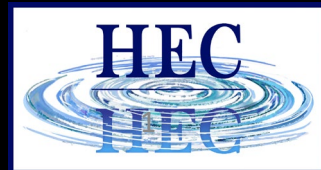


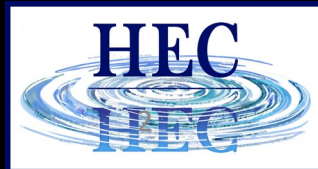
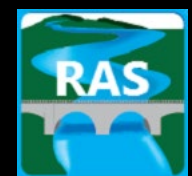
Overview of Unsteady Flow Modeling

Stanford Gibson, PhD
Hydrologic Engineering Center



Overview:

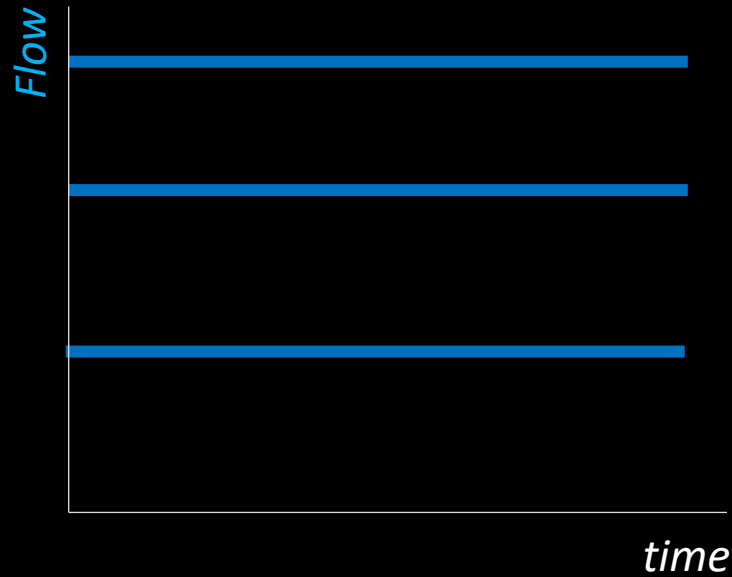
1. What is Unsteady Flow?
2. How is it different than Steady Flow?
3. Why would you use it?
4. Examples?



1. What is Unsteady Flow?

Steady Flow

$$Q(\cancel{t})$$

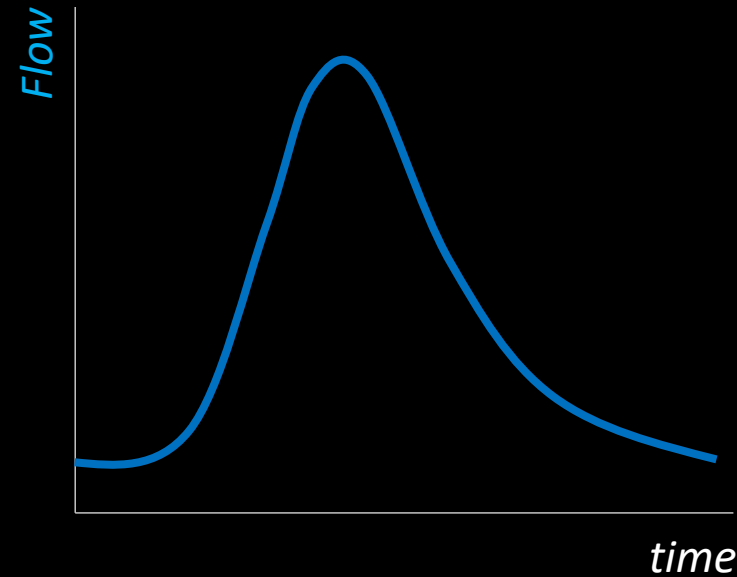


changes gradually

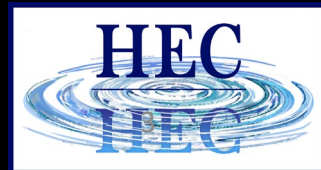
Flow ~~does not change~~ with time

Unsteady Flow

$$Q(t)$$



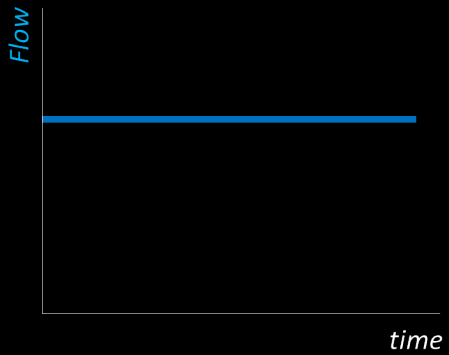
Flow changes with time



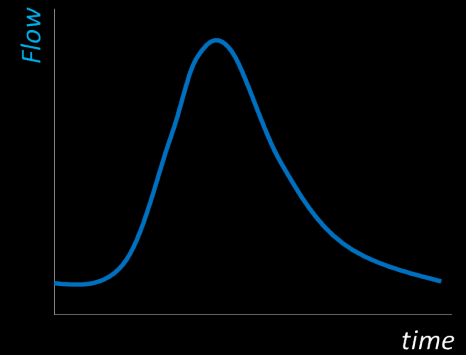
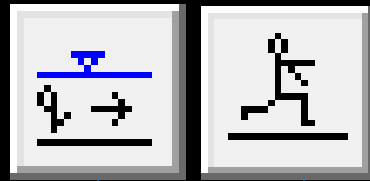
1. What is Unsteady Flow?

Steady Flow

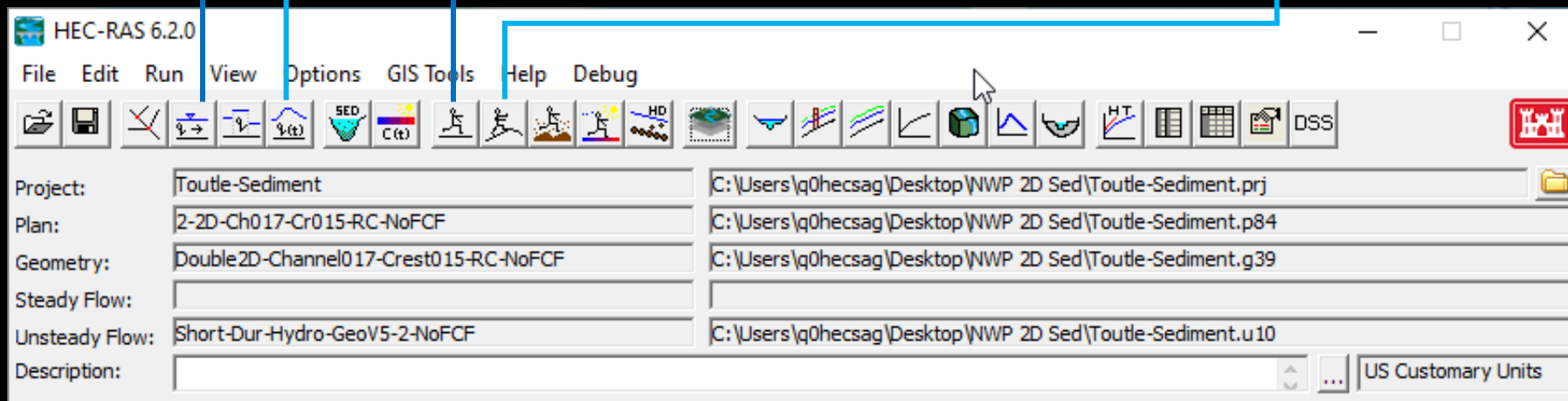
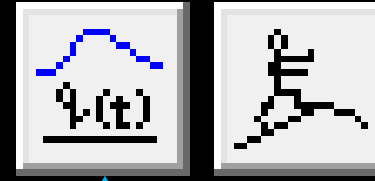
Unsteady Flow



$$Q(t)$$

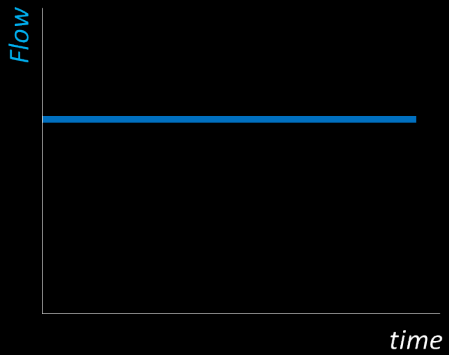


$$Q(t)$$

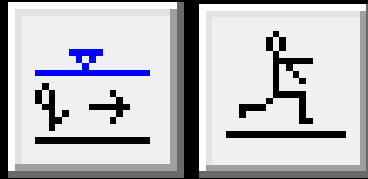


1. What is Unsteady Flow?

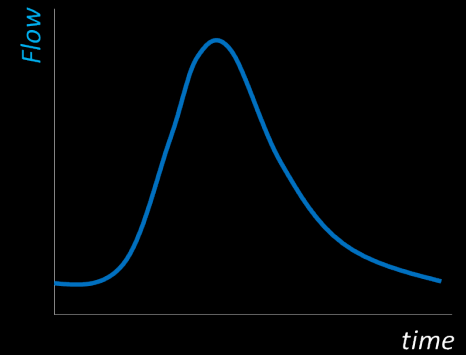
Steady Flow



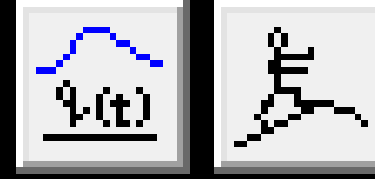
$$Q(\cancel{t})$$



Unsteady Flow



$$Q(t)$$



Overview:

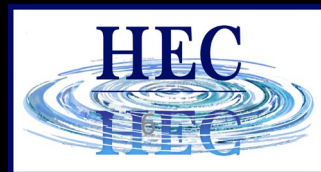
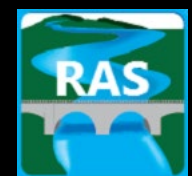
1. What is Unsteady Flow?

2. How is it different than Steady Flow?

i. Boundary Conditions

ii. Calibration

iii. Applications

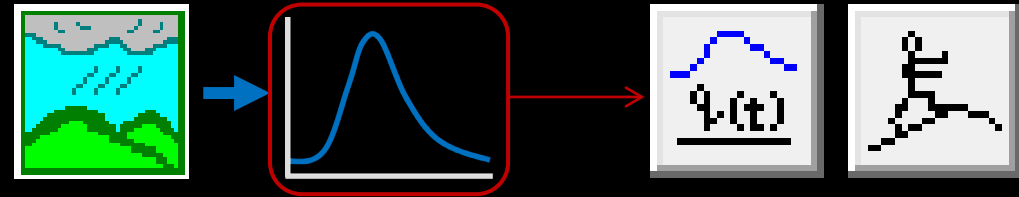
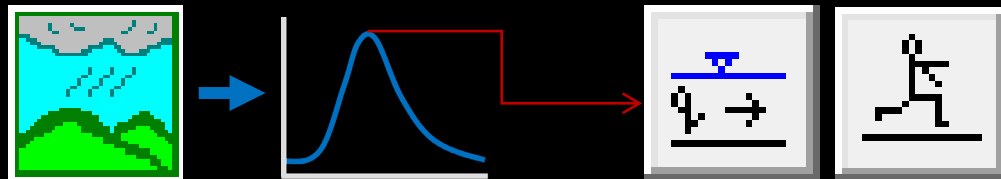


2. How is it different than Steady Flow?

Boundary Conditions

Hydrologic Routing

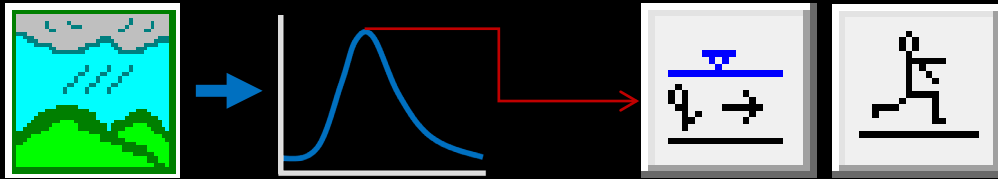
Hydraulic Routing



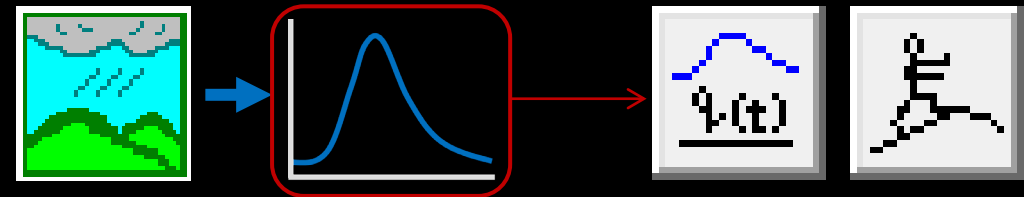
2. How is it different than Steady Flow?

Boundary Conditions

Hydrologic Routing



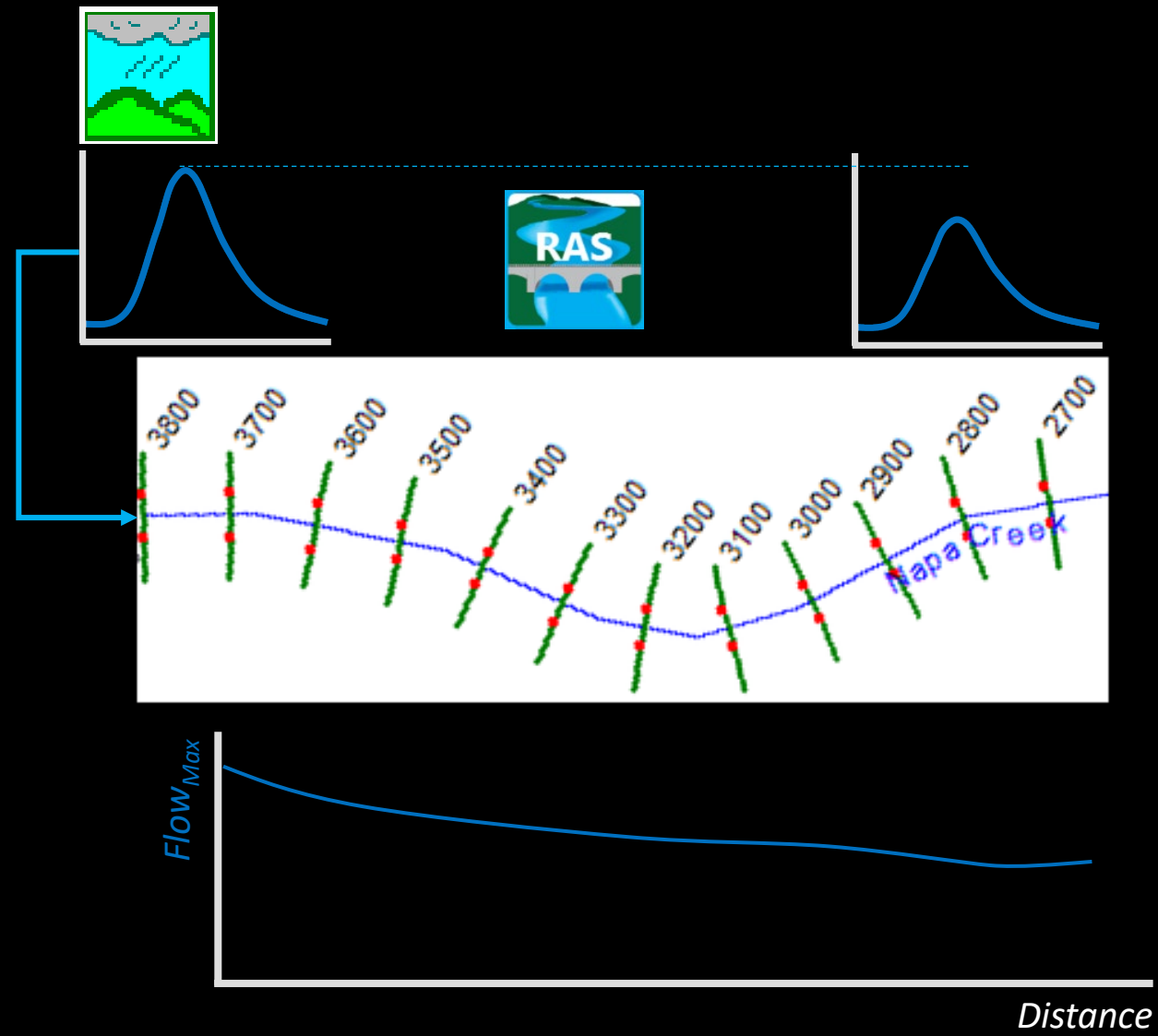
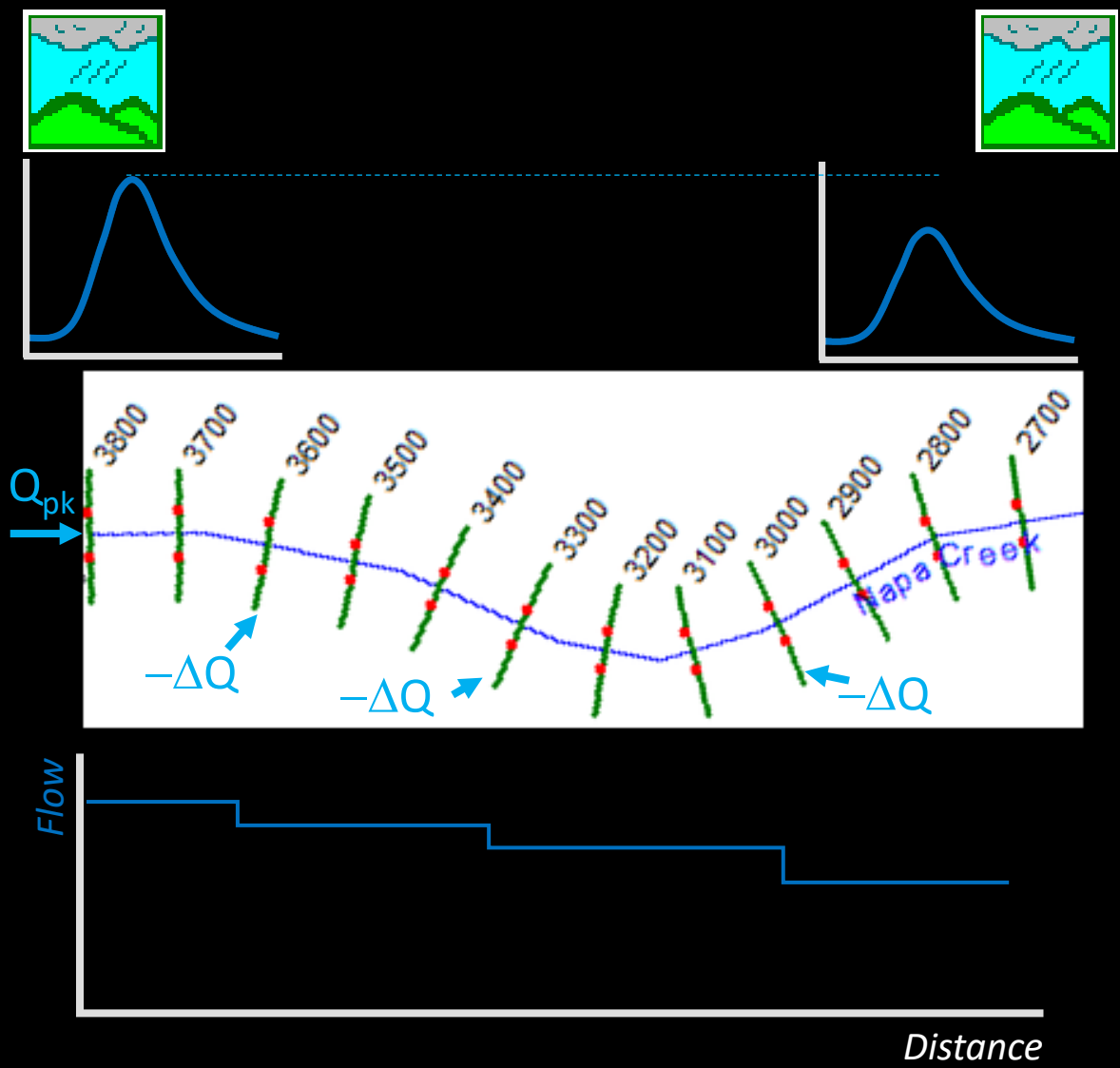
Hydraulic Routing



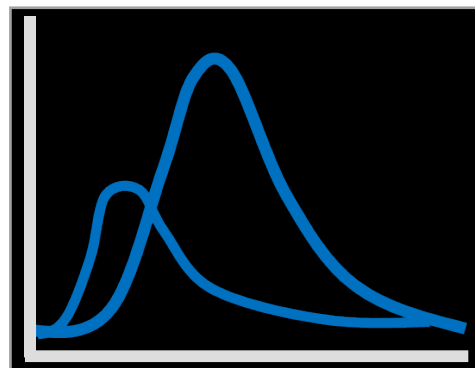
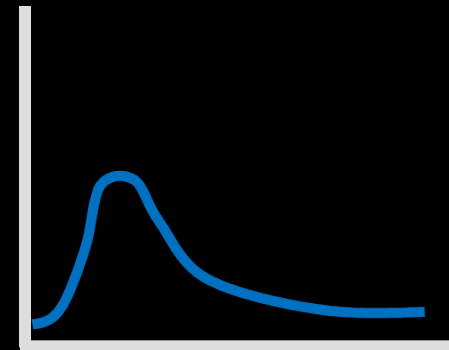
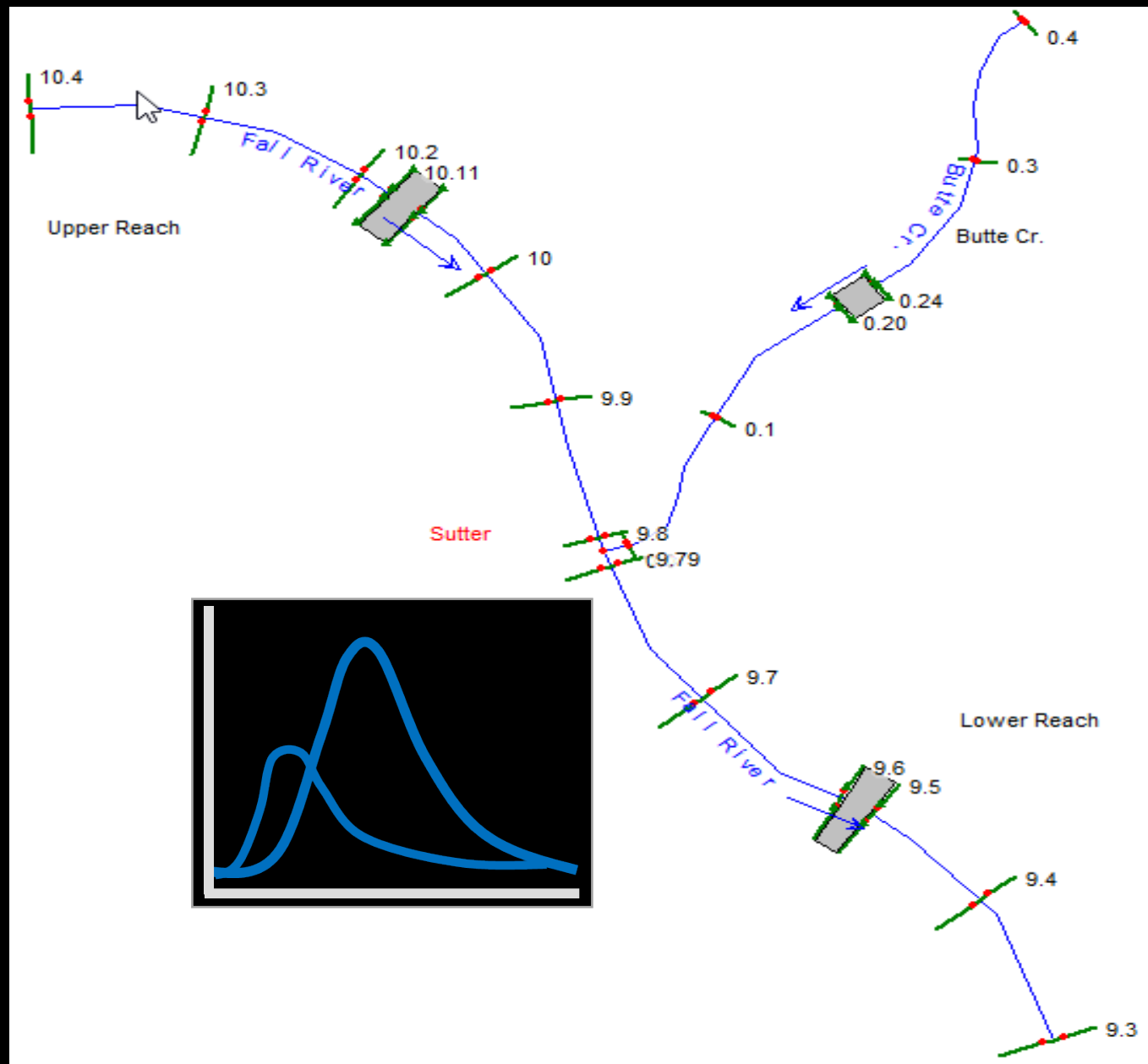
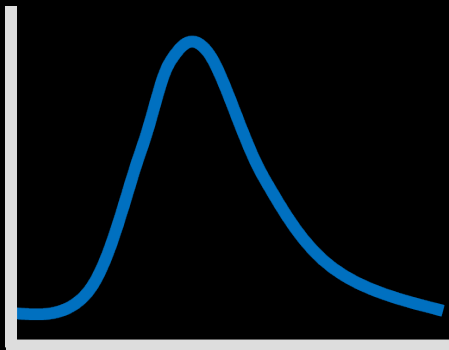
Example 1: Flood Attenuation

Hydrologic Routing
Steady Flow

Hydraulic Routing
Unsteady Flow



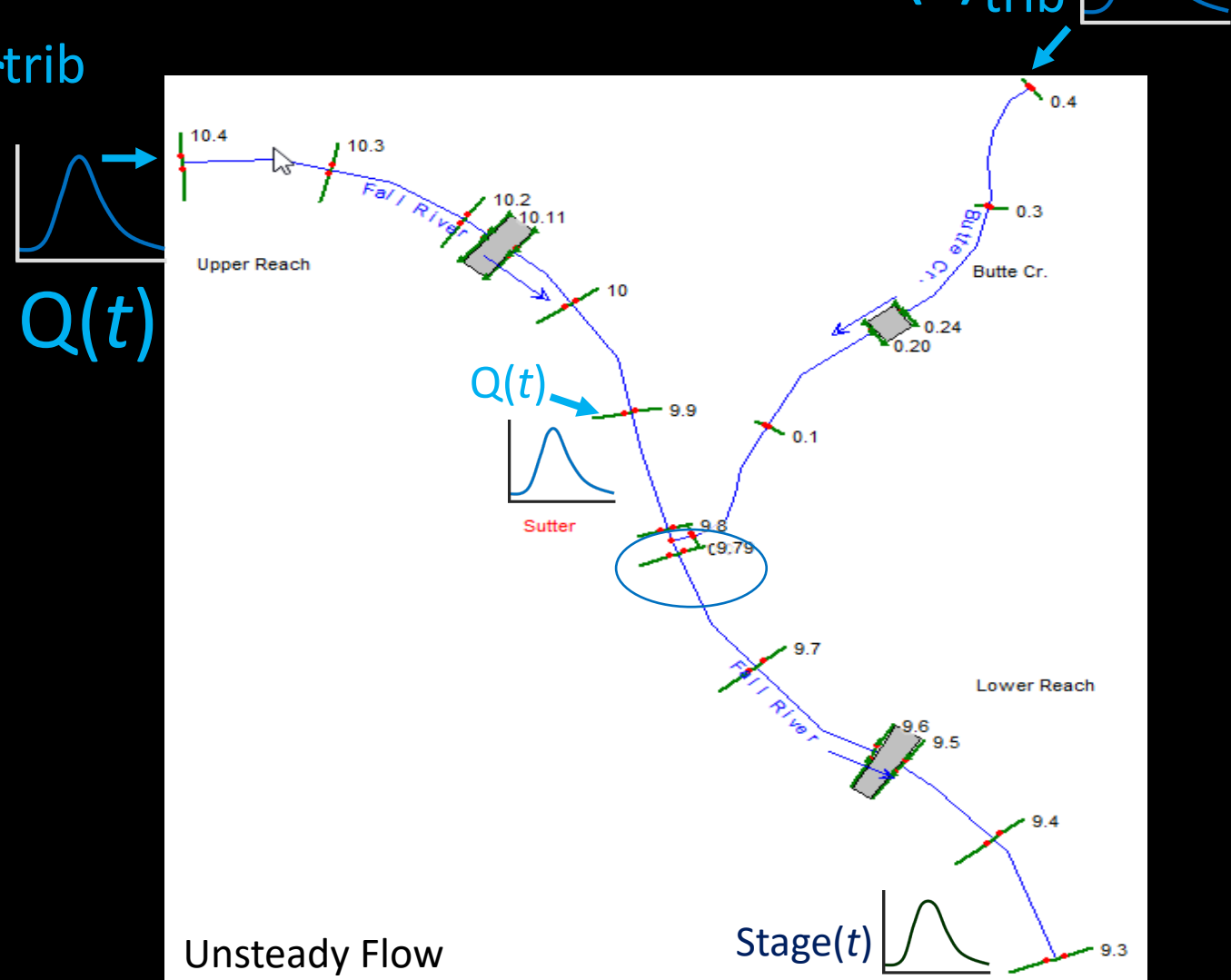
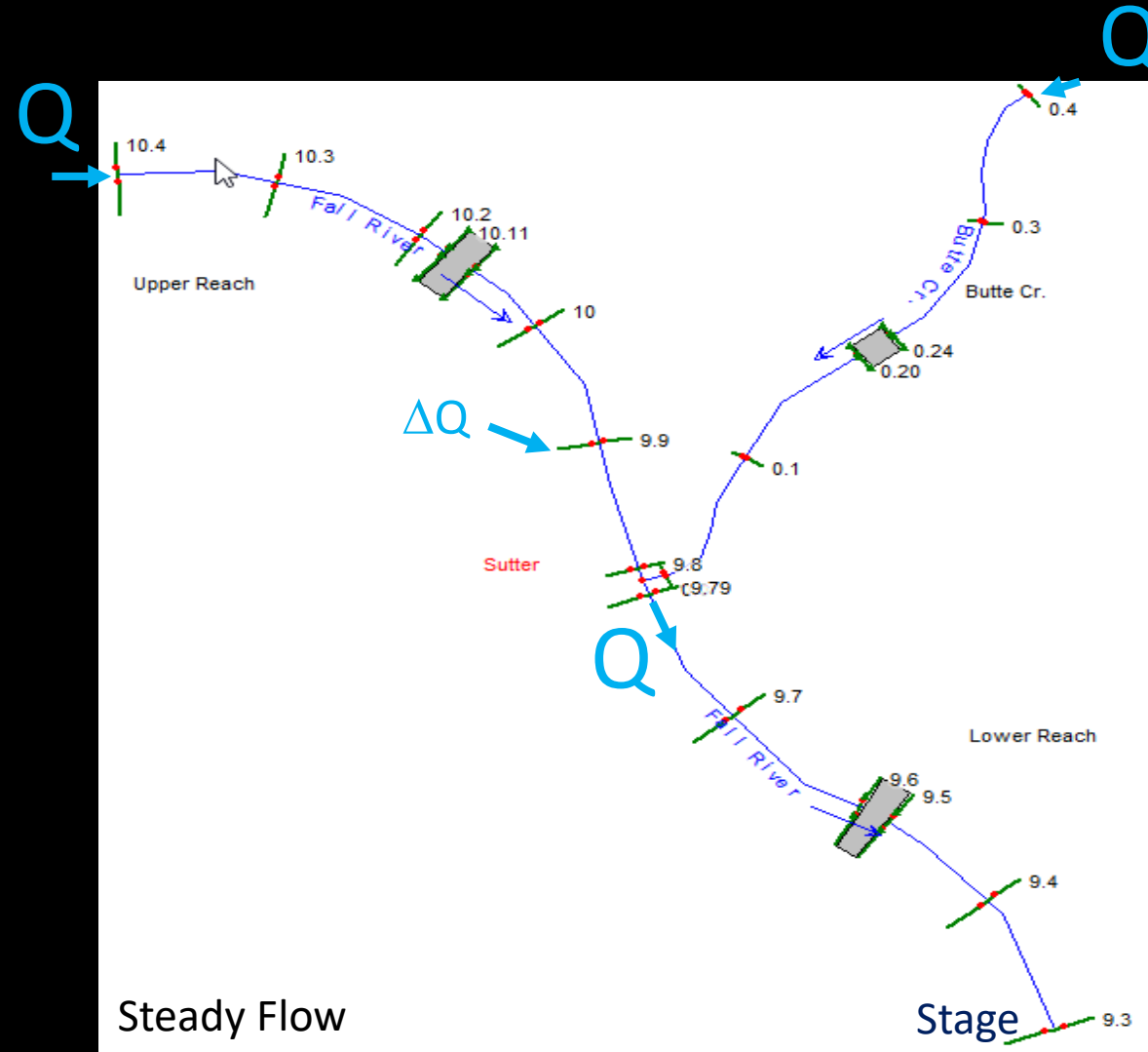
Example 2: Tributary Timing



Hydrologic Routing Steady Flow

Example 2: Tributary Timing

Hydraulic Routing Unsteady Flow

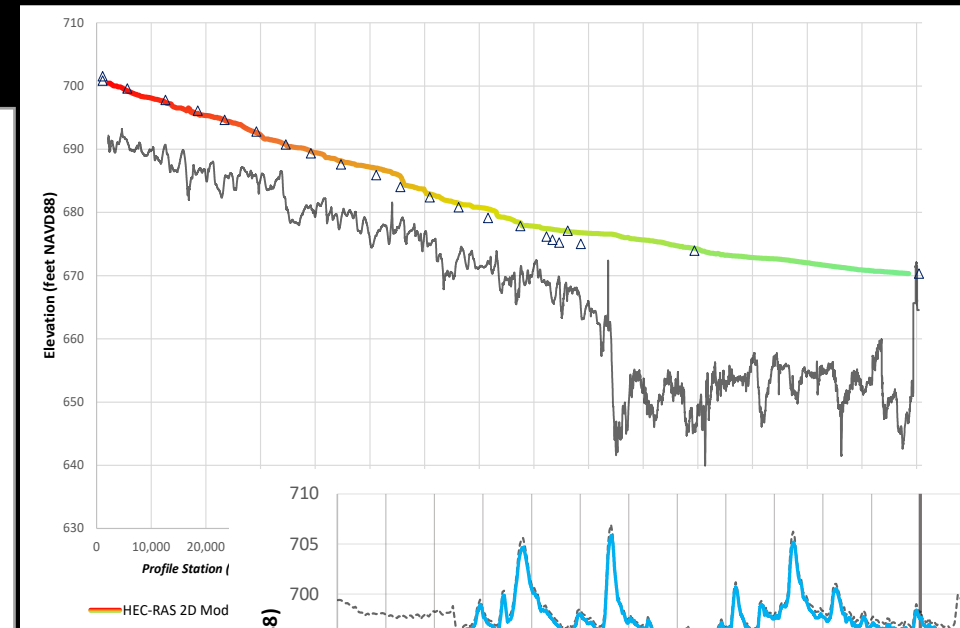
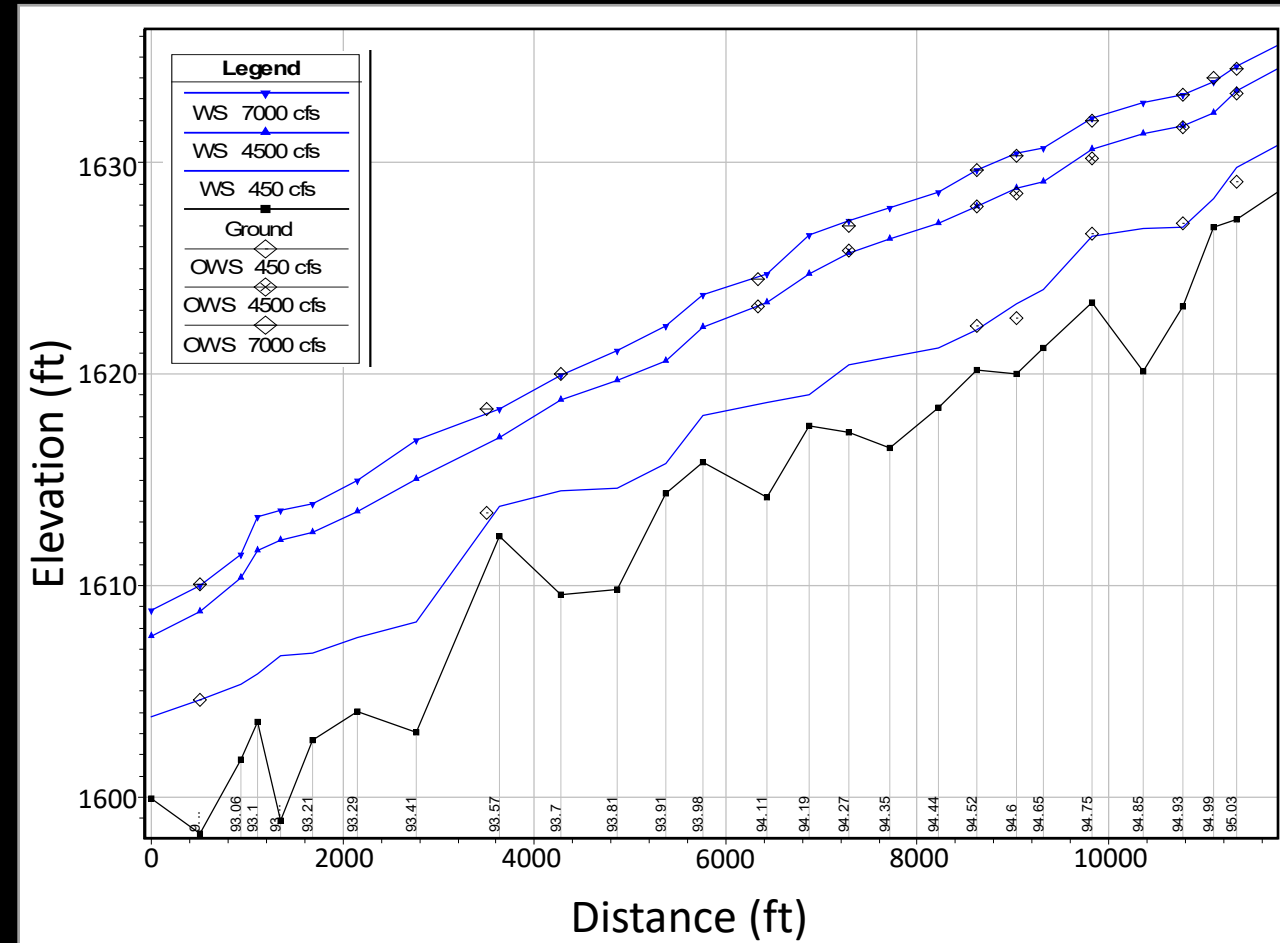


2. How is it different than Steady Flow?

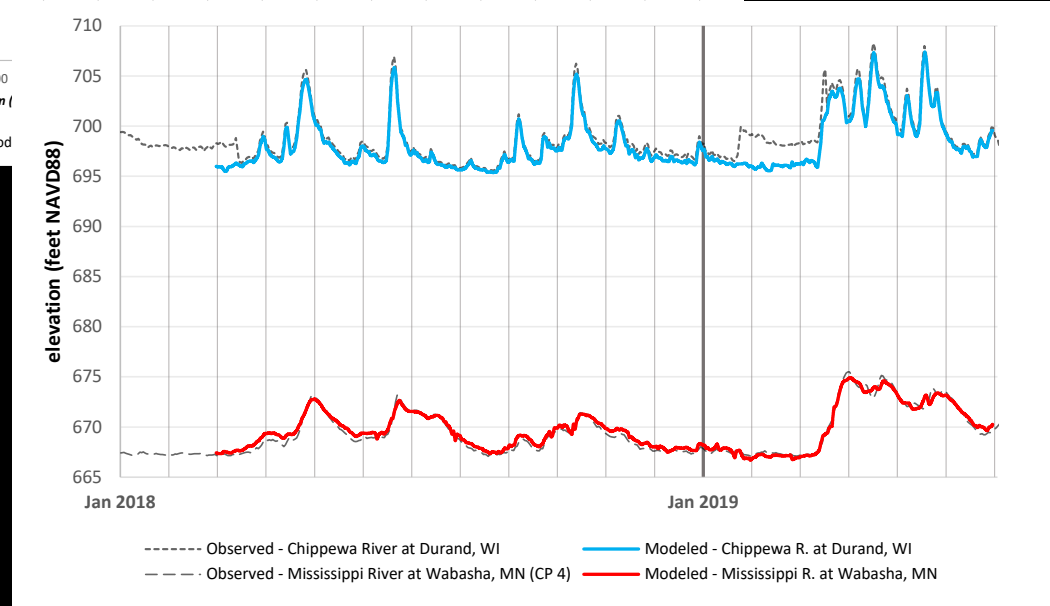
Steady
Flow

Calibration

Unsteady
Flow



By: Alex Nelson (MVP)

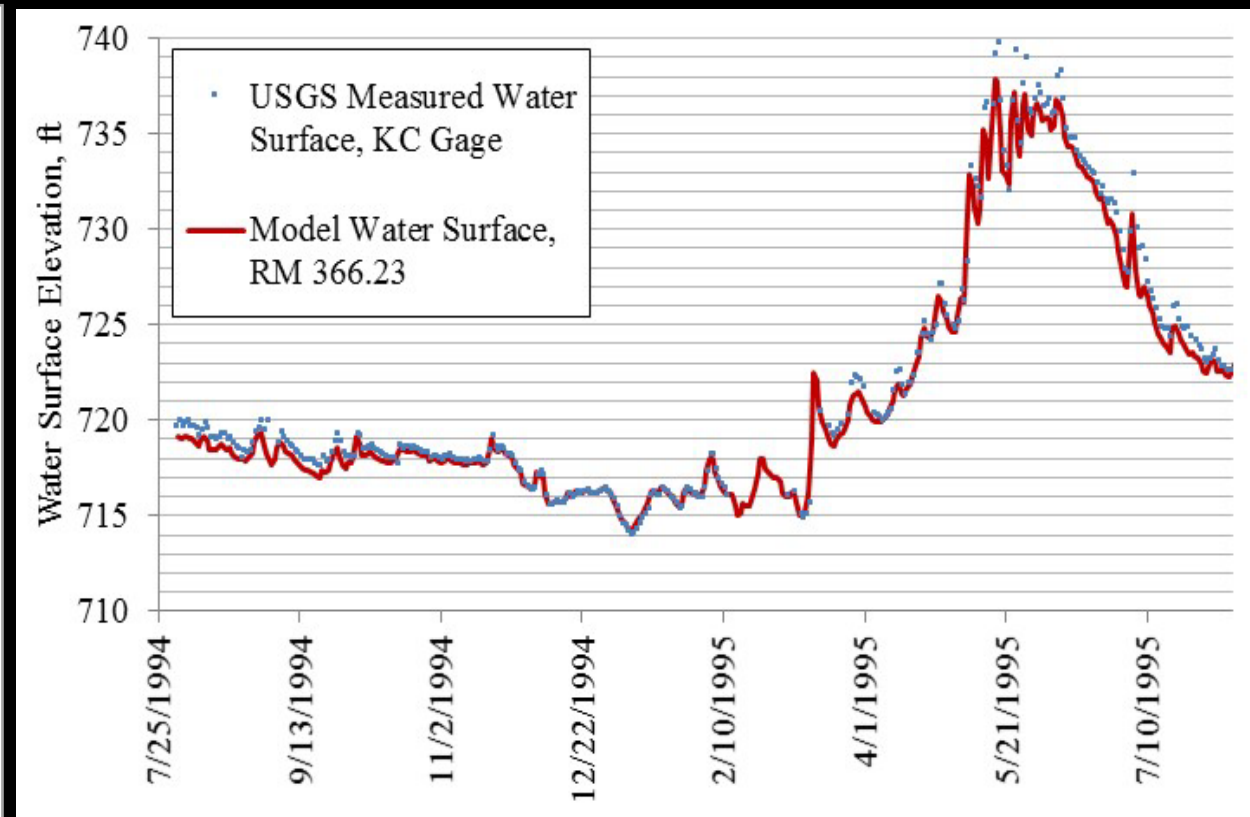
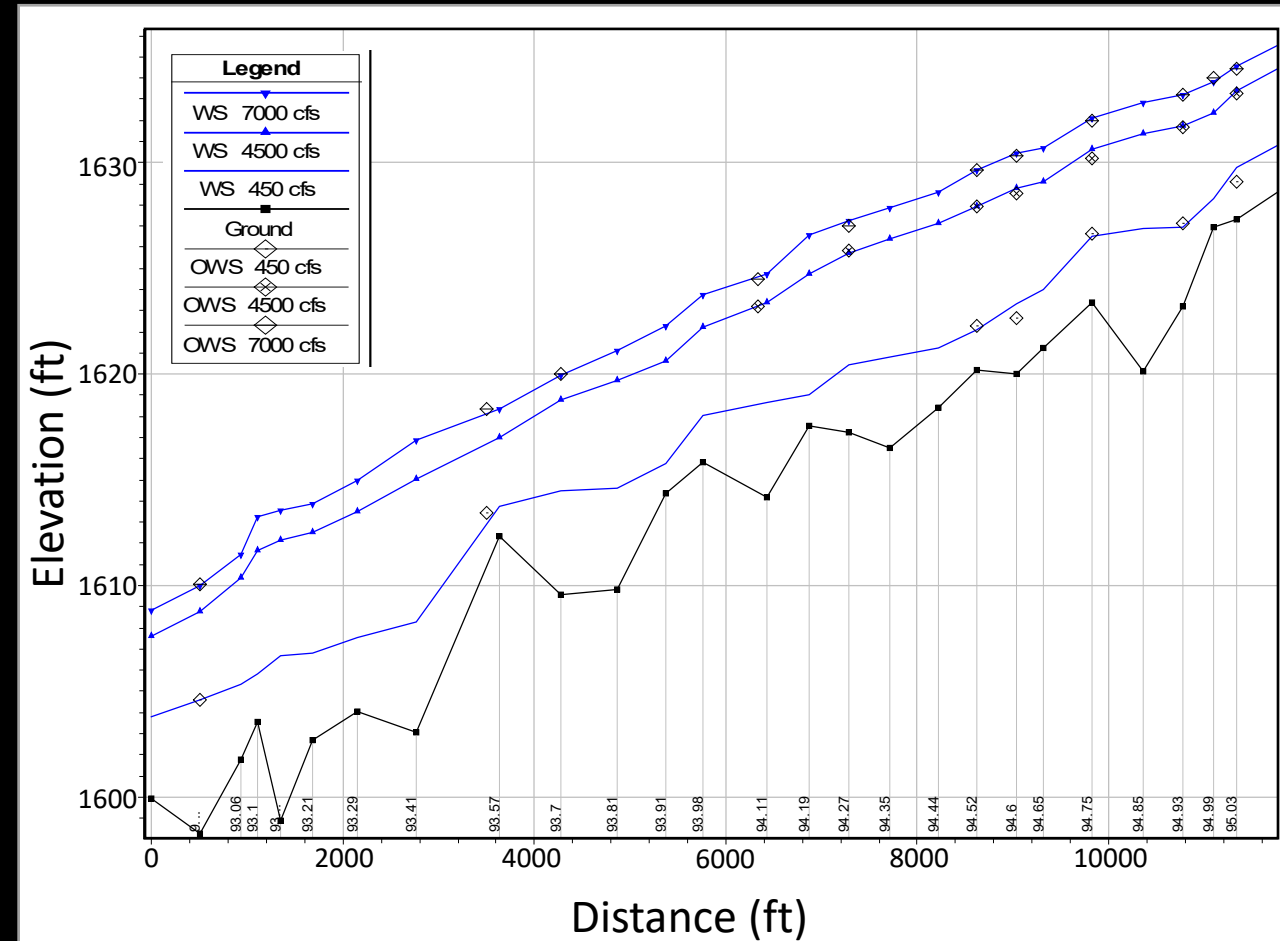


2. How is it different than Steady Flow?

Steady
Flow

Calibration

Unsteady
Flow



By: John Shelley, PhD (NWK)
From: Missouri River Bed Degradation Feasibility Study. USACE (2017).

2. How is it different than Steady Flow?

Applications

The screenshot displays the HEC-RAS software interface. The main window is titled 'Inline Structure Data - Gate Geometry with 3 Gate Groups'. It includes a menu bar (File, View, Options, Help) and several input fields: River (Nittany River), Reach (Weir Reach), River Sta. (41.75), Upstream XS (41.76), and Upstream channel length (90 ft). The description is 'Inline Weir and Gated Spillway'. The 'All Culverts' dropdown is set to 'No Flap Gates'. A plot shows 'Elevation (ft)' vs 'Station (ft)' with a legend for Ground, Ineff, and Bank Sta. The 'Gate Openings' dialog box is open, showing 'River: Nittany River Reach: Weir Reach RS: 41.75' and 'Gate Group: Left Group'. It has options for 'Read from DSS before simulation' and 'Enter Table'. The 'Enter Table' section is active, showing 'Data time interval: 1 Hour' and 'Use Simulation Time' with 'Date: 08APR 1999' and 'Time: 0000'. A table of 'Hydrograph Data' is visible, with columns for Date, Simulation Time, and Gate Opening Height (ft).

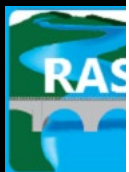
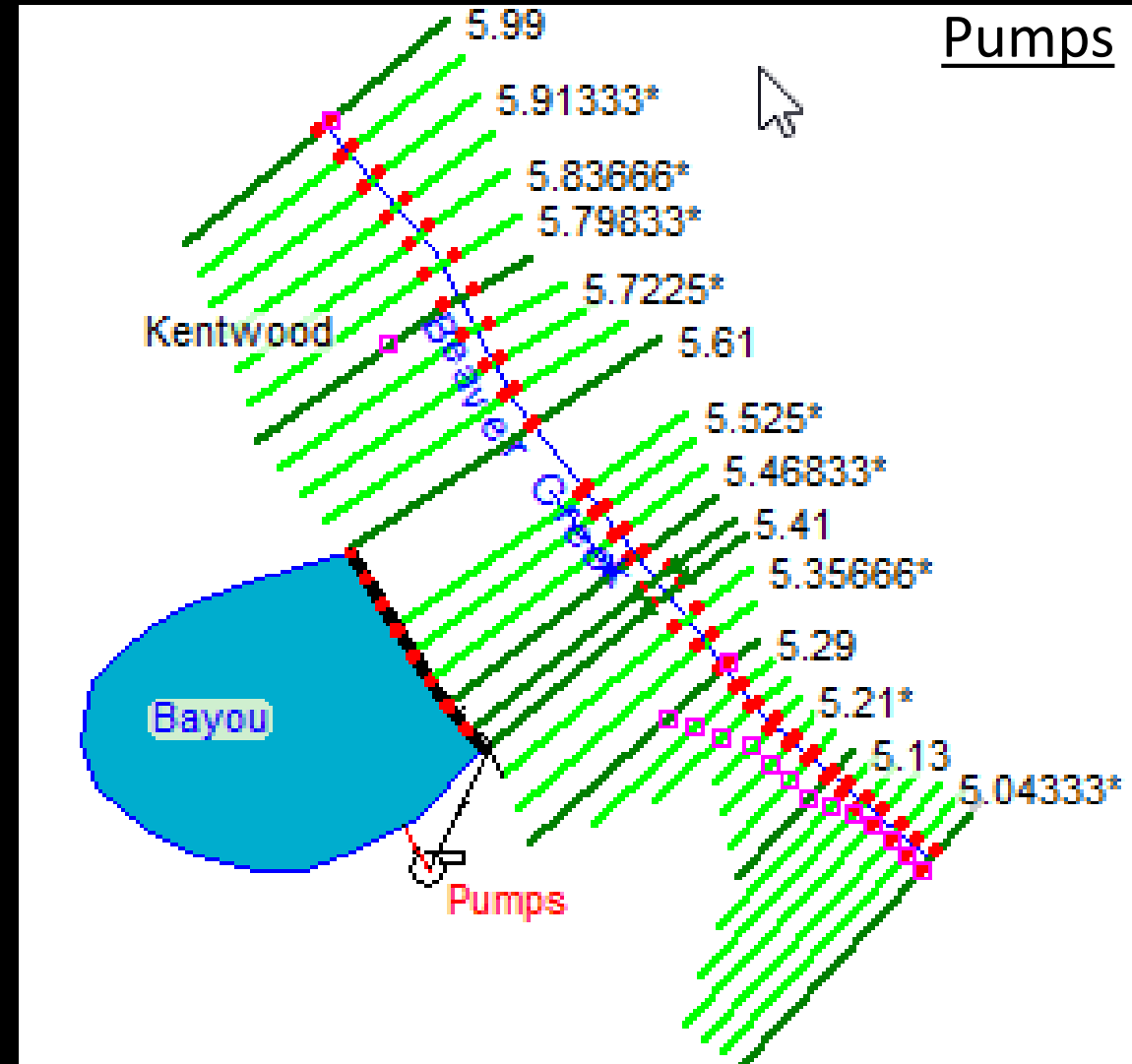
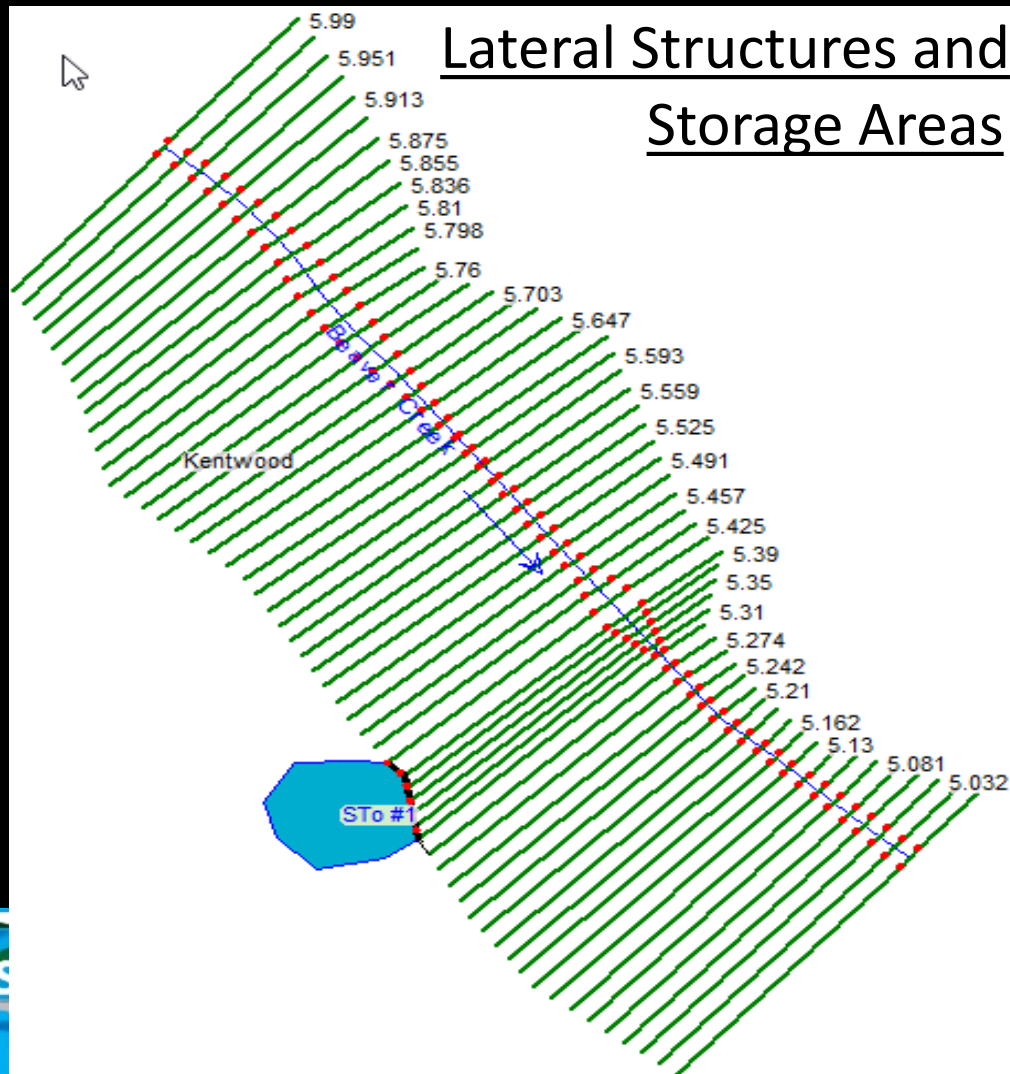
No. Ordinates	Date	Simulation Time (hours)	Gate Opening Height (ft)
1	07Apr 1999 2400	00:00:00	3
2	08Apr 1999 0100	01:00:00	3.23
3	08Apr 1999 0200	02:00:00	3.47
4	08Apr 1999 0300	03:00:00	3.7
5	08Apr 1999 0400	04:00:00	3.93
6	08Apr 1999 0500	05:00:00	4.17
7	08Apr 1999 0600	06:00:00	4.4
8	08Apr 1999 0700	07:00:00	4.63
9	08Apr 1999 0800	08:00:00	4.87
10	08Apr 1999 0900	09:00:00	5.1
11	08Apr 1999 1000	10:00:00	5.33
12	08Apr 1999 1100	11:00:00	5.57

Dams and Reservoirs:

- All – Volume Matters
- Operations $-f(t)$
 - Specified
 - Rules
- Dam Breach

2. How is it different than Steady Flow?

Applications



2. How is it different than Steady Flow?

Applications

Rule Operations

Description: Divert flow out of the system by using a two way table. Note the lateral structure is "abstract" (no weir or gate flow computations are used).

Gate Parameters				
Location	Open Rate (ft/min)	Close Rate (ft/min)	Max Opening	Min O

Summary of Variable Initializations:

User Variable	Description
1	

Rule Operations

row	Operation
1	! Get the Hour of the Day
2	'Hour of Day' = Time:Hour of Day(Beginning of time step)
3	!
4	! Get the average flow at the dam over the last hour;
5	! Average flow over an hour is used to prevent sudden changes.
6	'Flow at Inline Weir' = Inline Structures:Structure.Total Flow(Nittany River,W...
7	!
8	! Based on both the Flow and the Time;
9	! Use a 2-way table to look up the flow to divert.
10	'Flow to Divert' = Table Lookup(Inline Flow, Hour, Interpolate value)
11	!
12	! Set the amount of flow to divert.
13	Structure.Total Flow (Fixed) = 'Flow to Divert'

Enter/Edit Rule Operations... OK Cancel

Operational Rules:

- Dam Operations
- Lateral Gates
- Pumps
- Sediment



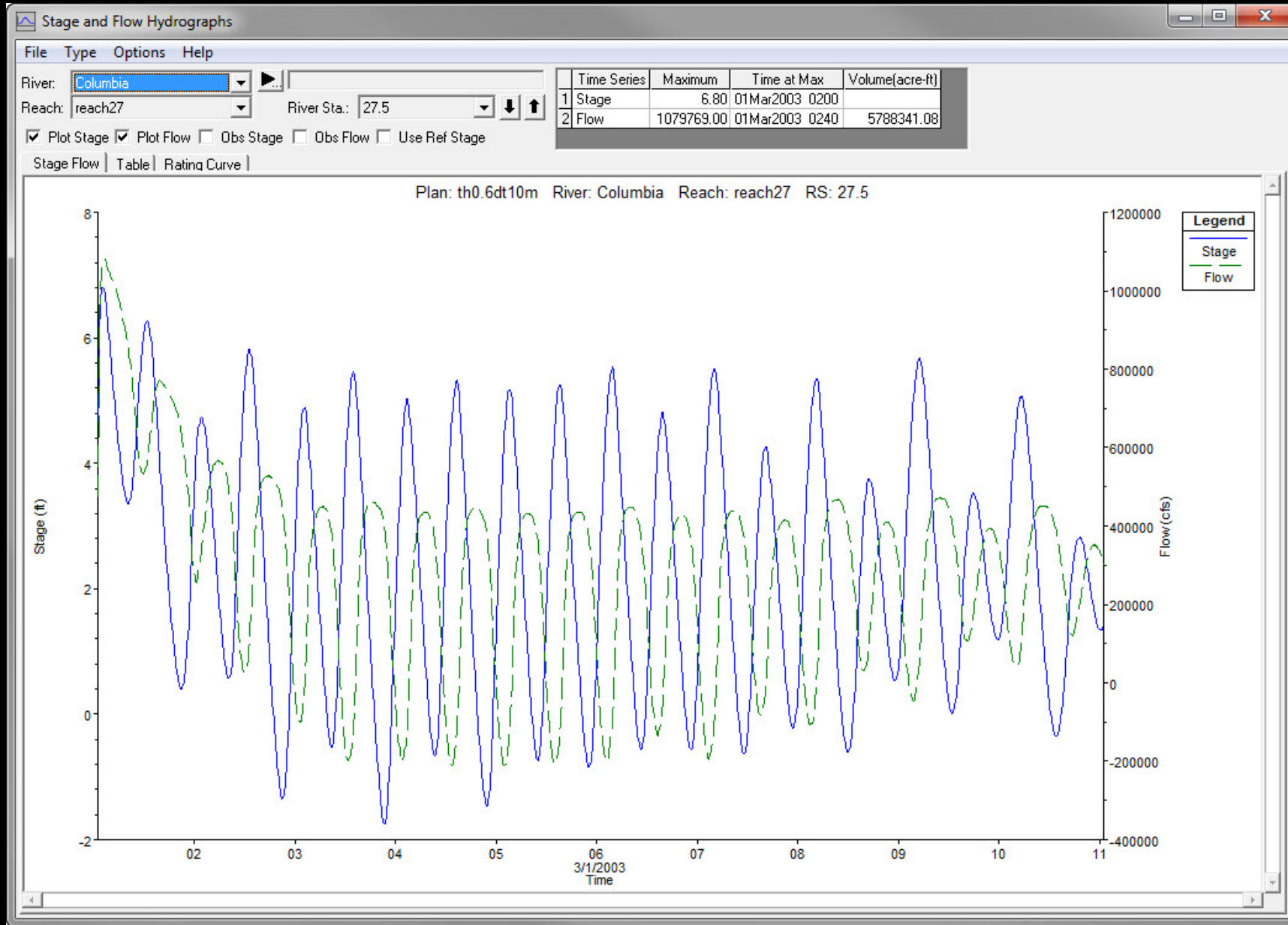
Unsteady Flow Examples

- Navigation Dam
- Lower Columbia River Tidal Flow
- Russian River Dambreak Model
- Allegheny/Ohio River Real Time Forecasting Model
- Operational Rules and Reservoir Flushing





Lower Columbia River Tidal Flow





Russian River Dam Breach Model



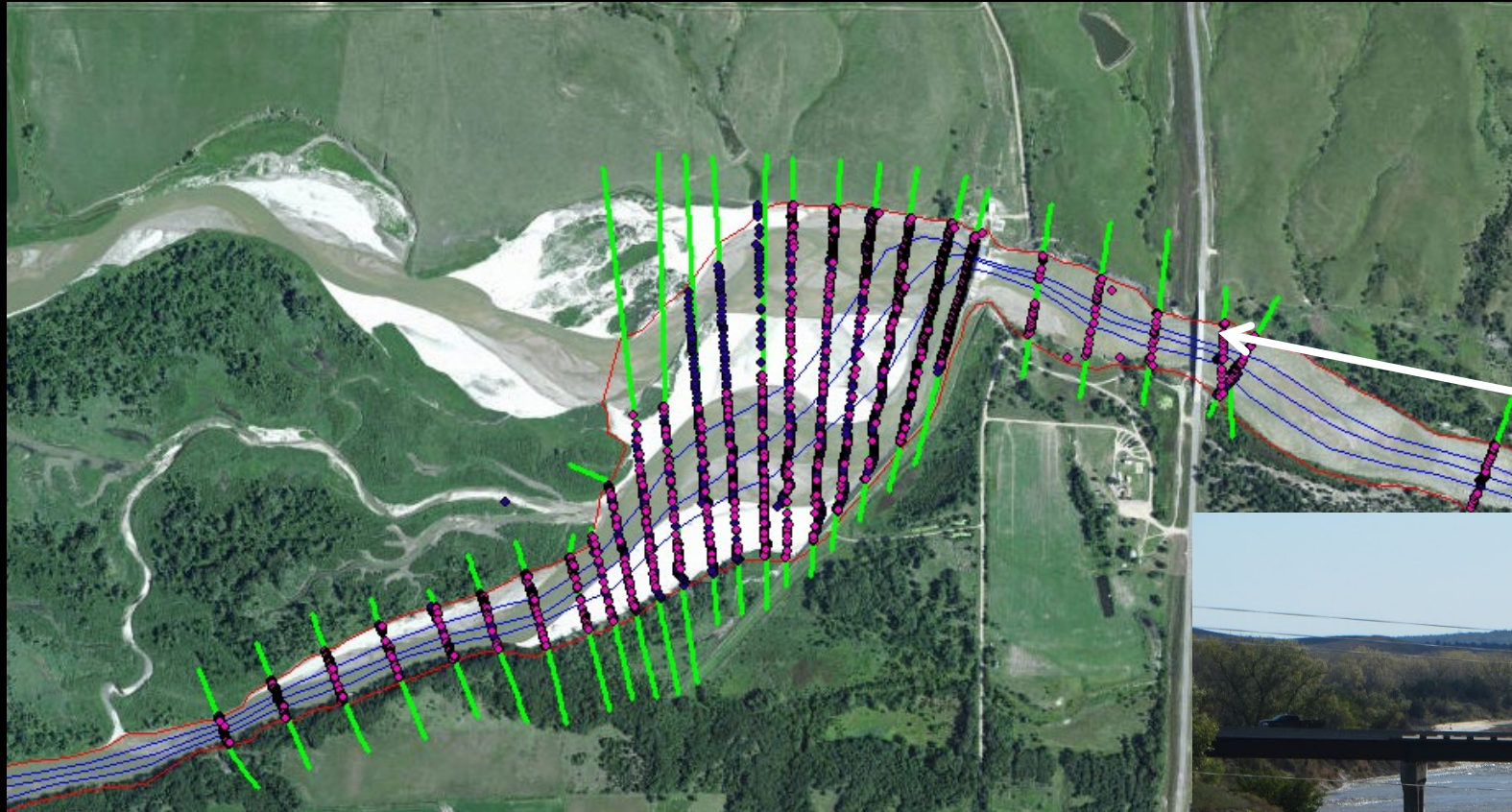


Spencer Dam Reservoir Flushing Model



Reservoir 97% Full of Sediment – Flushed 2X per year

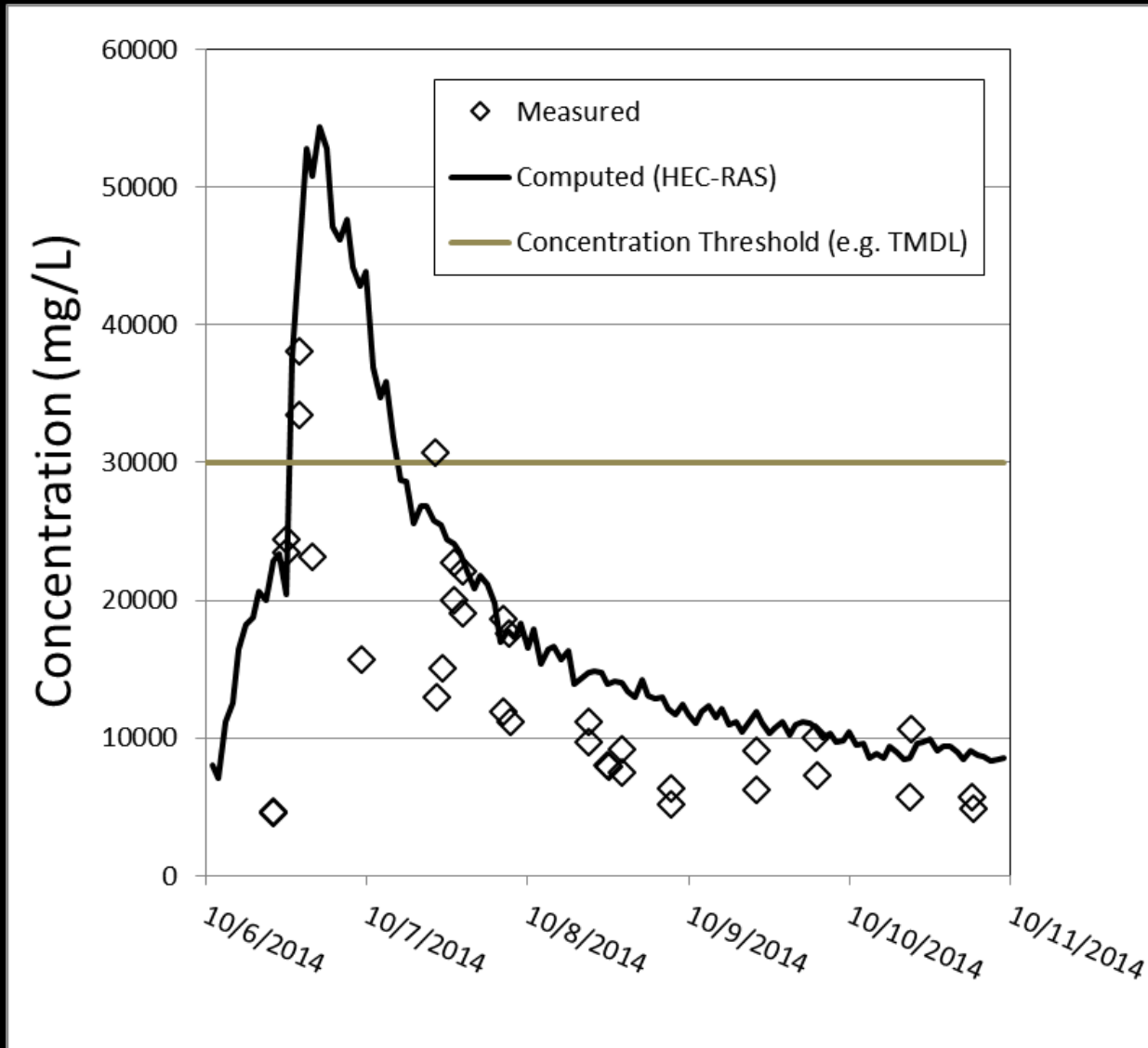




Sampling Bridge



07/10/2014 11:21



Operation Rules

Rule Based Operations Rule Font Size: 10 Bold Font

row	Operation
1	'DS_Conc' = Cross Sections:Sediment Concentration(Niobrara River,Reach 1,179818.5,Val...
2	'SimTime' = Time:Hour of Simulation(Beginning of time step)
3	If ('DS_Conc' > 30000) Then
4	! If Concentration Exceeds "TMDL" Slowly Close Gate
5	Gate.Opening(Sluice Gate) = 0
6	Gate.Opening(TainterGates) = 0
7	! If concentration is less than the "TMDL" then go forward with release schedule
8	Else
9	If ('SimTime' < 14) And ('SimTime' > 7) Then
10	! 0.385 = 5 ft/13hrs which opens the gates at a constant rate over the first 13 hours
11	Gate.Opening(TainterGates) = 0.7 * 'SimTime'-7
12	Elseif ('SimTime' >= 14) Then
13	Gate.Opening(TainterGate3) = 4
14	End If
15	!
16	! Open Flushing Gate after 13 hours of drawdown with the tainter gates
17	If ('SimTime' > 14) Then
18	Gate.Opening(Sluice Gate) = 5

Insert New Operation

Comment New Variable Get Sim Value Set Operational Param Branch (If/Else) Math Table

Get Simulation Value

Assign Result

Existing Variable

New Variable

DS_Conc

Solution

- Cross Sections
 - WS Elevation
 - Flow
 - WS Change
 - Flow Change
 - WS Error
 - Flow Error
 - Bed Change**
 - Sediment Concentration**
- Inline Structures

Set Node Location

River: Niobrara River

Reach: Reach 1

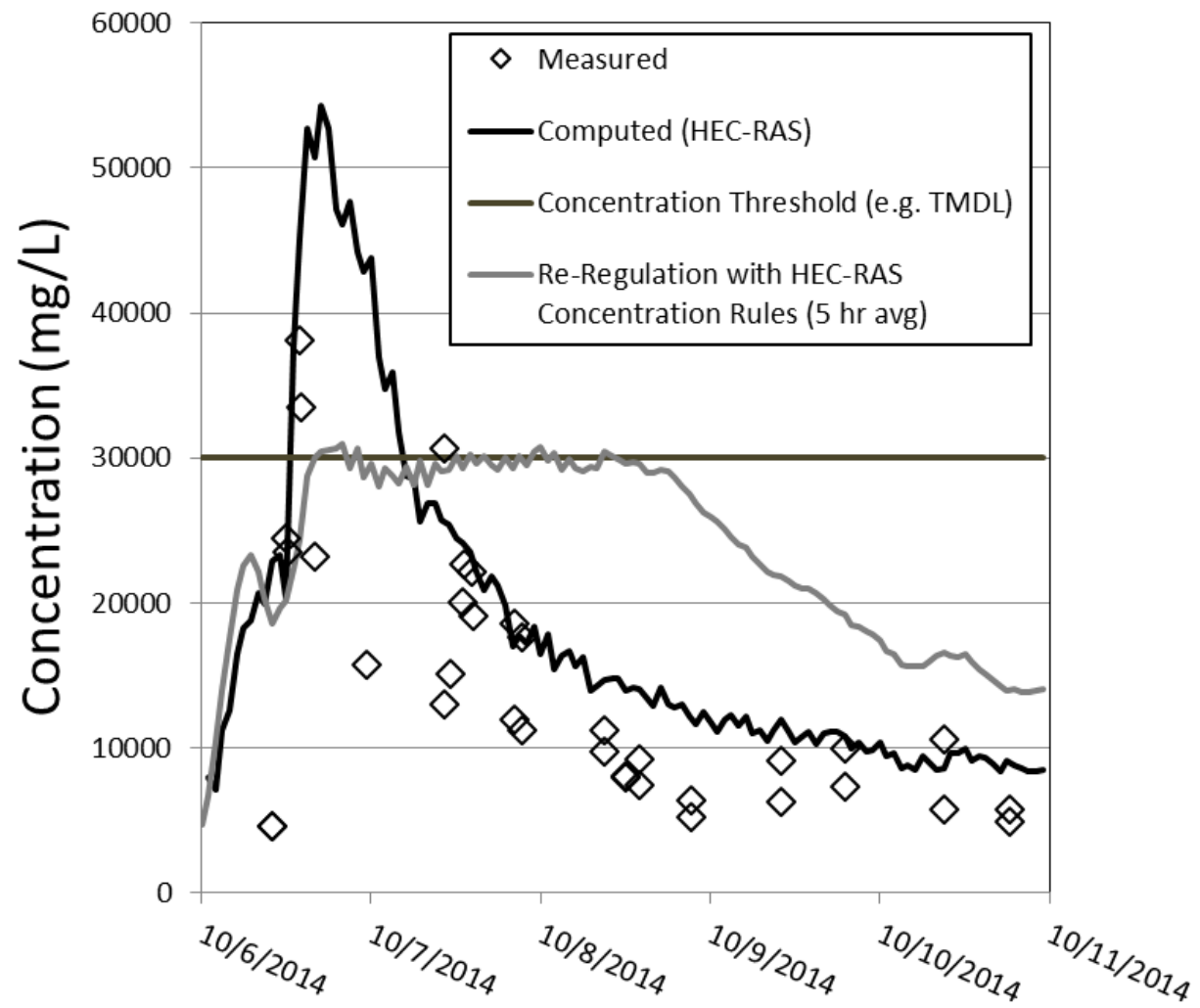
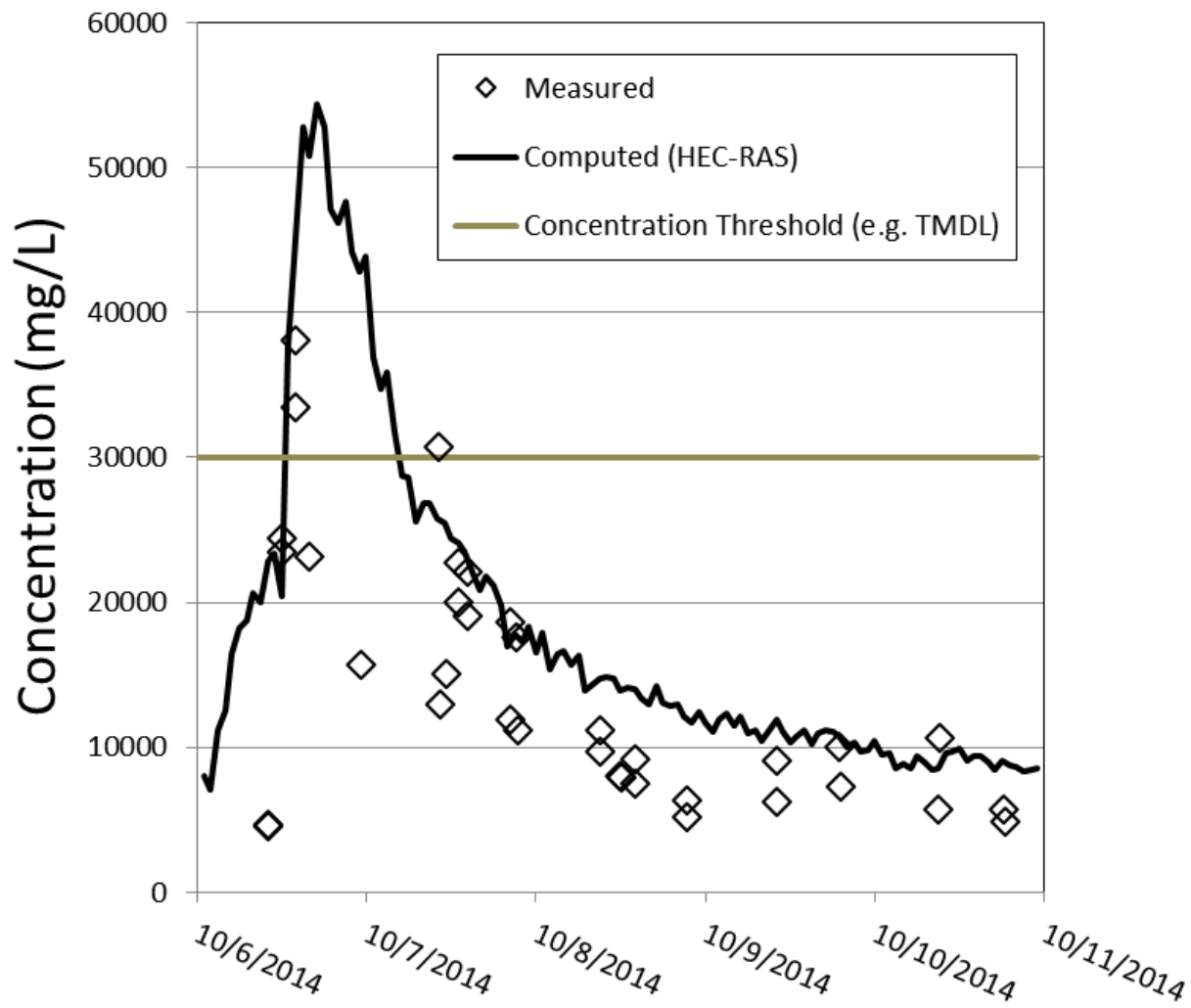
RS: 179818.5

(Simulation variables in bold are only a

Check Rule Set ... OK Cancel

Gibson, S. and Boyd, P. (2016) "Designing Reservoir Sediment Management Alternatives with Automated Concentration Constraints in a 1D Sediment Model," River Sedimentation: Proceedings of the 13th International Symposium on River Sedimentation, ed edited by S. Wieprecht, *et al.*

Gibson, S. and Boyd, P. (2016) "Monitoring, Measuring, and Modeling a Reservoir Flush on the Niobrara River in the Sandhills of Nebraska," Proceedings, River Flow 2016, ed Constantinescu *et al.*, 1448-1455.



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