstream LS may be able to divert 6000 cfs. This is more than the flow in the river!

If no warmup time steps are used, when the unsteady flow model starts, it will attempt to divert the full 6000 cfs out of the river during the first time step and the model would surely go unstable. However, warmup time steps can be used to reduce this shock.

[During the warmup period, all of the starting flows, such as upstream hydrographs and lateral inflows are held constant.]



Warm Up Time Steps



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During the first part of the warmup period, RAS automatically reduces the flow change from lateral structure. In the example where the user has selected 2000 warmup steps, for the very first warmup time step, RAS may only reduce the downstream flow by 60 cfs instead of the full 6000 cfs. The greater the number of user entered warmup time steps used, the smaller the initial change. (This is why the number of warmup time steps may be as large as 100,000.) This "reduction factor" is gradually wound down during the first two-thirds of the warmup period. During the last third of the warmup period, the full diversion is computed as normal. This last third allows the model to "settle down" (the original reason behind the warmup period option) before the main simulation is allowed to start at "time zero" (a negative time is displayed during the warmup period).

Alternately, say the upstream LS had been optimized and it had incorrectly optimized to a flow diversion of 2500 cfs (leaving only 500 cfs traveling downstream). The "shock reduction" would still be used, but in this case, the flow in the river might only be allowed to increase to 550 cfs for the very first warmup time step. This is also true of the "tailwater" side of the lateral structure if the structure is connected (the flow is not out of the system). Whatever flow (if any) the lateral structures inside of the looped network divert during the initial backwater, this diversion will also be subject to the reduction factor so as to prevent shocks to either side of the lateral structure.



Initial Elevation Storage Areas

- Set Stage
 - SA Min elevation for dry condition
 - Known Stage (historic data or desired pool)
- Leave Blank
 - Dry, If no LS or SA Conn inflow, Otherwise
 - Average WSEL from connections

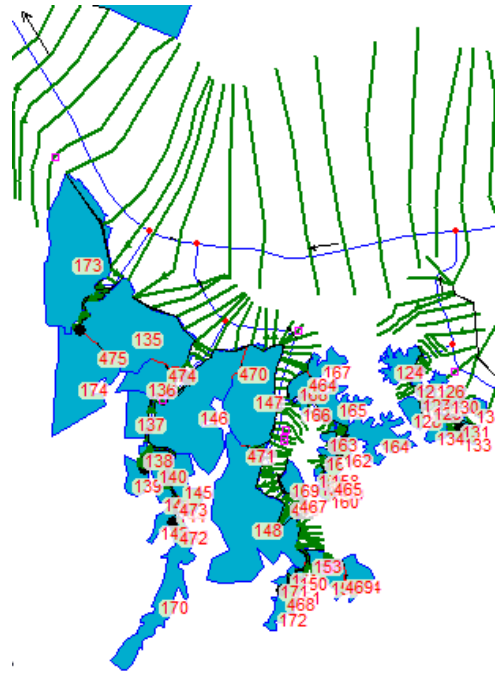
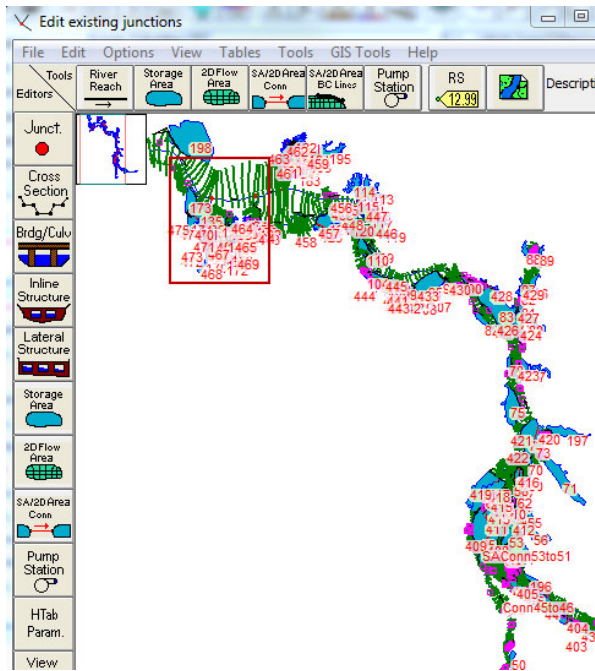
Initial Elevation of Storage Areas/2D Flow Areas (Optional)		Import Min SA Elevation(s)
<input checked="" type="checkbox"/>	Keep initial elevations constant during warmup	
Storage Area/2D Flow Area	Initial Elevation	
1 Sto #1	68	

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- The user may specify an initial stage for a given storage area. By default, this stage is allowed to vary during the warmup period (in order to allow things to settle down to equilibrium). Checking the keep initial stage option will prevent any changes to the user specified stage during the warmup period. So, for instance, a dry storage area will stay dry even if there is inflow. If there are no warmup time steps, this option will not have any effect.
- If the initial elevation is left blank, then the elevation in the storage area is determined immediately after the initial backwater. If there is no flow into the storage area (from lateral structures or storage area connectors), then the storage area is dry. If there is flow from a connection, RAS will set the initial elevation to the water surface from that connection. If there are multiple inflows, it will compute an average water surface.



Lower Columbia Storage Areas



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- The above example is from a model of the lower Columbia. The floodplain has a series of connected storage areas to represent the storage and routing of the flow that is outside of the river that is represented by the normal cross sections.
- To start the model during a high flow, the water surfaces in the storage areas need to approximate the water surface in the nearby river which can be done automatically if the storage area initial elevation is left blank.



Restart File

- Write an Initial Condition File at a desired time
- Create a new Unsteady Flow file and Plan
("Save As...")
- Select Use a Restart File option
- Adjust starting date, if needed

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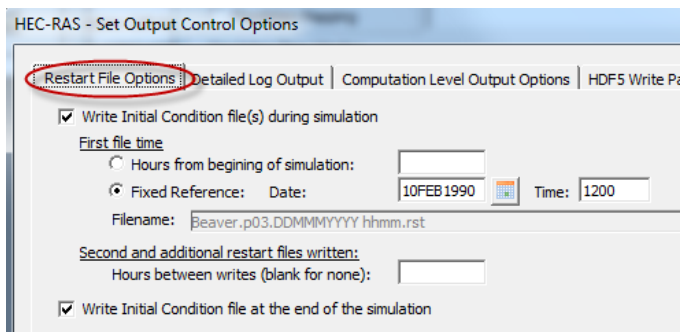
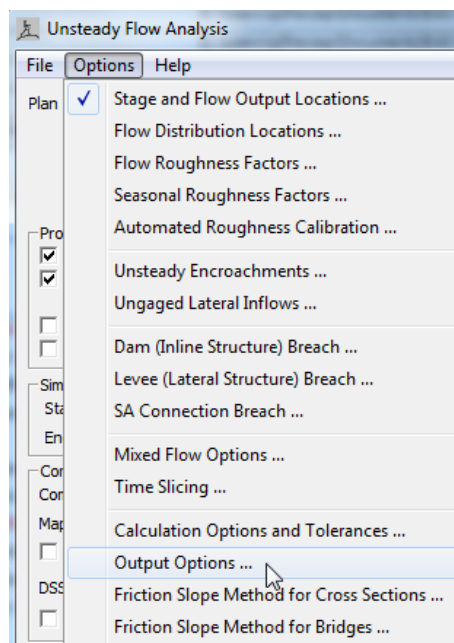
A **Restart** file can be saved from a simulation. This option may be useful when the software is having stability problems at the beginning of a run. Run the model in a mode that gets through the initial conditions. For instance, using a large number of warmup time steps. Another options is "dewatering" the model: Run the model with all the inflow hydrographs set to a constant flow, and set the downstream boundaries to a high tailwater condition. Run the model with decreasing tailwater down to a normal stage over time. Once the tailwater is a reasonable value for the constant flow, those conditions can be written out to a file, and then used as the starting conditions.

The **Restart** file can also be useful during model development. For instance, if a RAS model takes several hours to run on a computer, and then it goes unstable, a restart file can be written out just prior to the instability. The model can then be quickly and repeatedly run through the period of interest.

The **Restart** file starts the model in the same condition that it was saved. For instance, the state of all gate operations, navigation dams, levee breaches, etc. are saved.



Write Initial Condition File



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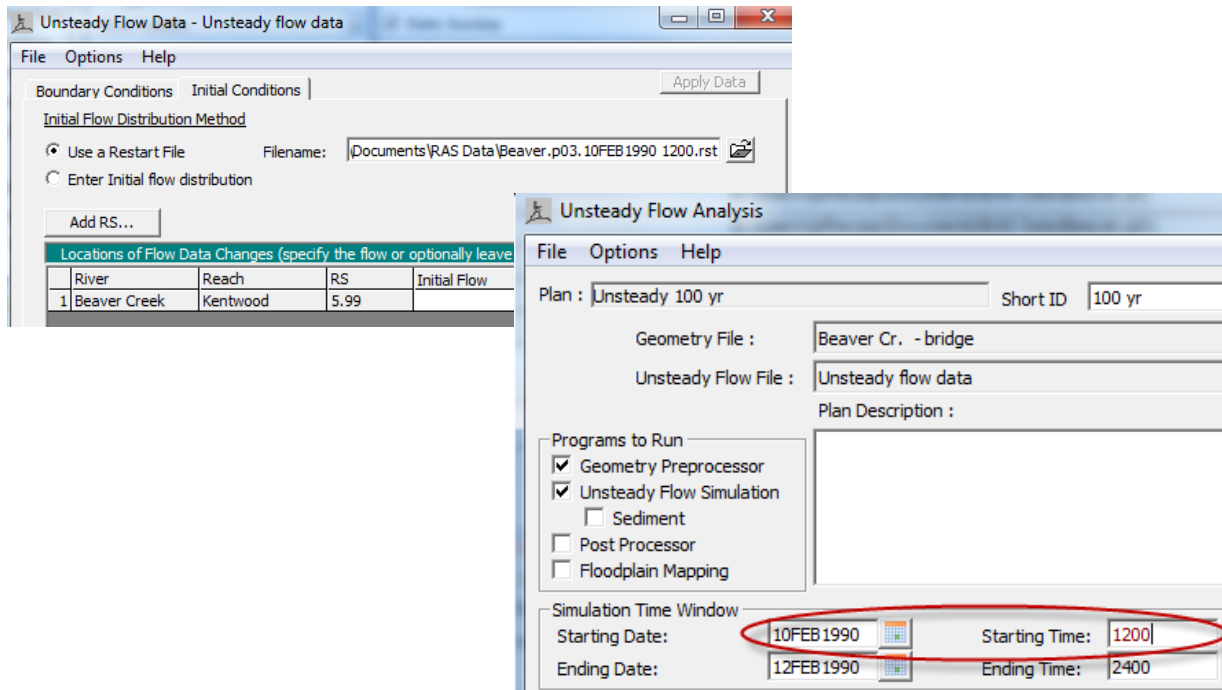
- To create a **Restart** file, go to the output options editor, select the **Restart File Options** tab and enter the date and time and then run the model.
- Although it is possible to both create and use a restart file using the same unsteady flow and plan, this is not recommended.
- Instead, create a new flow and plan file using the **Save as** option.

Note:

- To use the **Restart** file option, the geometry that is used when the restart file is created needs to be [pretty much] identical to the geometry that uses the restart file.



Select Restart



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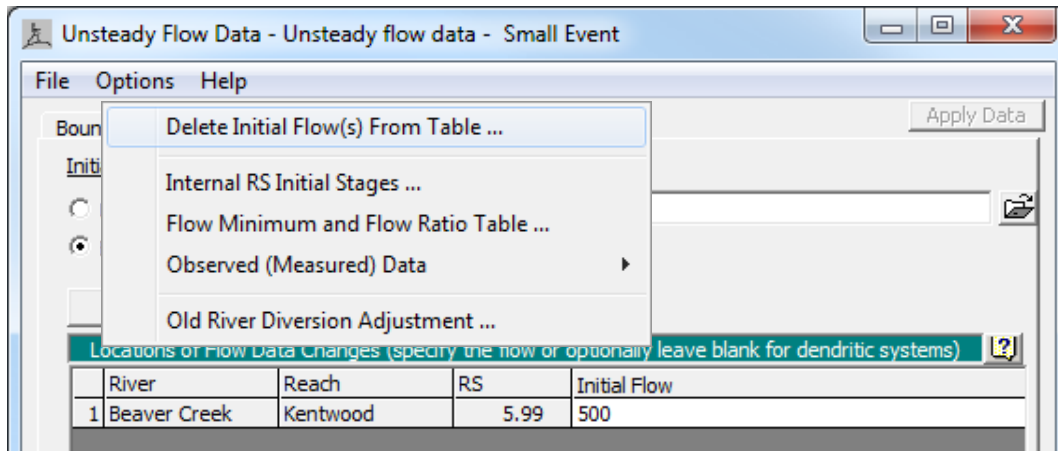
- In the initial condition editor, browse and select the desired restart file.
- Note that the name of the restart file contains both the project and plan identification as well as the date and time stamp (the simulation time when the restart file was created).
- If the restart file is written out in the middle of a long run, it would usually be recommended to change the starting date and time on the compute window to match the date and time of the restart file.
- There is no requirement that the date and time match. For instance, if the restart file is being used in lieu of the initial backwater and warmup period, it may not matter.

Note:

- The user must maintain sufficient continuity between the restart file and the unsteady flow run at time zero. For instance, if a gate is only open 0.5 feet in the restart file, but the unsteady model (that is using the restart file) is using a time series gate opening and the given starting time specifies a gate opening of 10.0 feet, instability is likely to result.



Options Menu



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The Unsteady Flow Window has the standard **File Menu** options. It is a good idea to save the data before going on to the next step.

The **Options Menu** has four options:

- Delete an added Boundary Condition. You cannot delete external boundaries because they are required.
- Internal RS Initial Stages to set a stage at the start of simulation.
- Flow Minimum and Flow Ratio Table
- Add Observed Data - this option is helpful when calibrating model to simulate an historic flood event.



Internal RS Initial Stages

- Select:
 - River
 - Reach
 - River Station
- Add Location to table
- Define Initial Elevation
- Optionally used upstream of Inline Structures to set pool WSEL

Locations and Initial Stages				
	River	Reach	RS	Elev
1				

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The initial stage can be set for a river station. Normally, this would be defined by the computed water surface profile during the initial conditions stage of the computation process. This option is useful at locations upstream from a control structure where the initial stage is NOT the 'normal' backwater elevation. For instance, an inline structure using time series gate opening will compute a water surface at the dam that satisfies steady-state hydraulics which may or may not be the desired starting pool elevation.

Select the River, Reach and River Station where the initial stage is to be defined. Then 'click' the **Add an Initial Stage Location** button. The location will be added to the table below. Then you can enter the initial stage for that location.



Flow Minimum & Flow Ratio Table

- Global Editing to:
 - Add constant,
 - Multiply values, or
 - Set Values
- Minimum Flow value for boundary
- Multiplying factor to modify hydrograph for boundary

Unsteady Flow Data - Flow Minimum and Flow Factor Table

Selected Area Global Edits

Add Constant Multiply Factor Set Values

Summary of the flow minimum and flow ratio factors

	Boundary Location		Minimum Flow	Ratio Factor
1	Beaver Creek	Kentwood	5.99	900
2	Beaver Creek	Kentwood	5.836	1200

OK Cancel

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The boundary hydrographs can be modified with global editing to:

Add a constant value to the input

Multiply input values by a factor

Set values to an input value

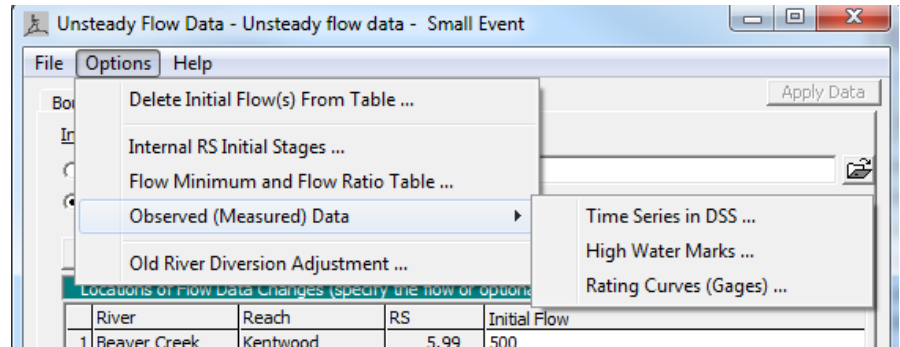
The following two options are also available on all flow hydrograph input windows.

1. The flow hydrograph for model boundaries can be monitored to ensure that the flow values do not drop below an input minimum value. If the value is less than the minimum, the value is set to the minimum.
2. The flow hydrograph for model boundaries can be easily modified by a constant ratio. This allows easy testing of model sensitivity to input flow values, or an analysis of model results with larger flood events.



Observed (Measured) Data

- Time Series in DSS
- High Water Marks
- Rating Curve (Gage)



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There are 3 options available to enter observed data:

1. Time-series data can be entered to define observed stage or flow data. There data must be in a DSS file.
2. High-water marks can be defined
3. A Rating Curve can be defined



Observed Time Series Data

- Add Selected location
 - River
 - Reach
 - River Station
- Select DSS File
- Select Pathname to read Observed Data

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Observed time-series data can be added to the unsteady flow data set. First select the model location where the observed data would apply. Select River, Reach, and River Station and press **Add selected location**. The location will appear in the table below. Several locations can be selected.

The second step is the selection of DSS records to read the observed data. The lower half of the window has the standard DSS file and record selection features. Filters can be selected for pathname parts to facilitate record selection. A DSS Record should be selected for each Location selected. Remember the time window set for the simulation will be used to extract the observed data, so be sure there is observed data for the time window.



High Water & Rating Curves

- High Water
 - Select location
 - Add an Obs. WS
 - Define Distance downstream & stage
- Observed Rating
 - Select location
 - Distance downstream
 - Stage – Flow data

Observed WS Location			Observed Water	
River	Reach	RS	Dn Dist	High Water
1				

Observed Rating Curves	
Stage (ft)	Flow (cfs)
1	
2	
3	
4	
5	
6	
7	
8	

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High Water Marks can be defined for locations along the river reach.

First the nearest upstream cross section is selected and added to the Observed Water Surface Locations. The distance downstream from the section and the observed stage are then entered in the table.

Observed Rating provides for a Rating Curve or Measured Flow Data to be entered.

1. The Rating curve is defined in typical Stage – Flow relationship, starting from the lowest stage and sequentially increasing.
2. The Measured Point Data is entered by pressing that button and entering the observed stage and flow, along with optional description. These data do not have to define a complete rating.

Boundary & Initial Conditions

