Modeling Bridges and Culverts

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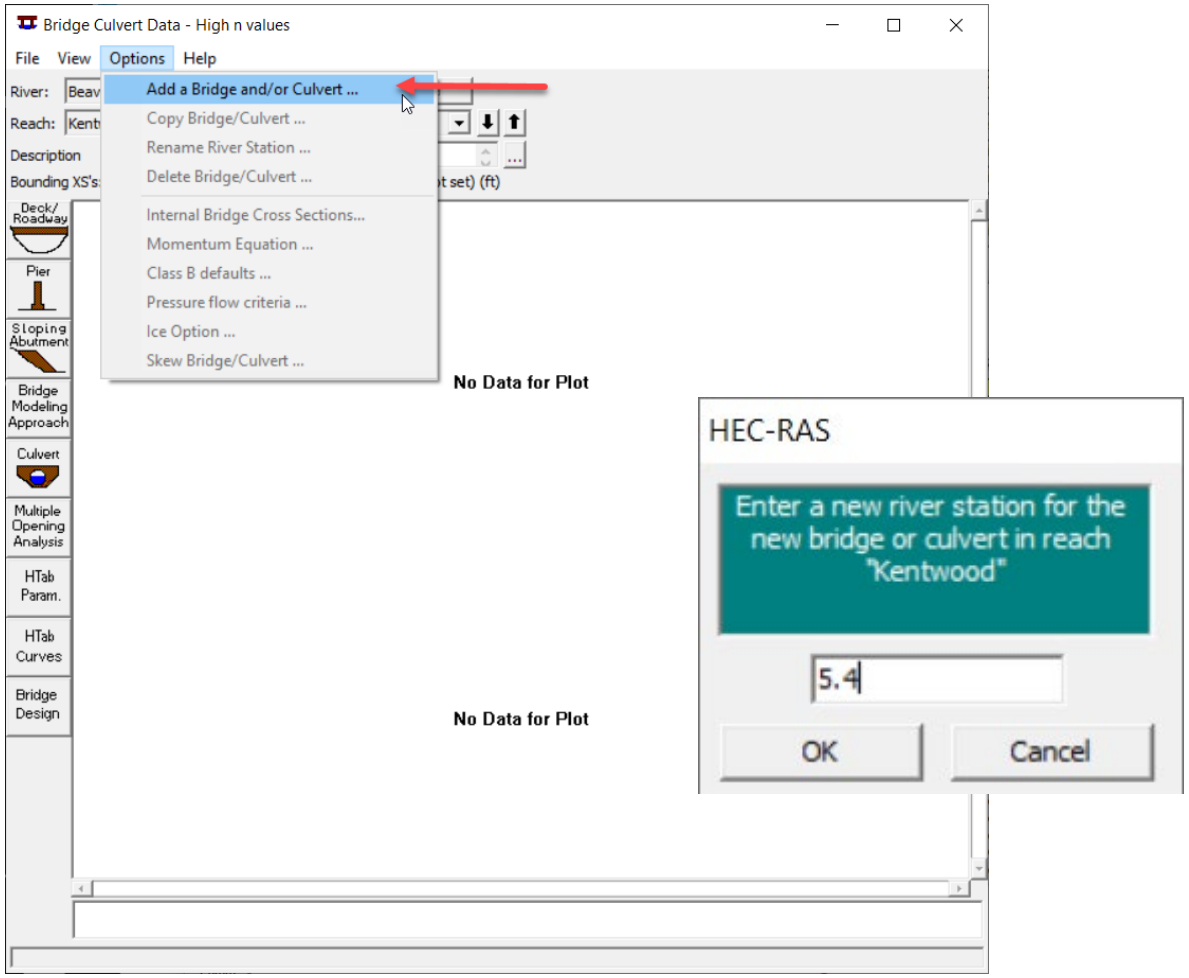
Objectives

- How to Add a Bridge
- Understanding Flow through a Bridge
- Enter Parameters for Bridge Modeling
- Evaluate Bridge Results

Adding a Bridge or Culvert

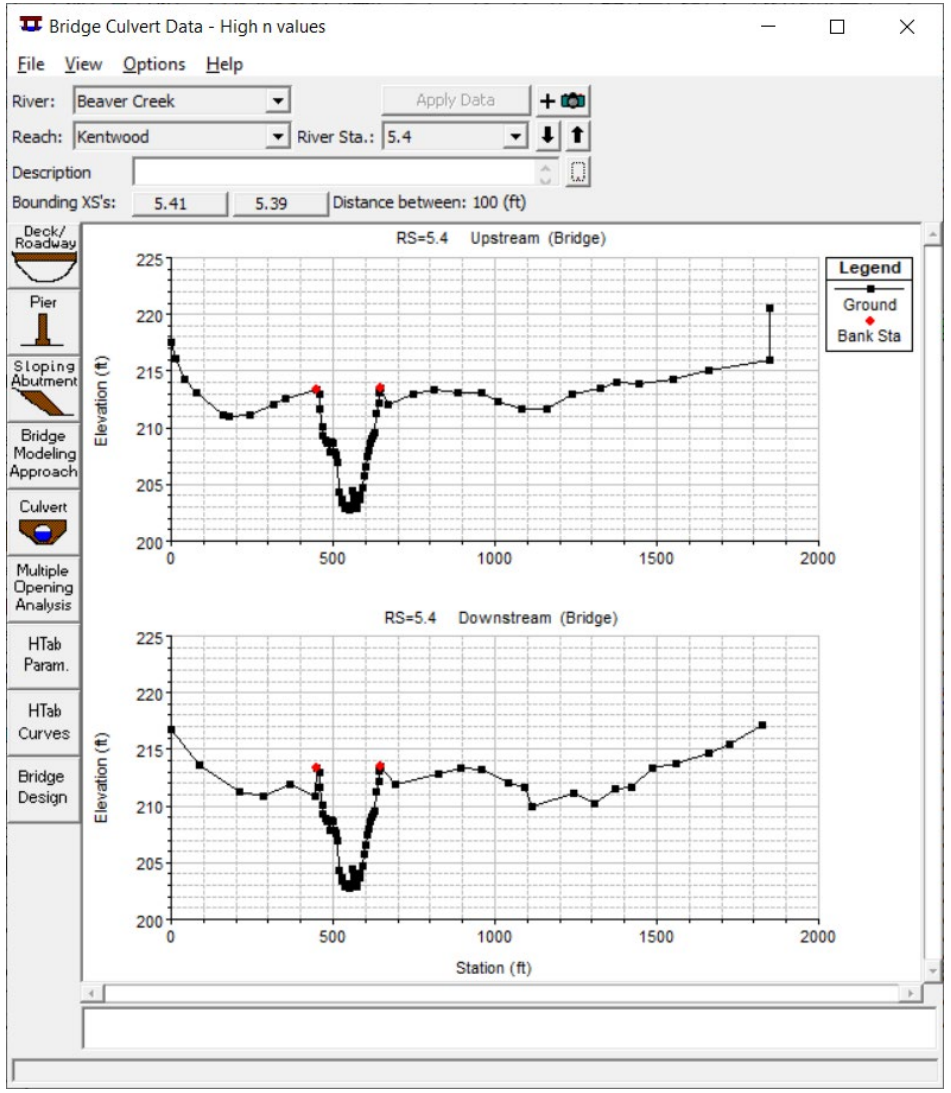
- Select River - Reach
- Option - Add a Culvert
- Enter River Station
- OK



Bridge - Culvert Data Window

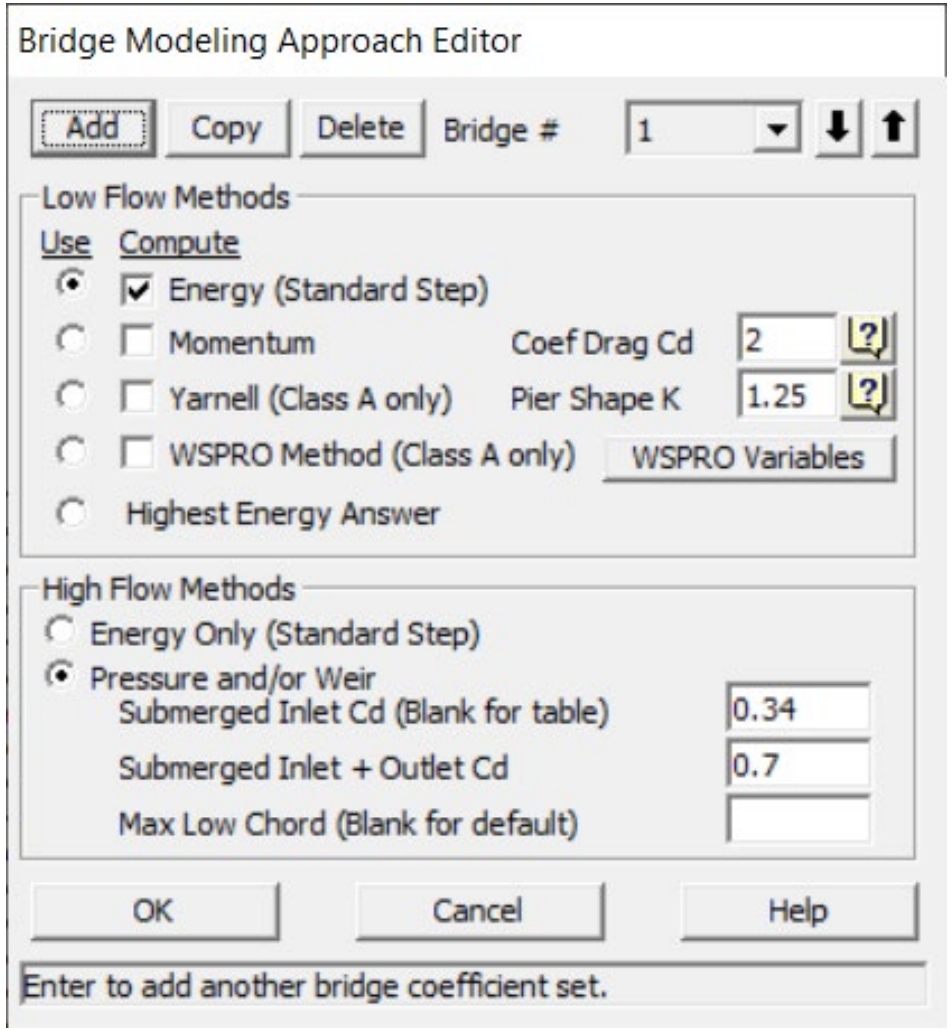
Bridge Application

- Deck/Roadway
  - Top of Road
  - Approach Fill area
  - Bridge Low chord
- Pier Data
- Sloping Abutments
- Bridge Modeling Approach

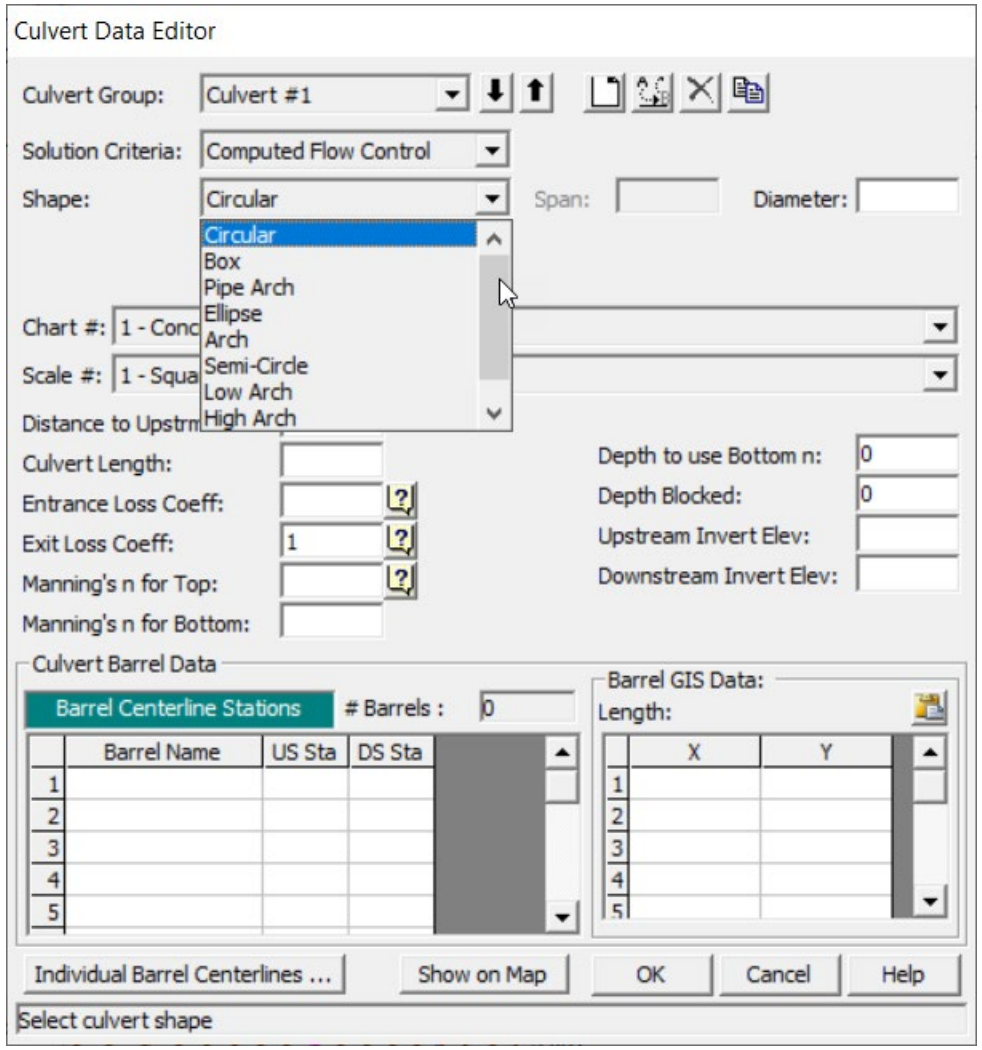


Bridge Modeling Approach

- Low Flow Methods
  - Energy
  - Momentum
  - Yarnell
  - WSPRO
- Use or Compute
- Highest Energy option
- High Flow Methods
  - Energy Only
  - Pressure & Weir

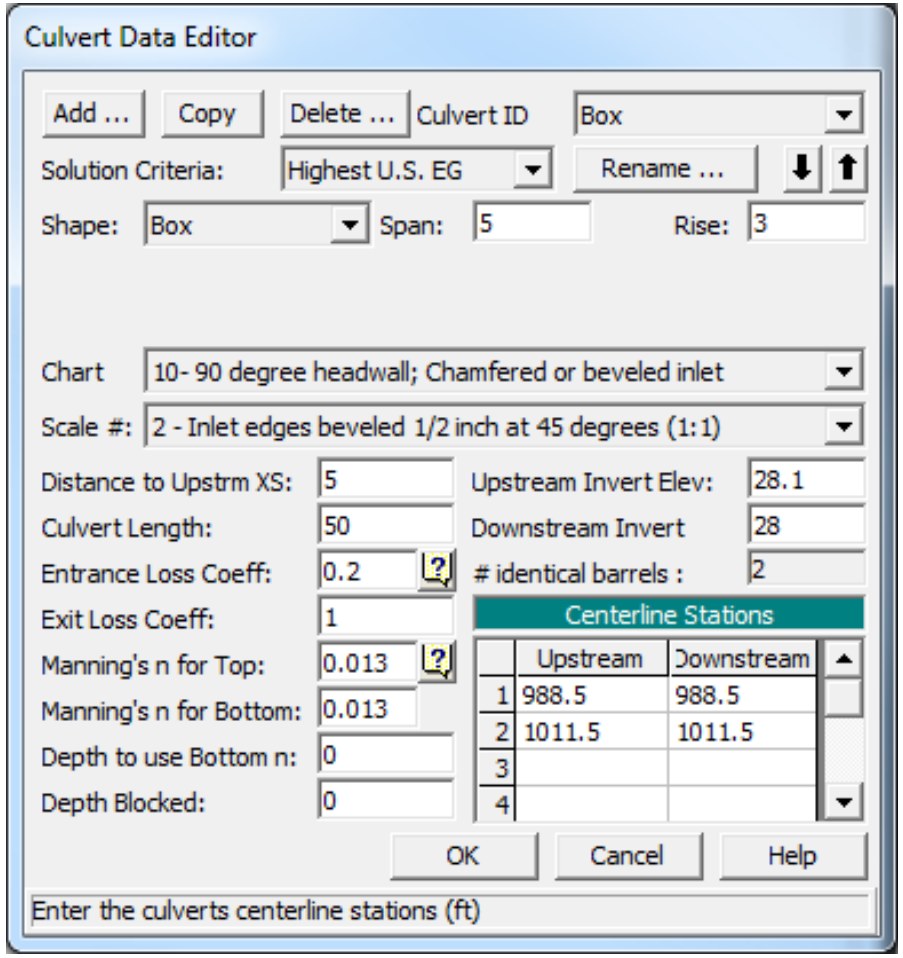


Culvert Data



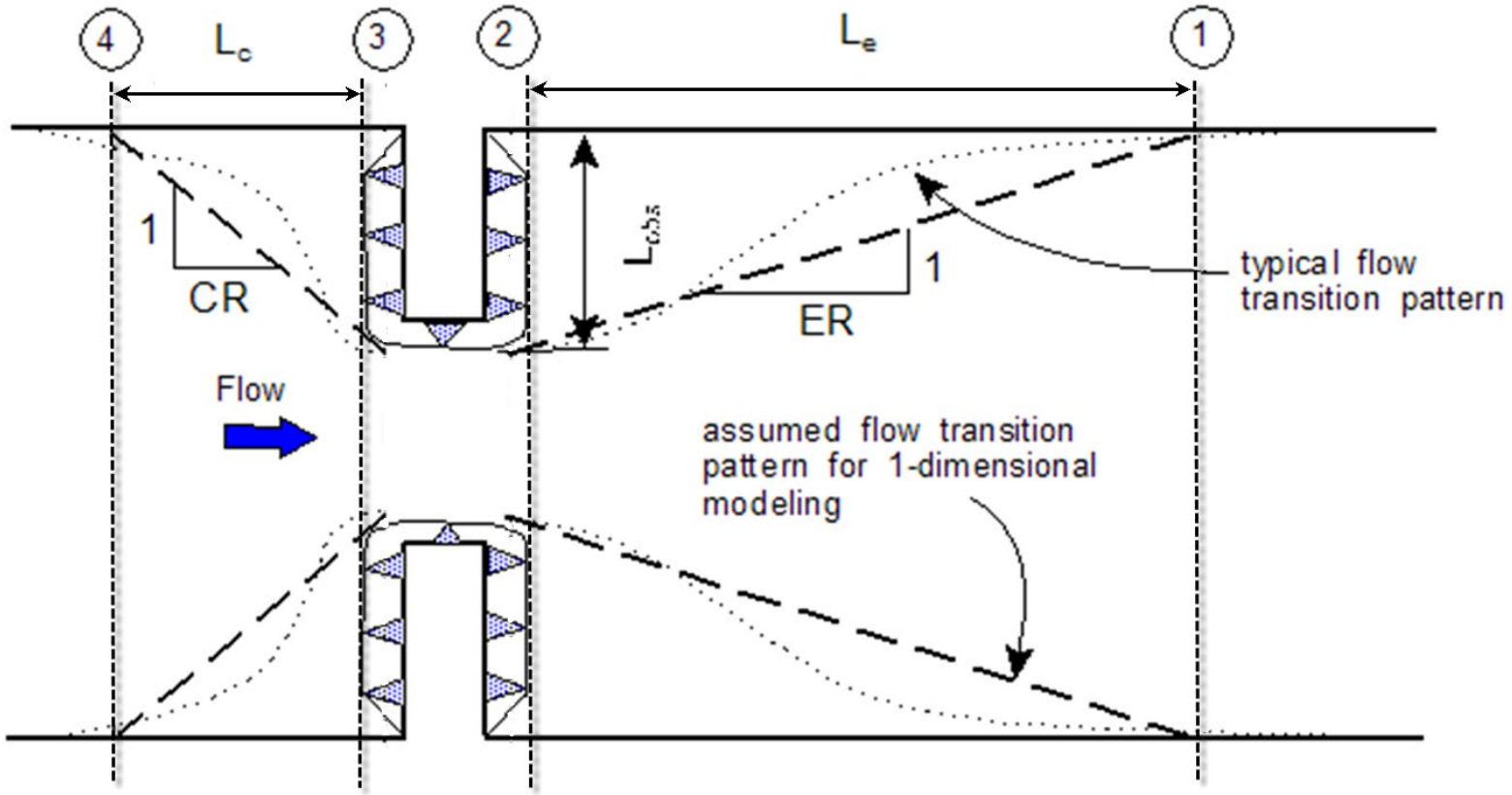
- Culvert #1 (can Rename)
- Shape - 9 available
- Size reflects shape
- Chart - culvert type
- Scale - entrance type
- Distance to upstream section
- Culvert Length

Culvert Data - continued



- Entrance Loss
- Exit Loss
- Manning n culvert
- Manning n Bottom
- Depth for bottom n
- Depth Blocked
- Invert Elevations
- Centerline Stations
- OK

Flow Transitions



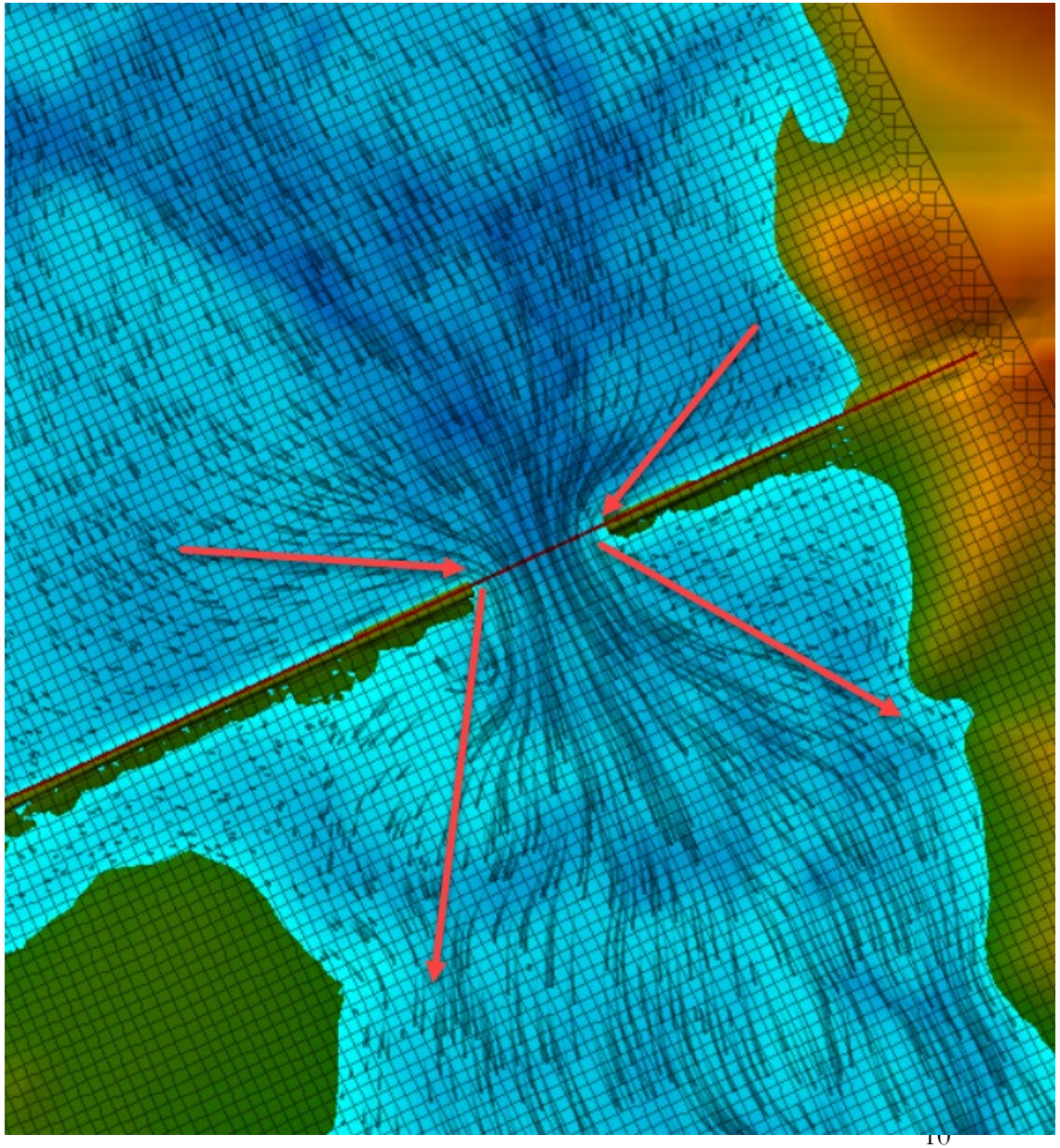
See Appendix B "Flow Transitions in Bridge Backwater Analysis" in *Hydraulics Reference*, a summary from HEC RD #42, September 1995.

Ineffective Area Option

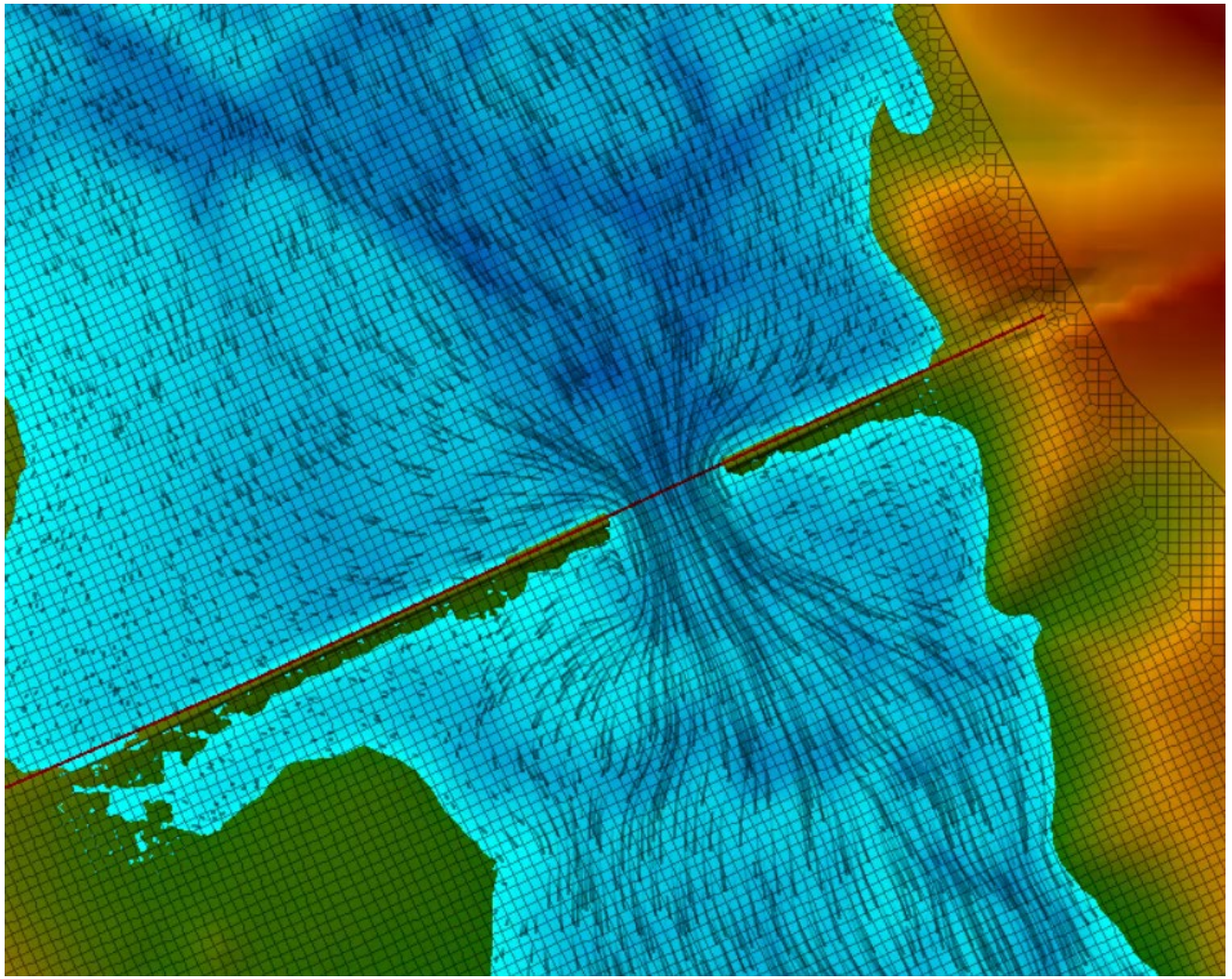
- Bounding sections provide full conveyance.
- When all flow is under bridge, overbanks cannot convey flow through highway fill.
- Ineffective area option indicates overbank storage instead of conveyance.
- Station should be near abutments.
- Elevation is set to define when overbanks become effective - when water flows over the roadway.

Ineffective-Flow at Bounding Cross Sections

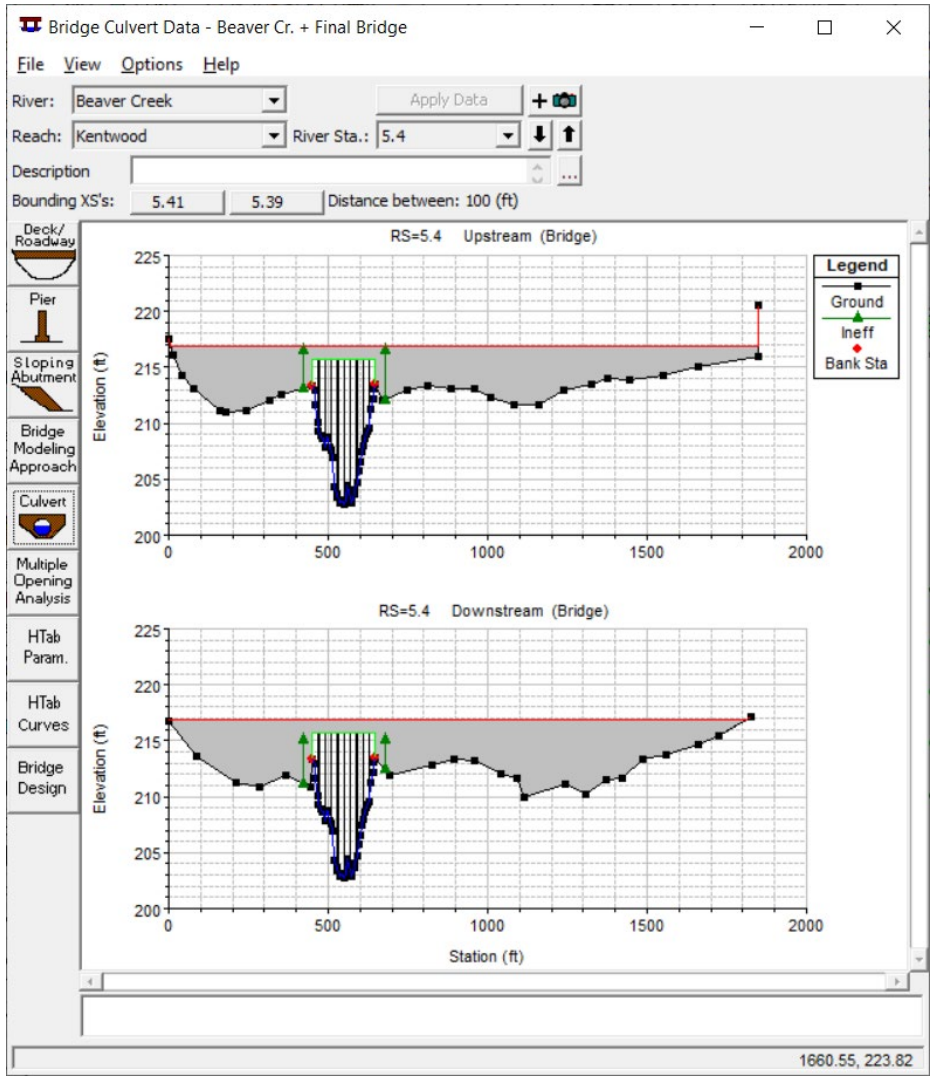
- **Contraction/Expansion** coefficients ***do not*** apply to unsteady flow solution for contraction/expansion reaches

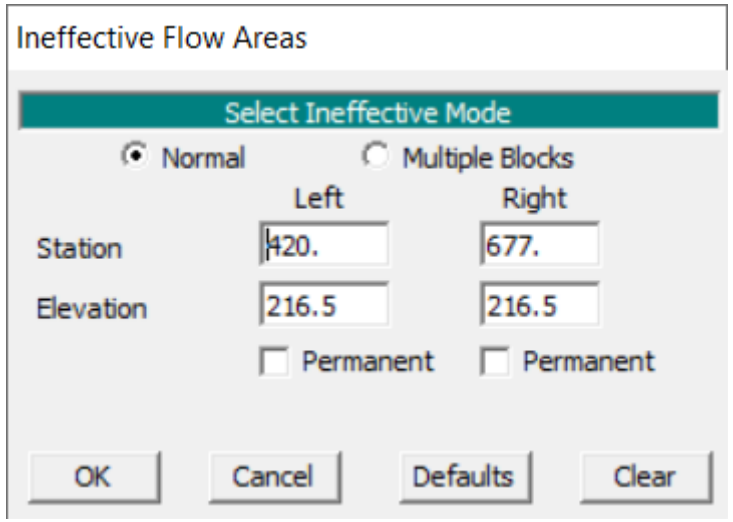


Ineffective-Flow at Bounding Cross Sections



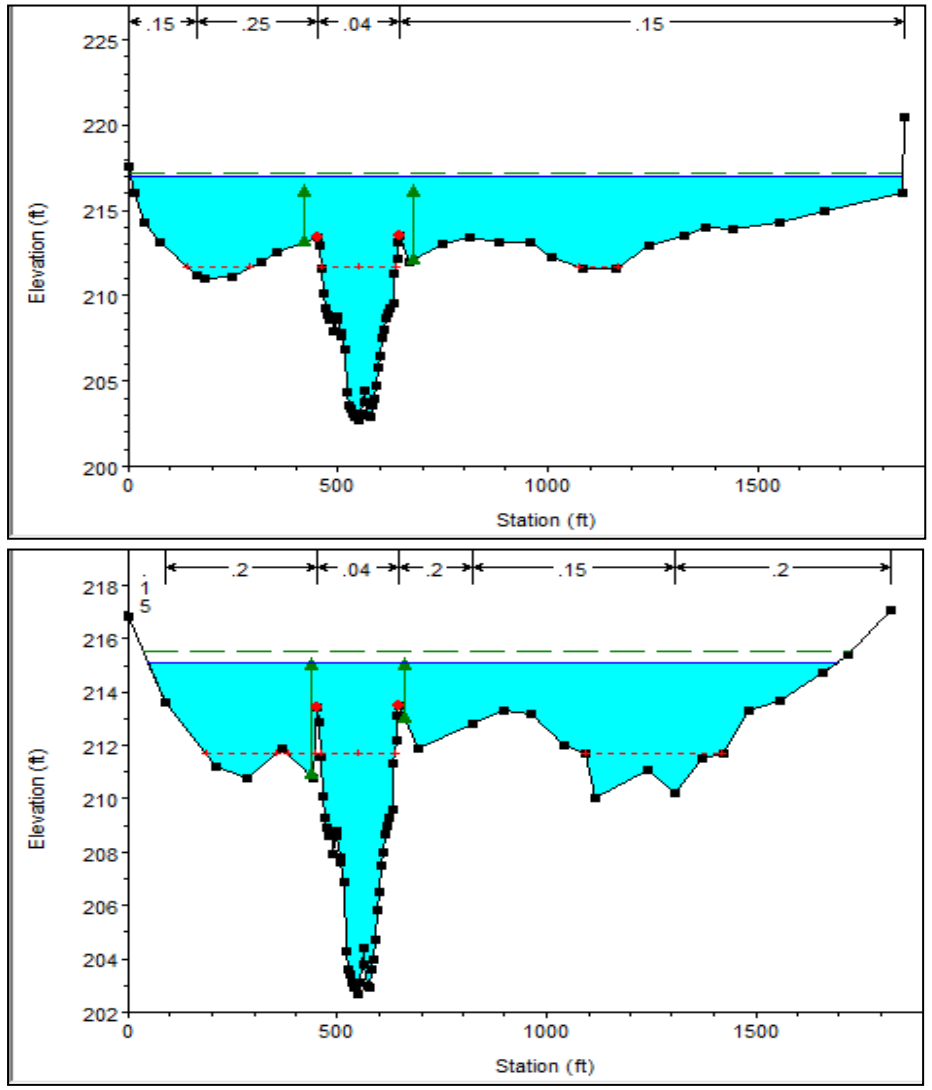
Ineffective Area Option





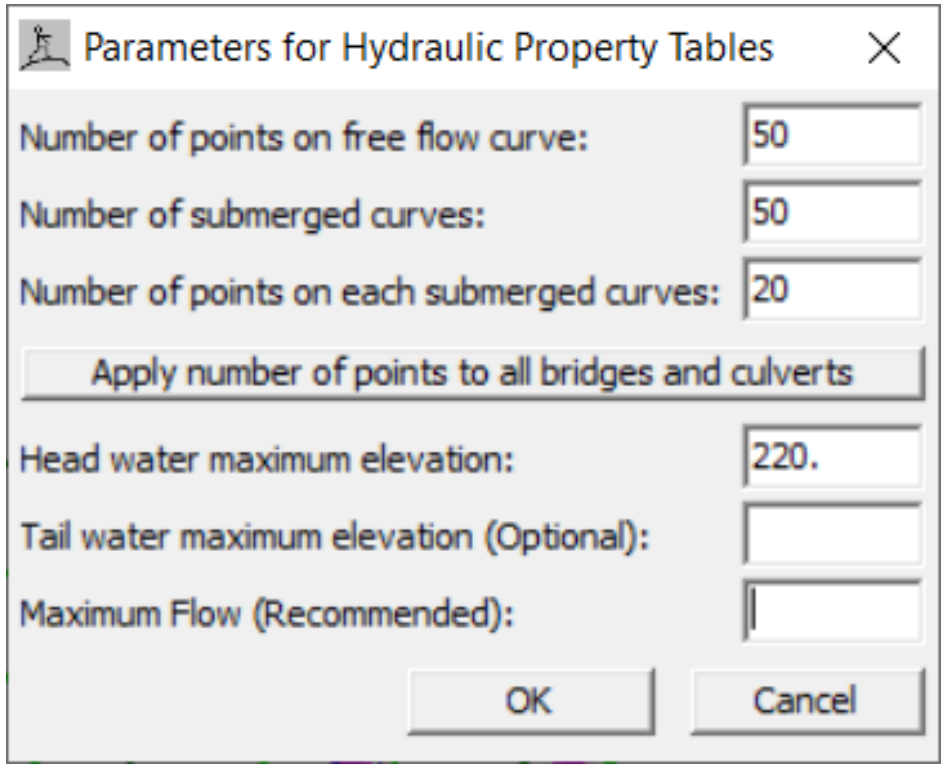
- Normal
- Multiple Blocks
- Permanent

Hydraulic Parameters



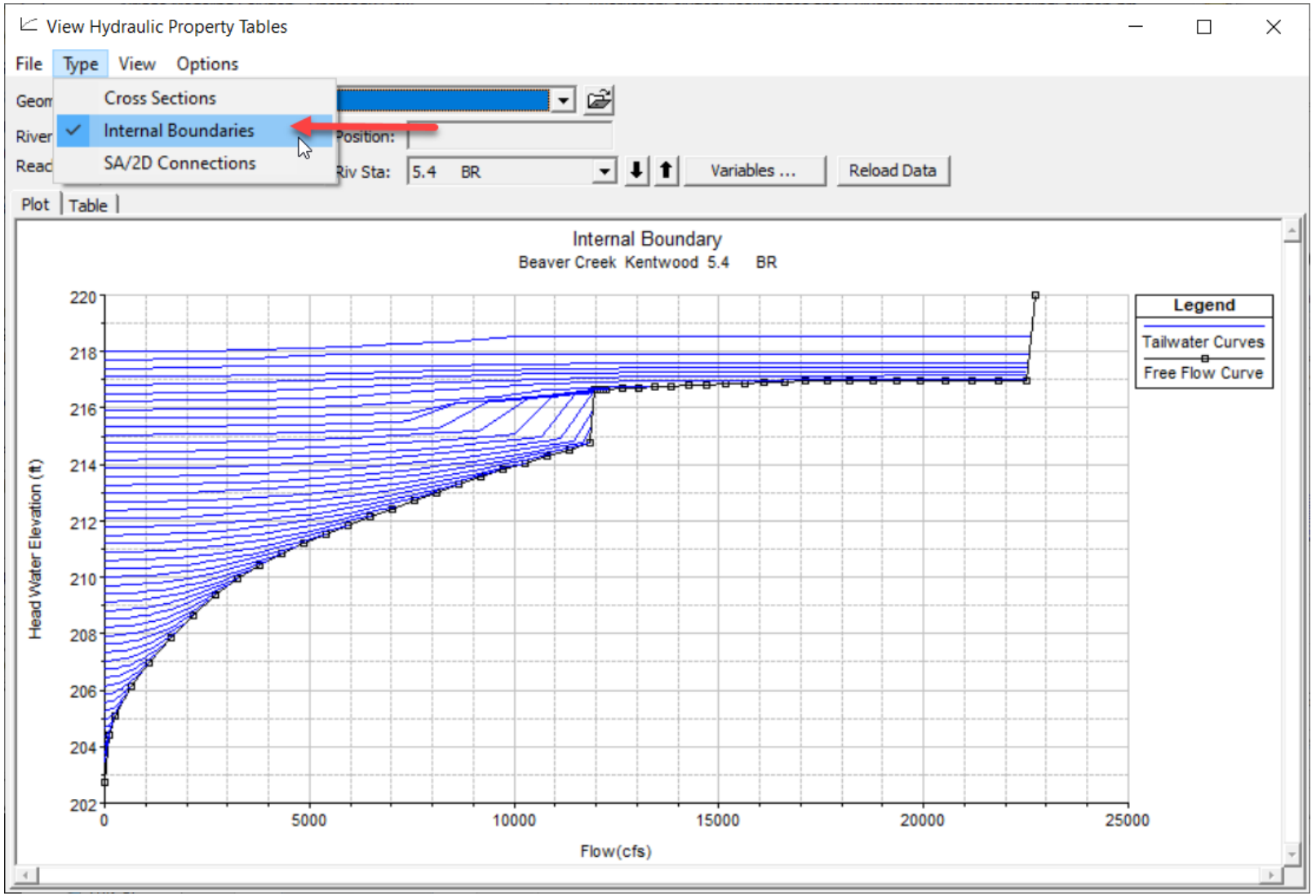
- Fix Bridge Solution first
  - Use steady flow analysis
  - Run range of flow profiles
  - Set bridge solution options
- HTab Param button provides data window
- Data entered for each bridge and culvert

Hydraulic Property Tables

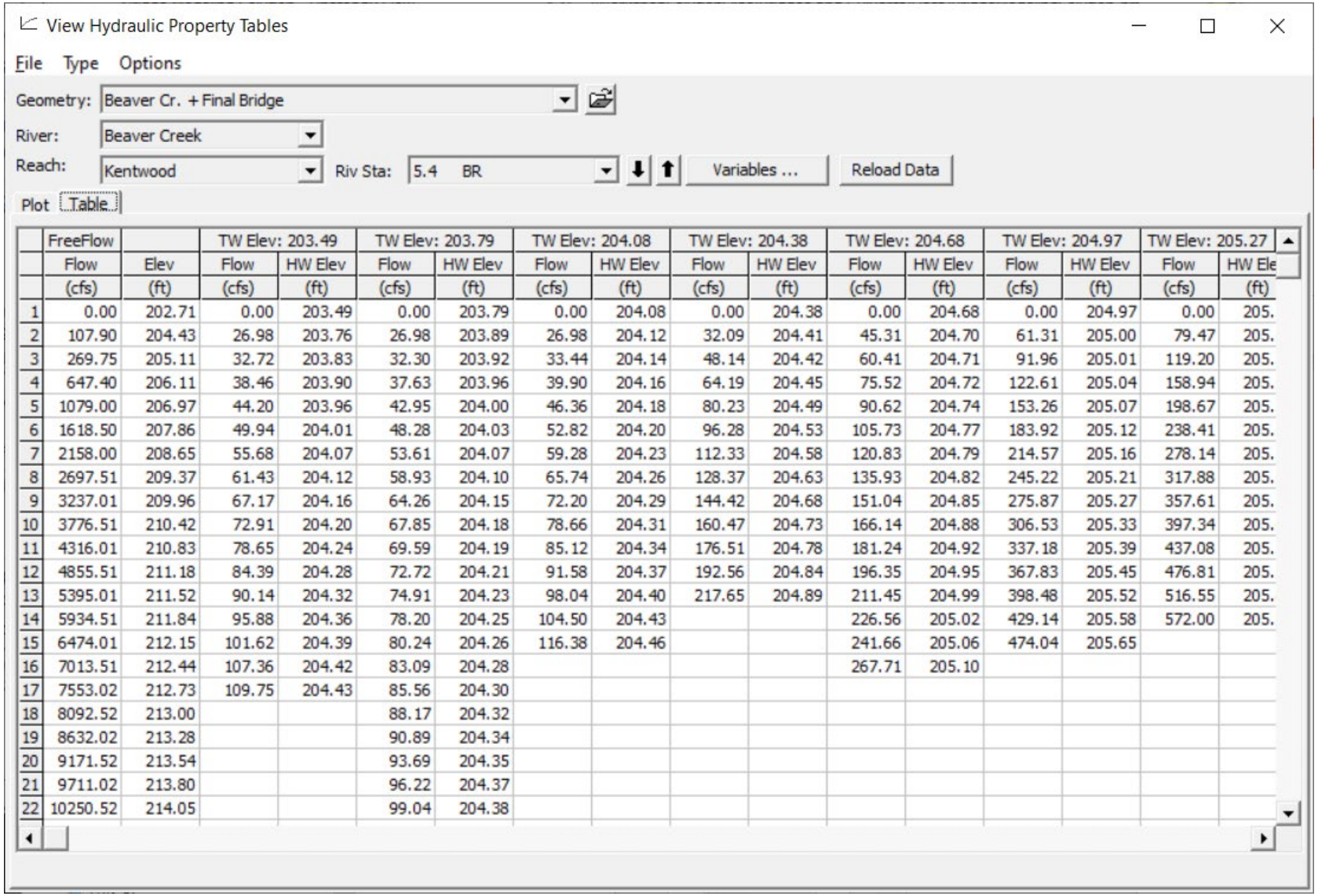


- Default setting shown
  - Max curves = 50
  - Max points = 20
- Apply to all?
- Max headwater elevation
- Optional
  - Max tailwater elevation
  - Max flow

Hydraulic Properties Plot

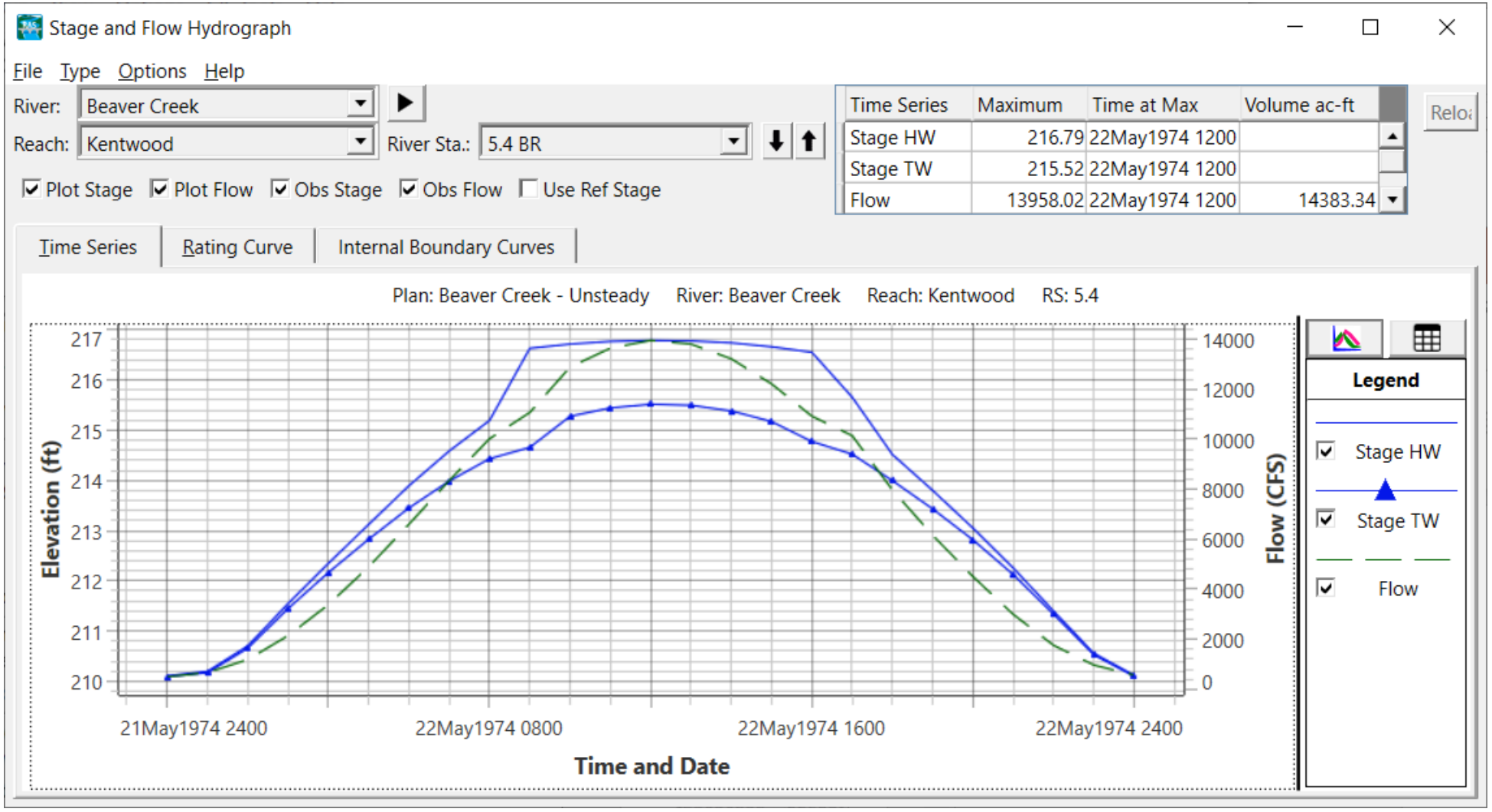


Hydraulic Properties Table

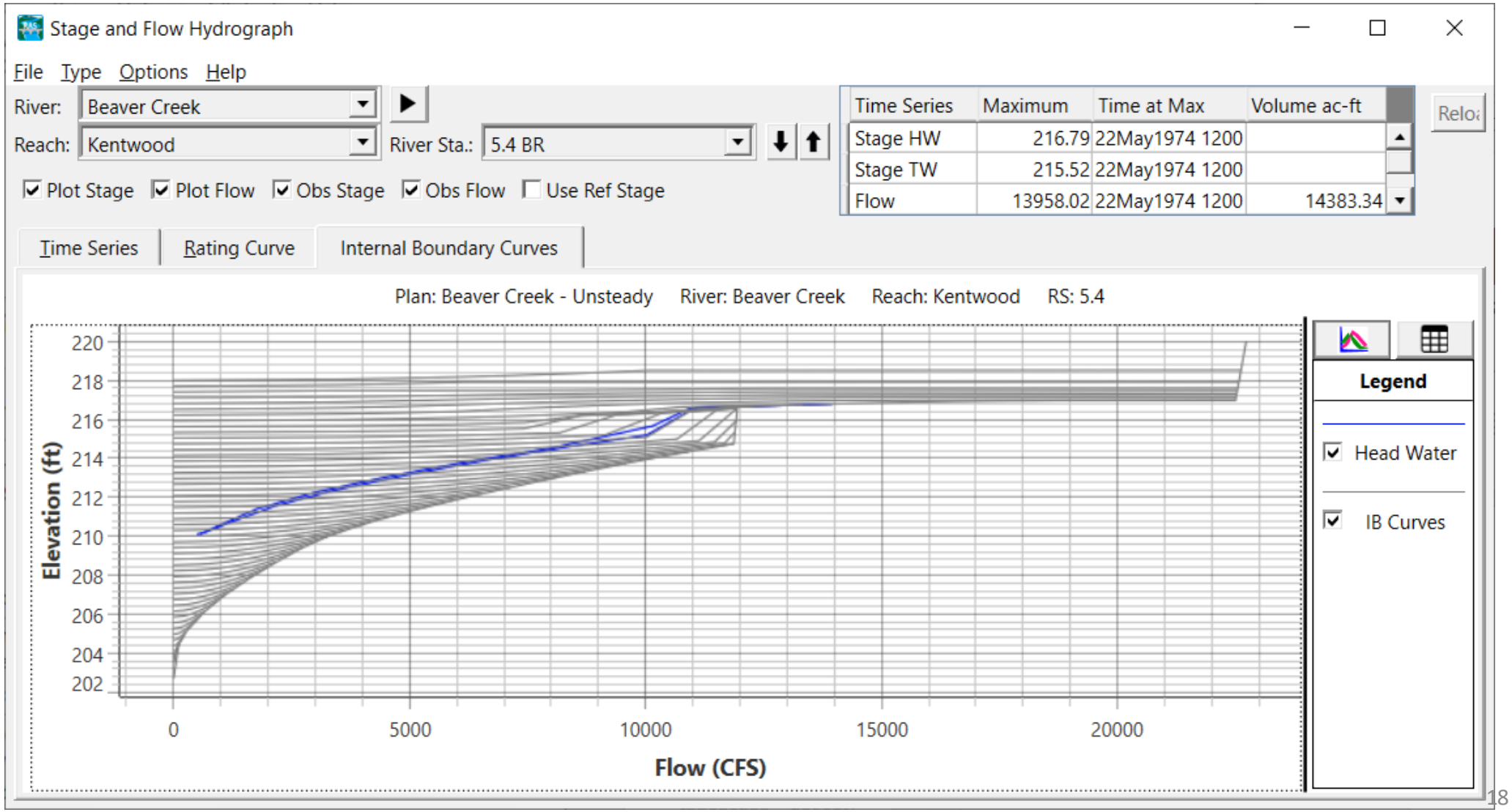


	FreeFlow		TW Elev: 203.49		TW Elev: 203.79		TW Elev: 204.08		TW Elev: 204.38		TW Elev: 204.68		TW Elev: 204.97		TW Elev: 205.27	
	Flow	Elev	Flow	HW Elev	Flow	HW Elev	Flow	HW Elev	Flow	HW Elev	Flow	HW Elev	Flow	HW Elev	Flow	HW Ele
	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)	(cfs)	(ft)
1	0.00	202.71	0.00	203.49	0.00	203.79	0.00	204.08	0.00	204.38	0.00	204.68	0.00	204.97	0.00	205.
2	107.90	204.43	26.98	203.76	26.98	203.89	26.98	204.12	32.09	204.41	45.31	204.70	61.31	205.00	79.47	205.
3	269.75	205.11	32.72	203.83	32.30	203.92	33.44	204.14	48.14	204.42	60.41	204.71	91.96	205.01	119.20	205.
4	647.40	206.11	38.46	203.90	37.63	203.96	39.90	204.16	64.19	204.45	75.52	204.72	122.61	205.04	158.94	205.
5	1079.00	206.97	44.20	203.96	42.95	204.00	46.36	204.18	80.23	204.49	90.62	204.74	153.26	205.07	198.67	205.
6	1618.50	207.86	49.94	204.01	48.28	204.03	52.82	204.20	96.28	204.53	105.73	204.77	183.92	205.12	238.41	205.
7	2158.00	208.65	55.68	204.07	53.61	204.07	59.28	204.23	112.33	204.58	120.83	204.79	214.57	205.16	278.14	205.
8	2697.51	209.37	61.43	204.12	58.93	204.10	65.74	204.26	128.37	204.63	135.93	204.82	245.22	205.21	317.88	205.
9	3237.01	209.96	67.17	204.16	64.26	204.15	72.20	204.29	144.42	204.68	151.04	204.85	275.87	205.27	357.61	205.
10	3776.51	210.42	72.91	204.20	67.85	204.18	78.66	204.31	160.47	204.73	166.14	204.88	306.53	205.33	397.34	205.
11	4316.01	210.83	78.65	204.24	69.59	204.19	85.12	204.34	176.51	204.78	181.24	204.92	337.18	205.39	437.08	205.
12	4855.51	211.18	84.39	204.28	72.72	204.21	91.58	204.37	192.56	204.84	196.35	204.95	367.83	205.45	476.81	205.
13	5395.01	211.52	90.14	204.32	74.91	204.23	98.04	204.40	217.65	204.89	211.45	204.99	398.48	205.52	516.55	205.
14	5934.51	211.84	95.88	204.36	78.20	204.25	104.50	204.43			226.56	205.02	429.14	205.58	572.00	205.
15	6474.01	212.15	101.62	204.39	80.24	204.26	116.38	204.46			241.66	205.06	474.04	205.65		
16	7013.51	212.44	107.36	204.42	83.09	204.28					267.71	205.10				
17	7553.02	212.73	109.75	204.43	85.56	204.30										
18	8092.52	213.00			88.17	204.32										
19	8632.02	213.28			90.89	204.34										
20	9171.52	213.54			93.69	204.35										
21	9711.02	213.80			96.22	204.37										
22	10250.52	214.05			99.04	204.38										

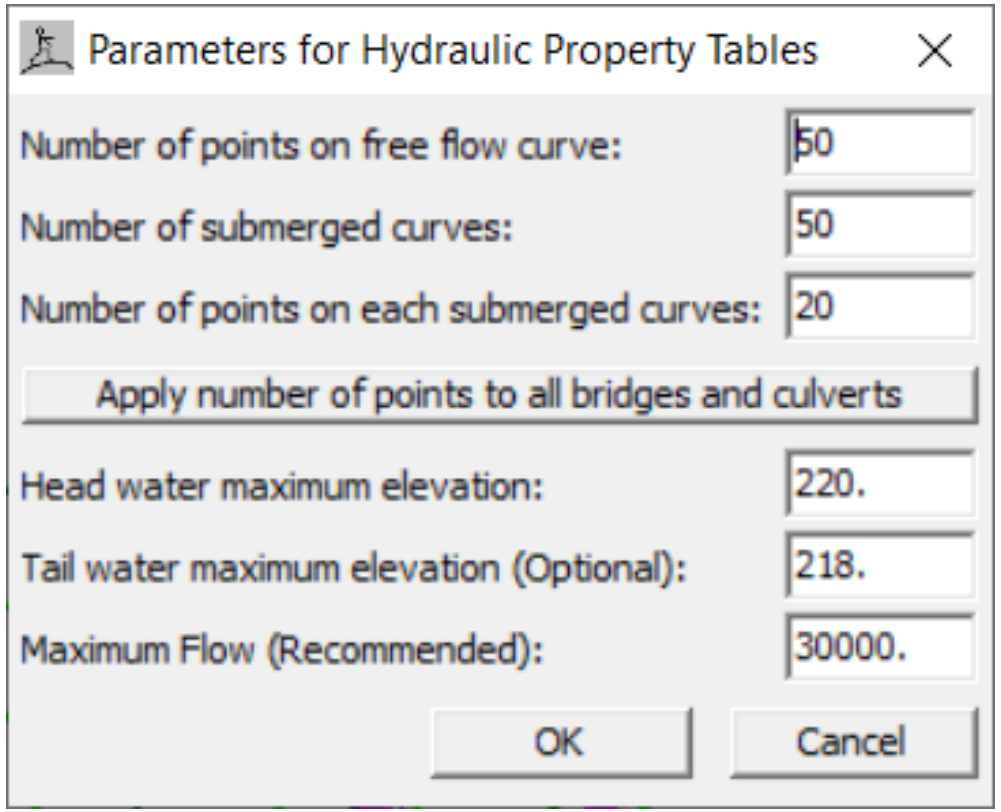
Stage & Flow Hydrograph



Internal Boundary Rating Curve

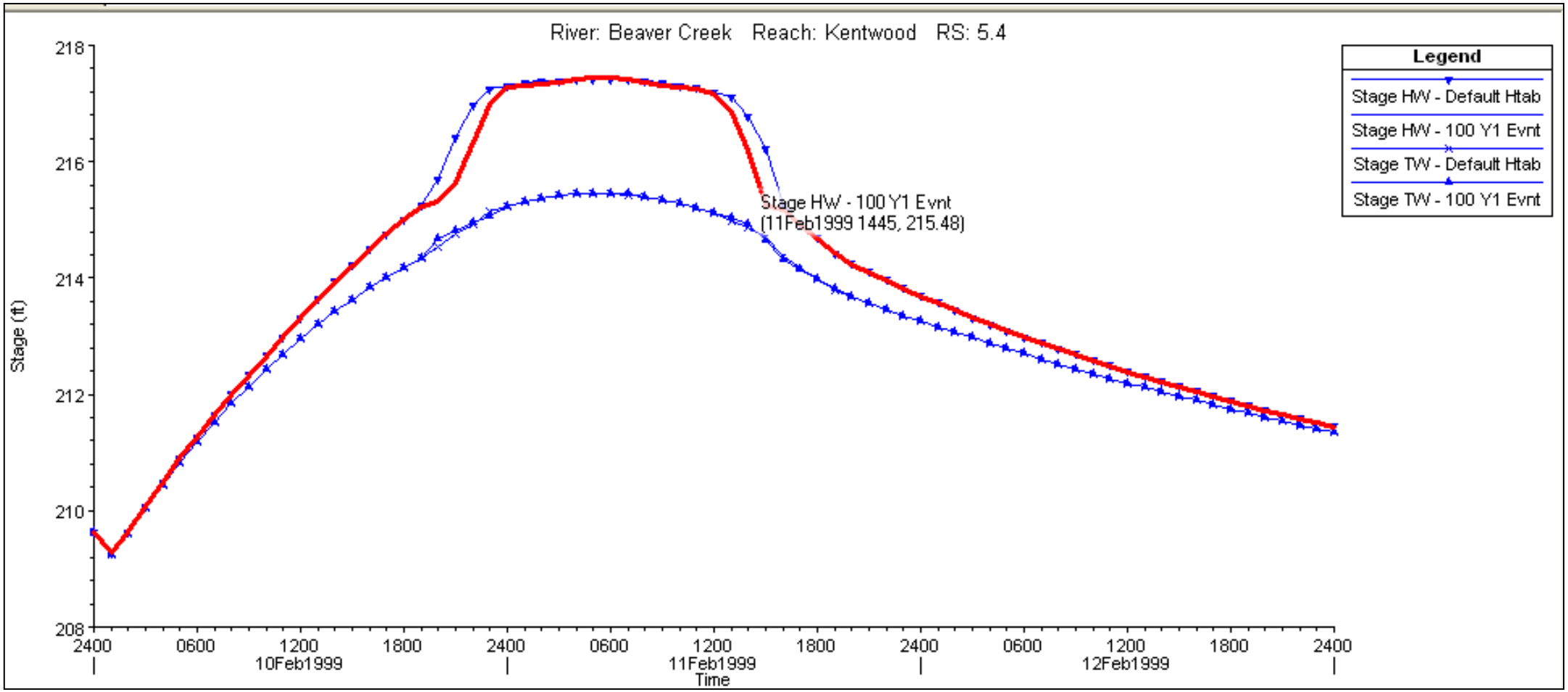


HTAB - Set Optional Settings

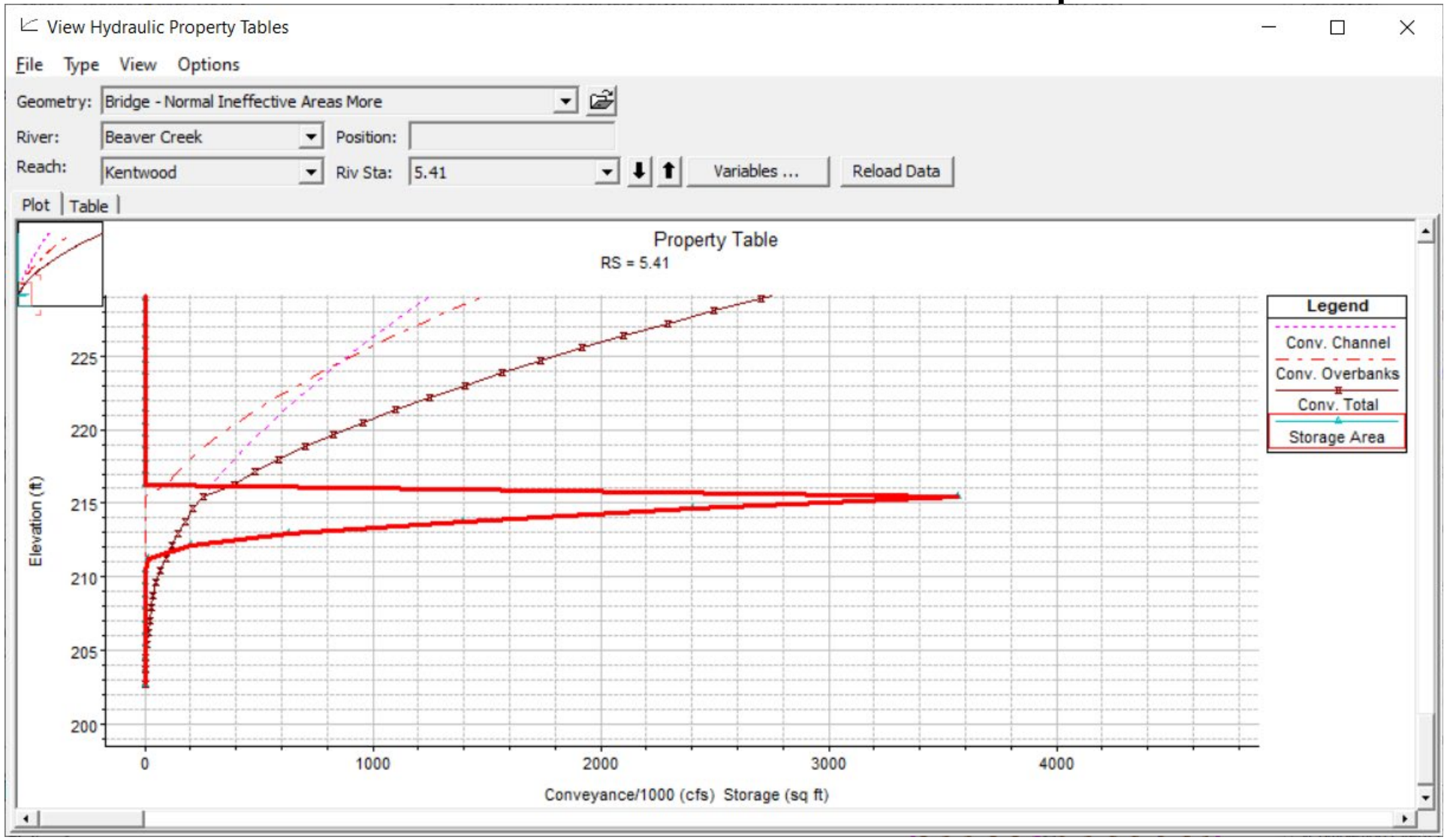


- Number of curves & points
- Shorten the range to provide better definition
  - Reduce Headwater
  - Set Max Tailwater
  - Set Max Flow

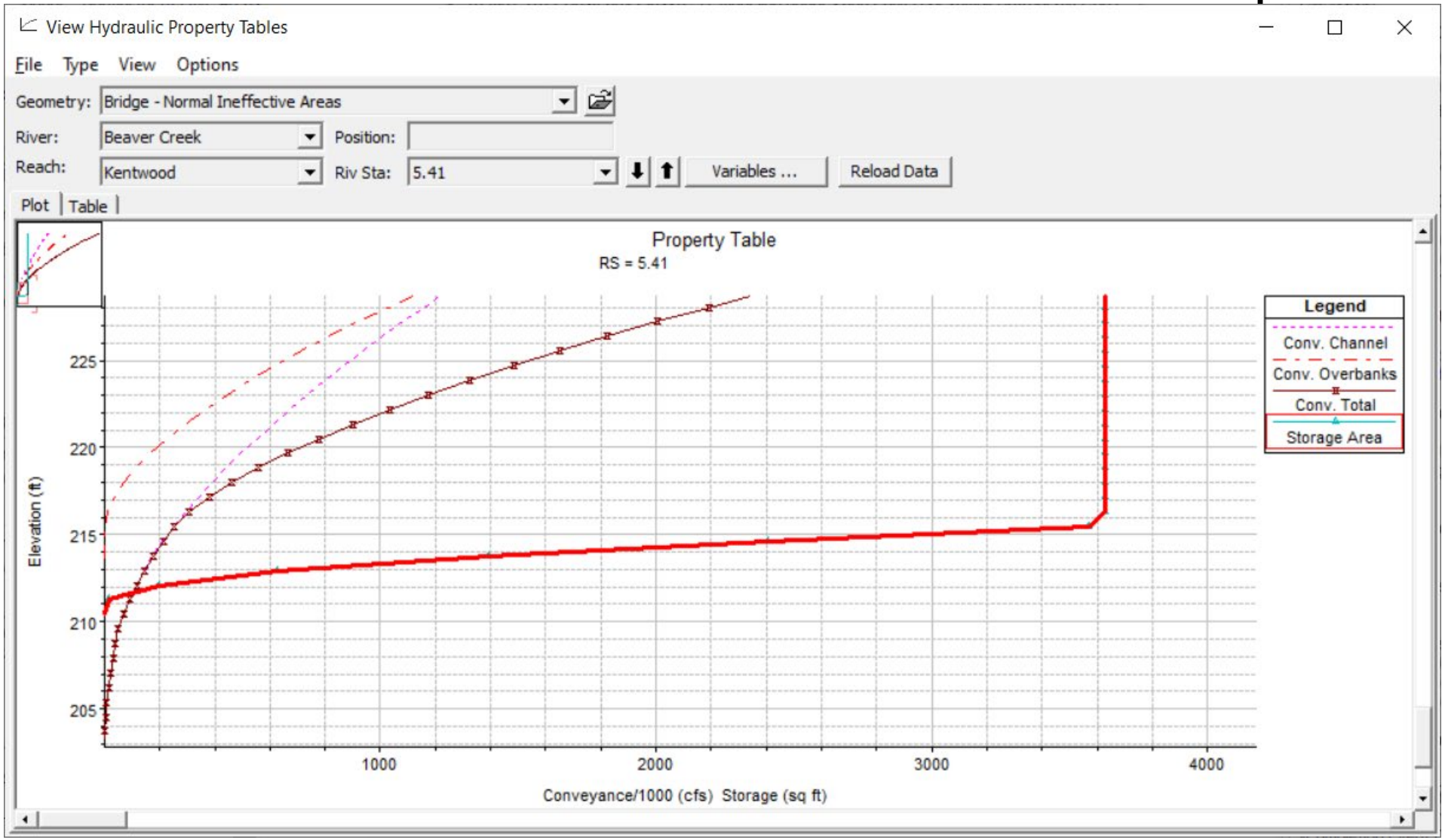
Stage & Flow Hydrographs
Few & Many Points on HTAB Curves



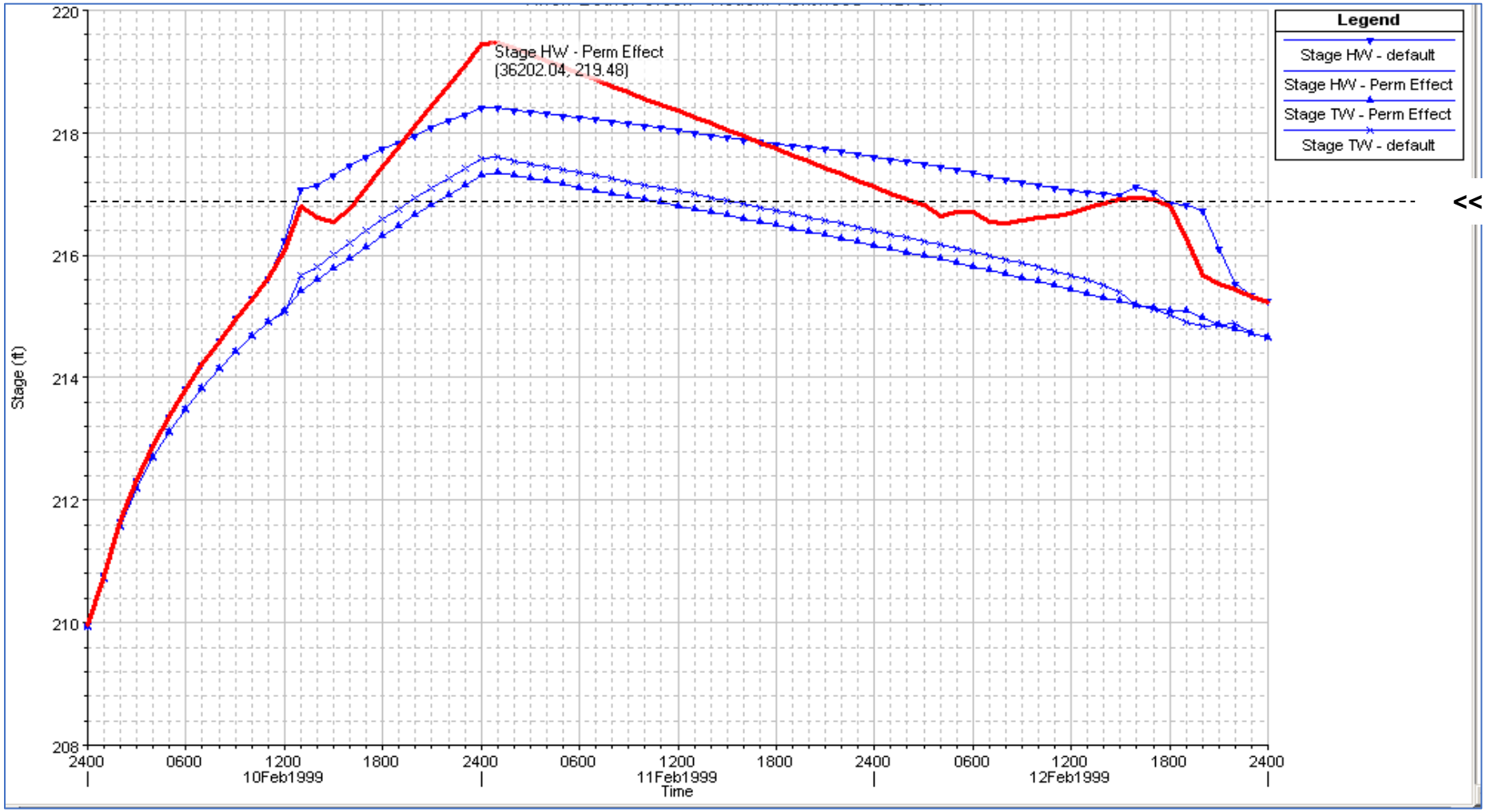
HTAB - Normal Ineffective Area Option



HTAB - Permanent Ineffective Area Option



Headwater - Tailwater Stage
Normal & Permanent Ineffective Area



Multiple Ineffective Areas

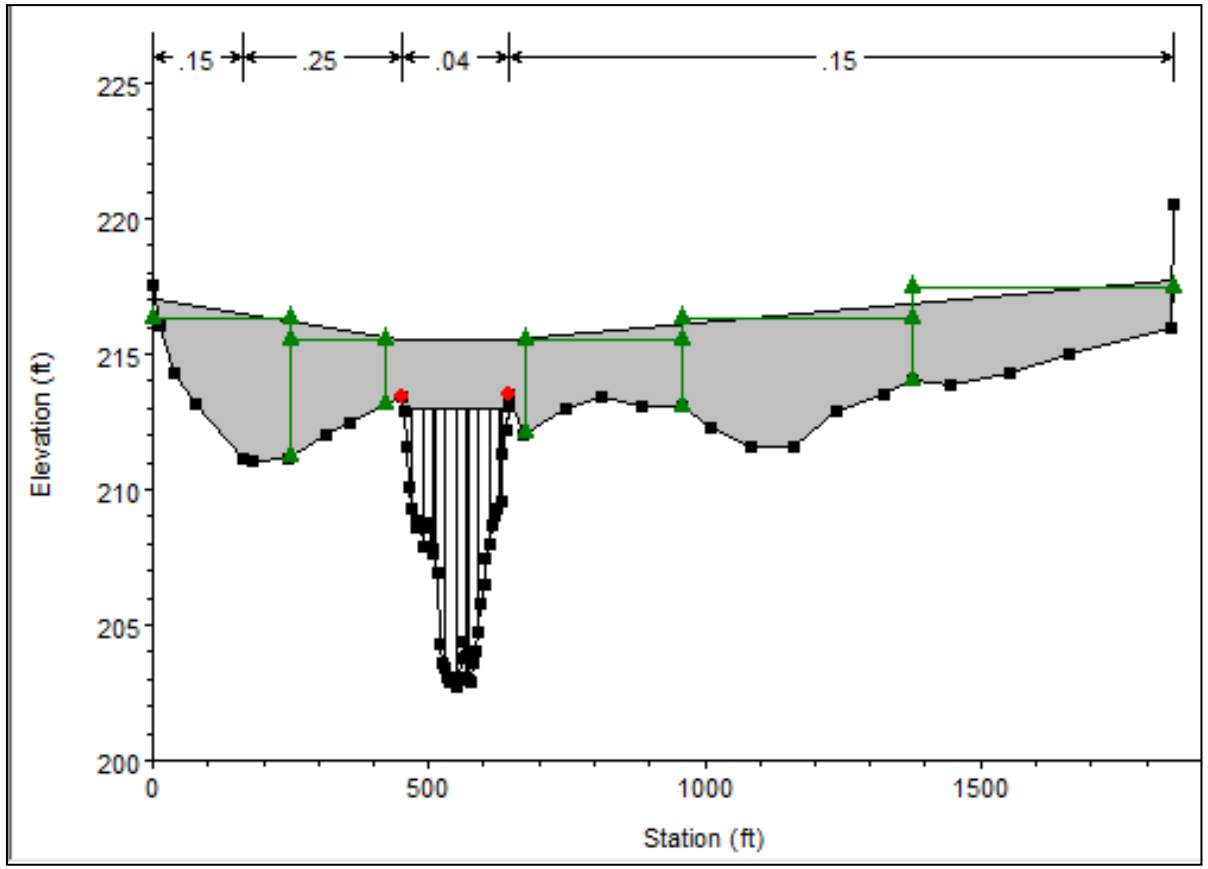
Ineffective Flow Areas

Select Ineffective Mode

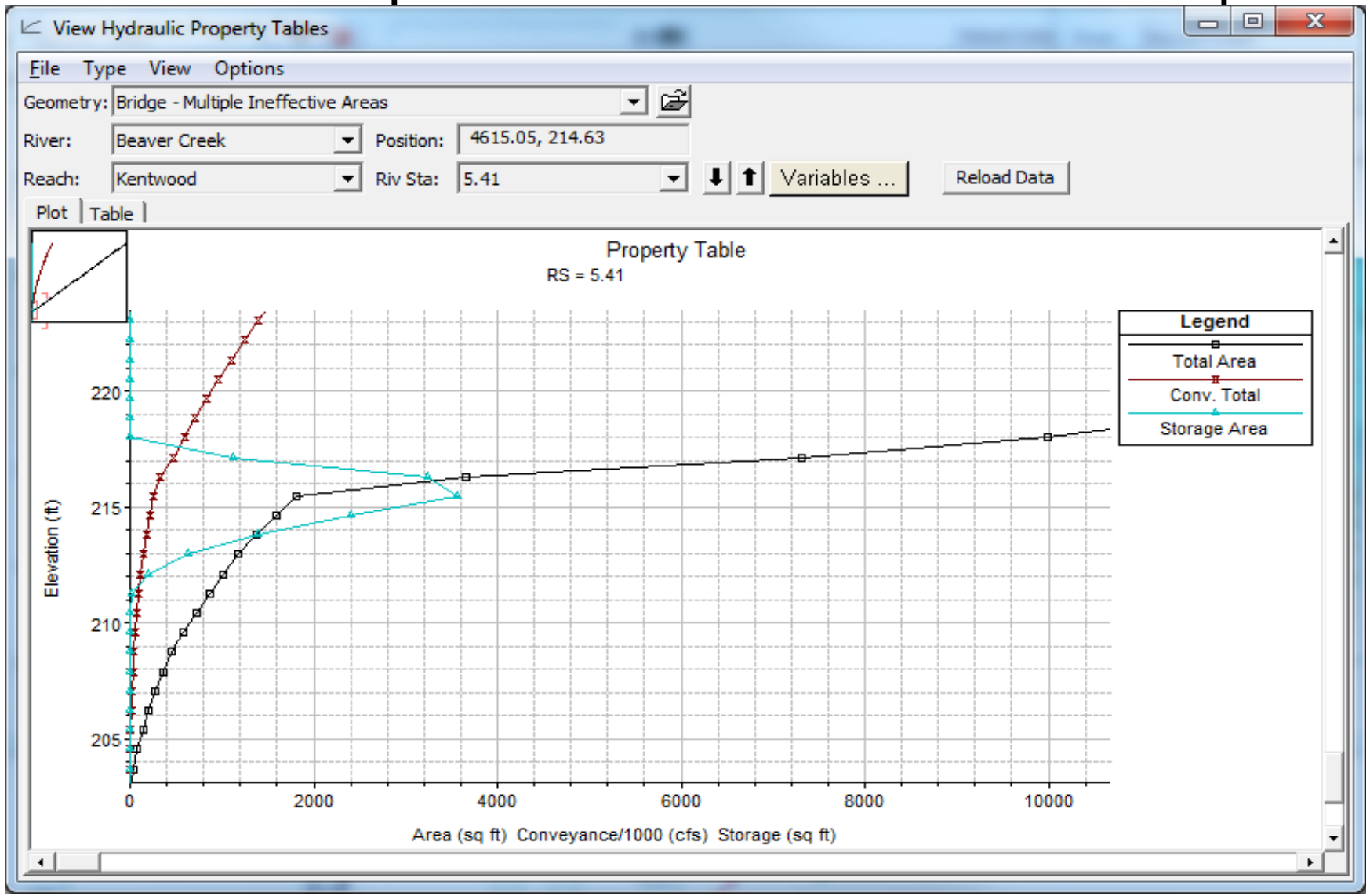
Normal Multiple Blocks

	Start Sta	End Sta	Elev	Permanent(y/n)
1	0	250	216.3	n
2	250	420	215.5	n
3	677	960	215.5	n
4	960	1375	216.3	n
5	1375	1850	217.5	n

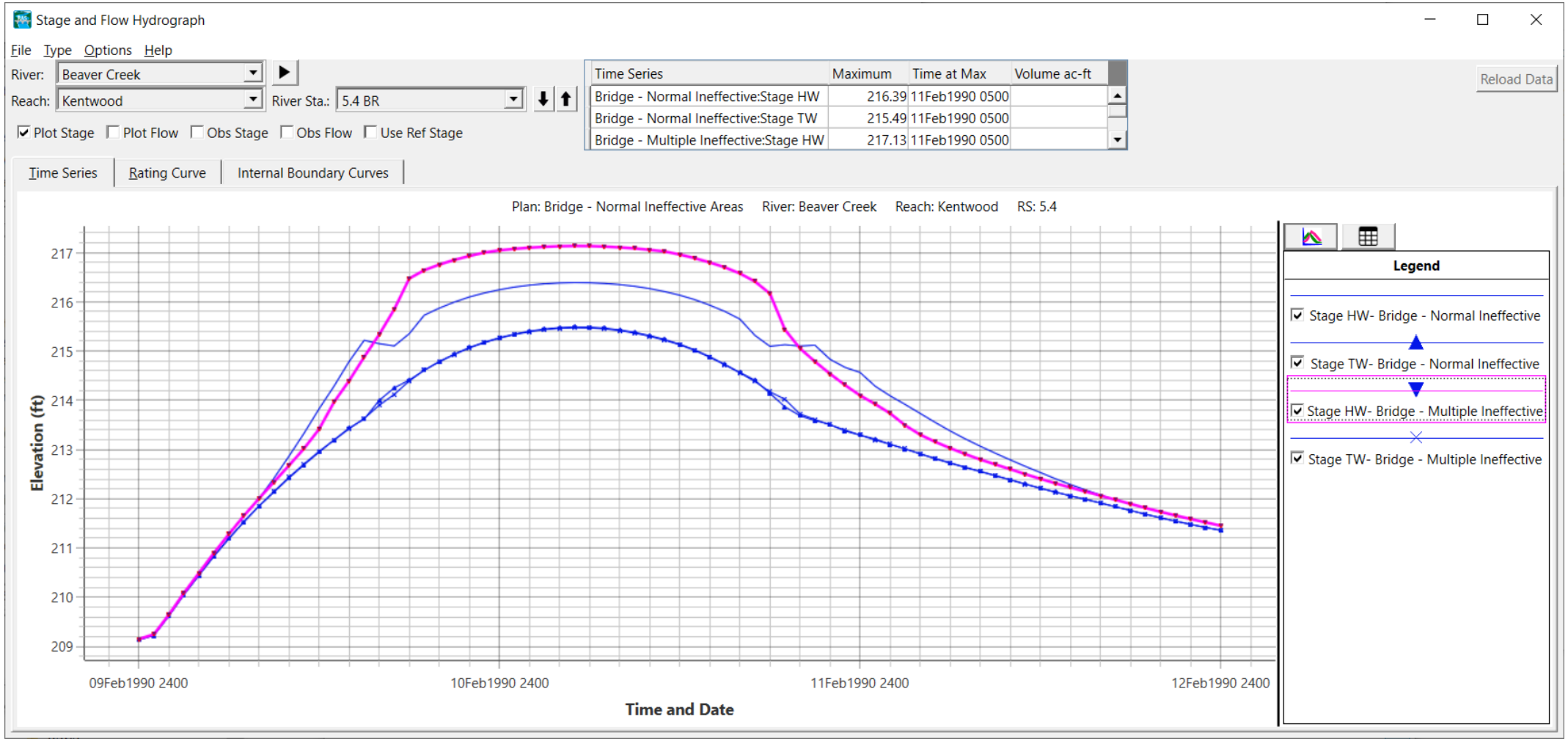
OK Cancel Defaults Clear



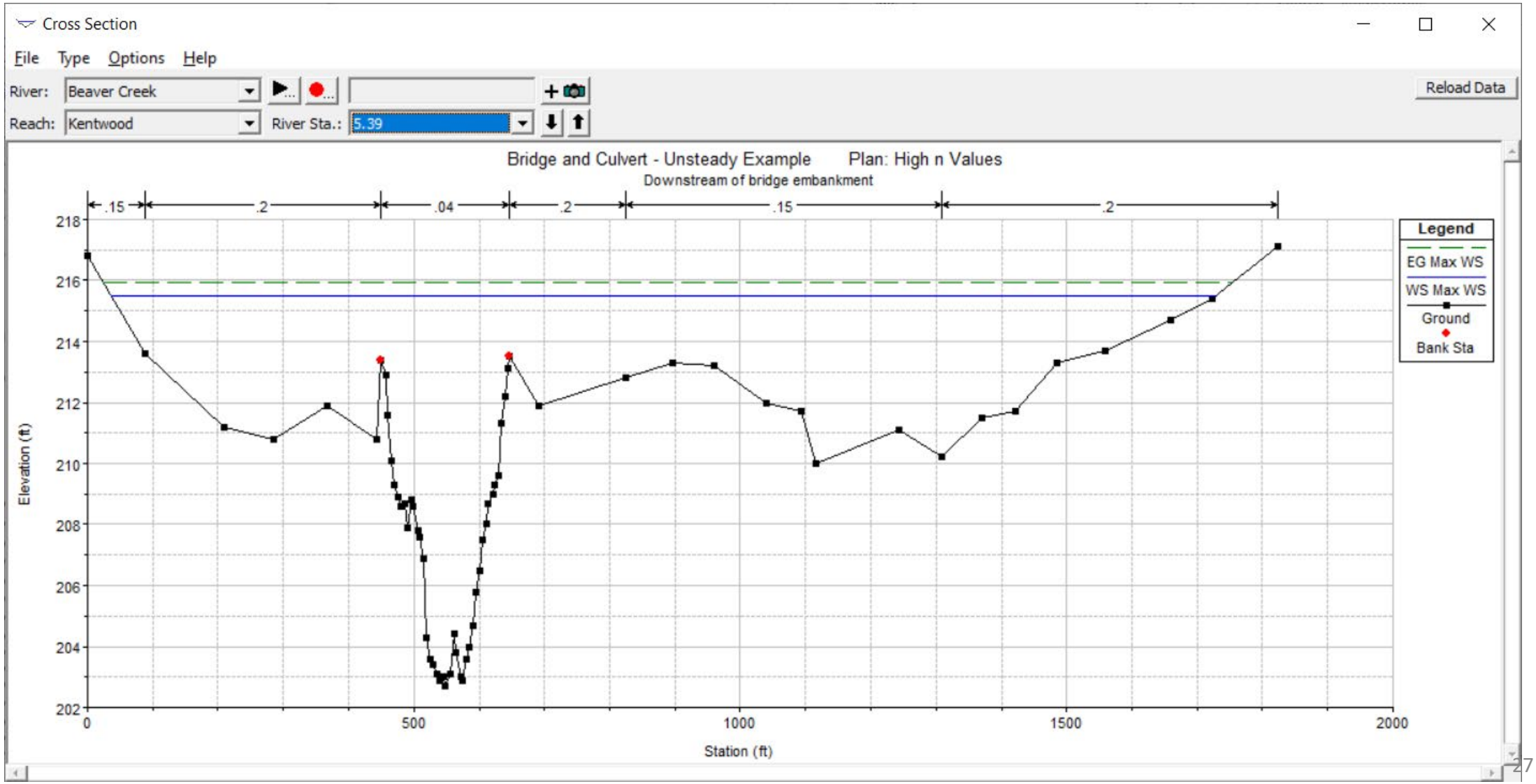
HTAB - Multiple Ineffective Areas Option



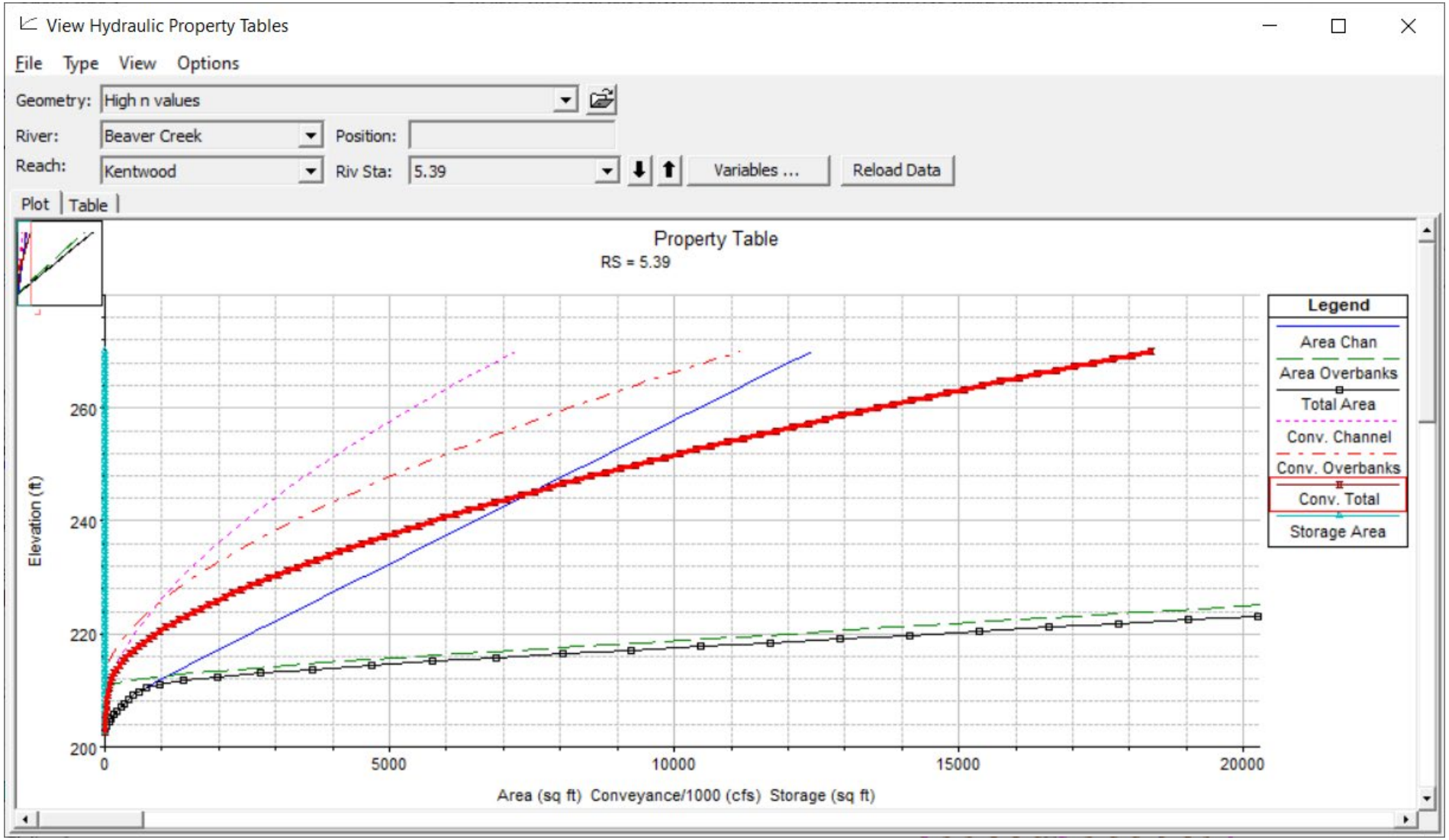
Headwater - Tailwater Stage
Normal & Multiple Blocked Ineffective Area



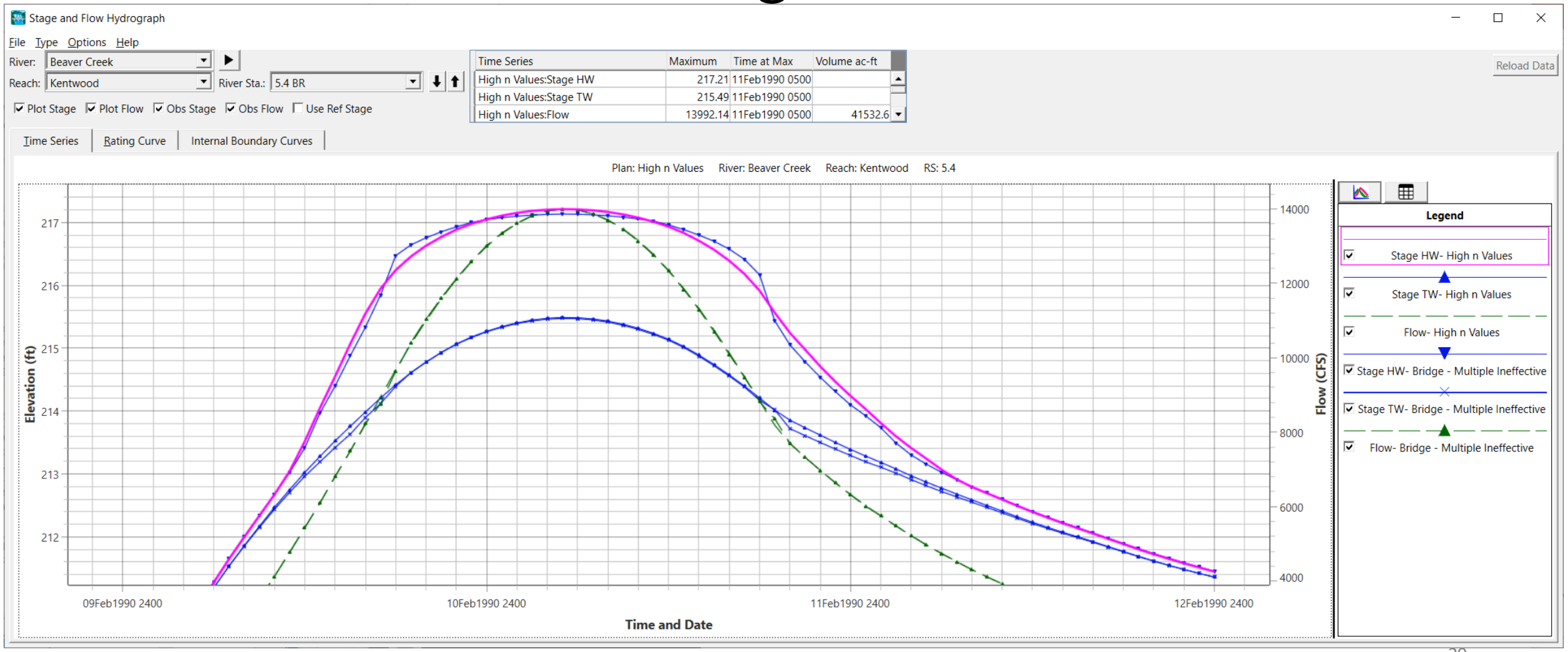
High *n* values for Ineffective Areas



HTAB - High *n* for Ineffective Area



Headwater - Tailwater Stage Ineffective Areas vs High *n* Values

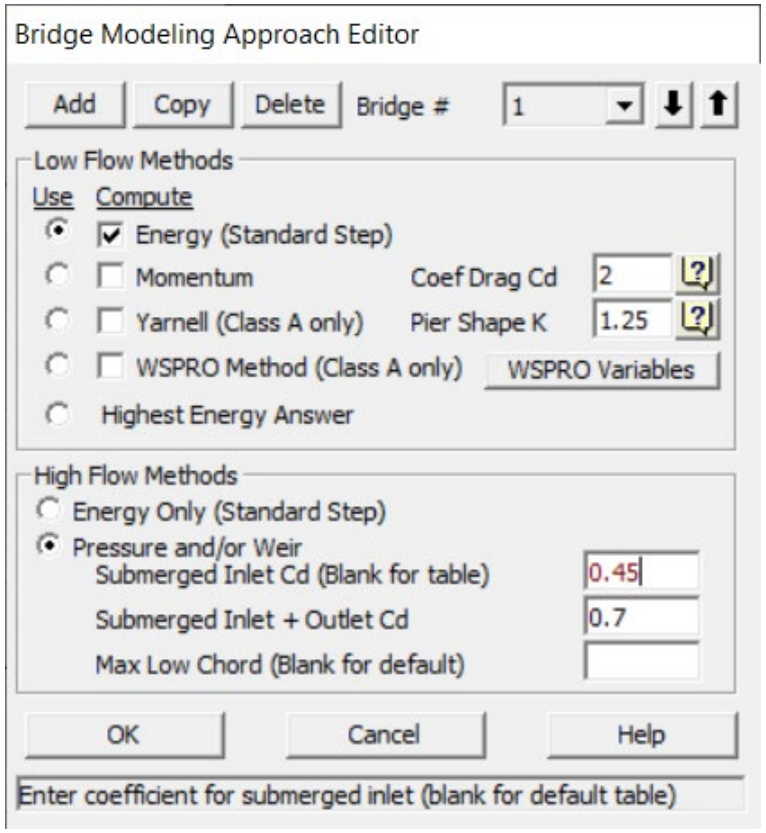


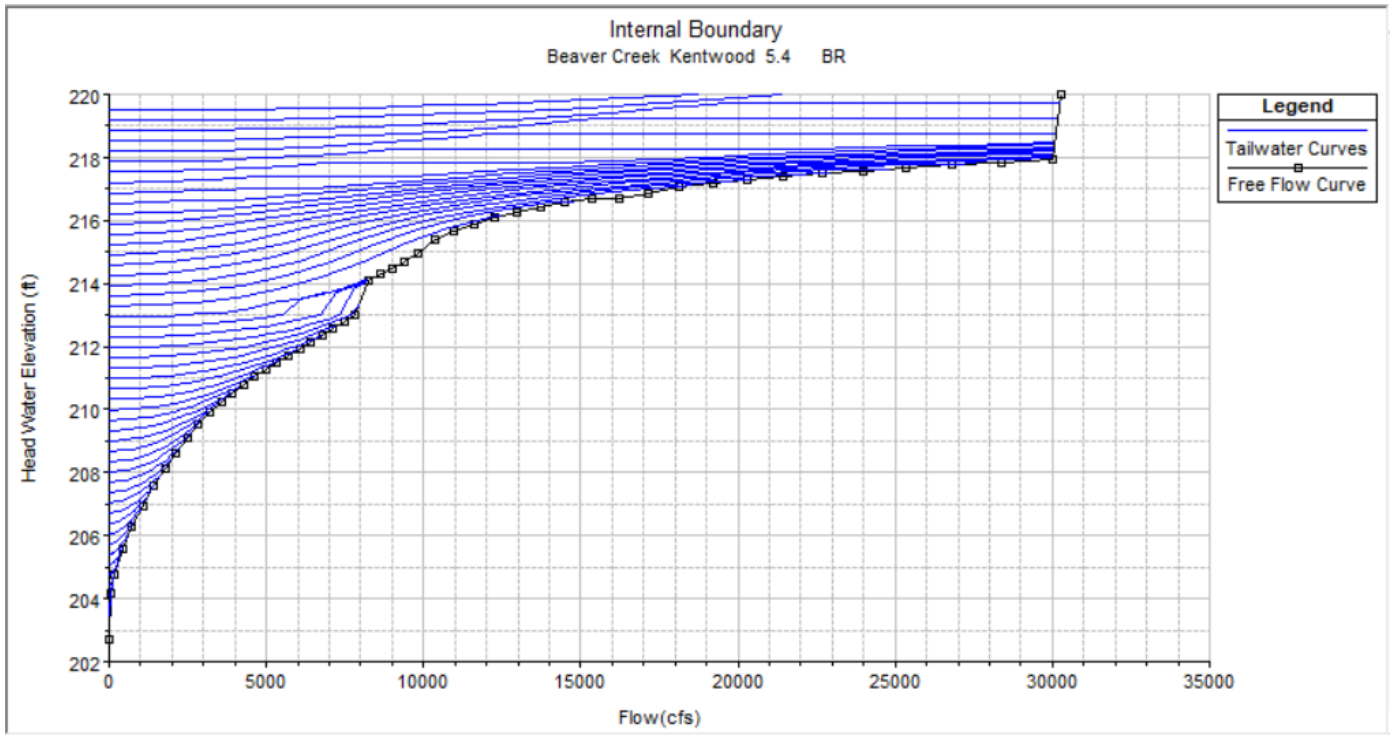
Ineffective Area Recommendations

1. Use the Ineffective Area option to eliminate overbank flow in the bounding sections where the flow is blocked by the roadway, until significant roadway overflow
2. Use higher overbank *n* to "balance" overbank flow in bounding sections with computed overflow
   - Expect transition problems near controlling elevations
   - Higher overbank *n* will tend to reduce computational shock
3. If the Ineffective Area option creates instability, try Higher n only
4. Review bridge solutions with Bridge Tables
5. Document adjustments in Bridge Description Box

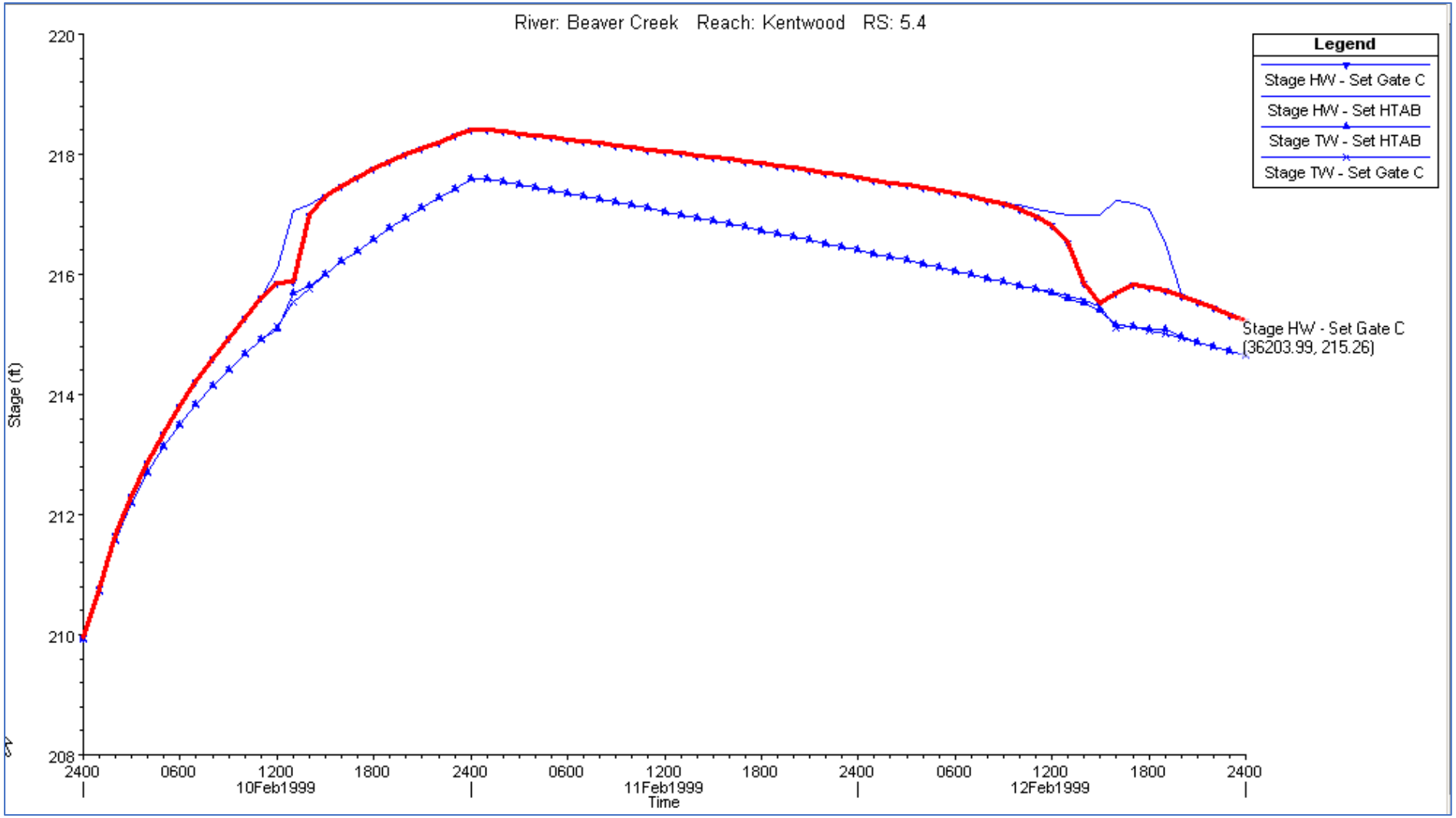
Internal Boundary for Bridge with Fixed Sluice Gate Coefficient

- If Pressure & Weir Rating creates a problem:



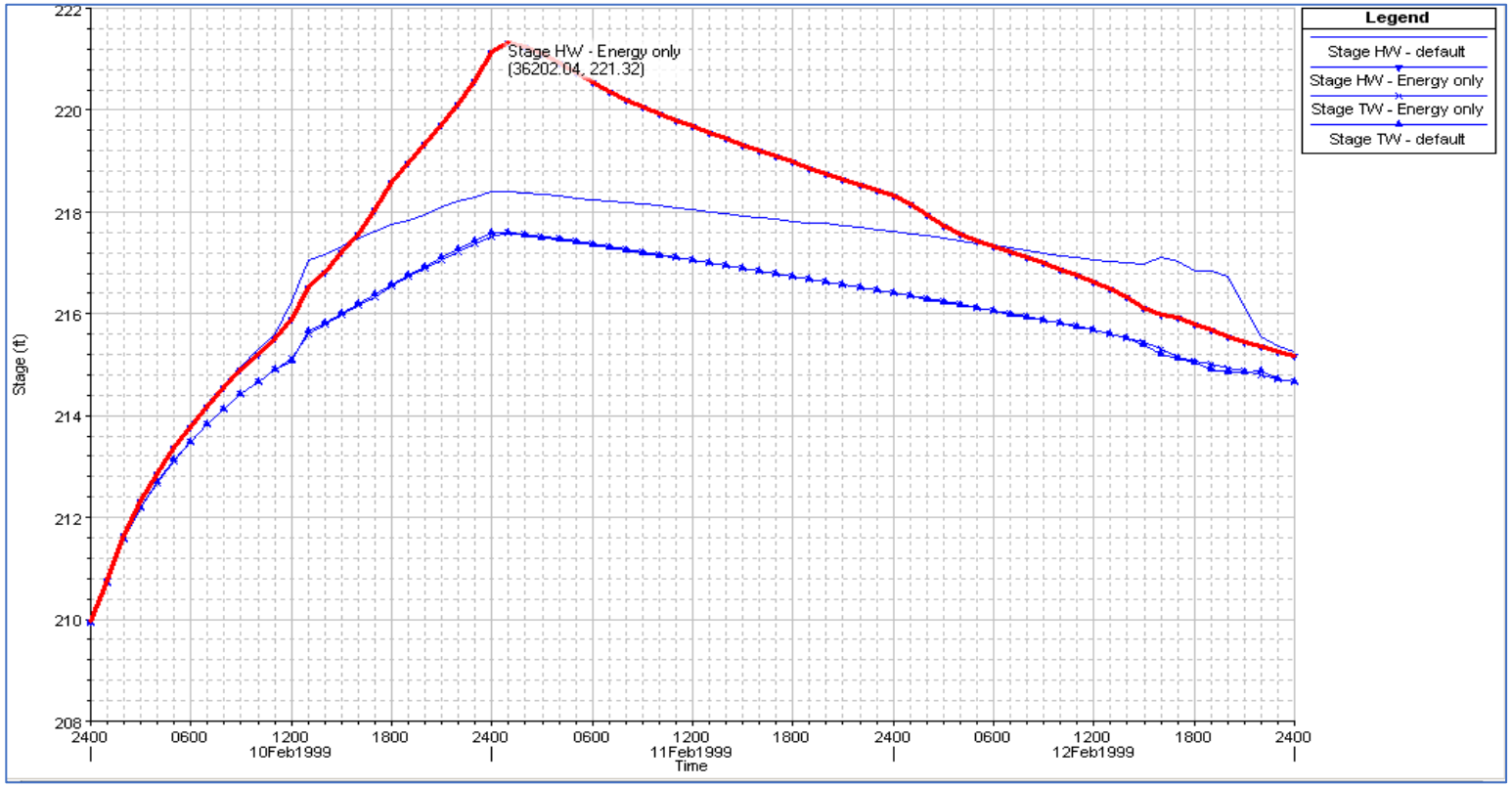


Default & Set Sluice Gate Coefficient

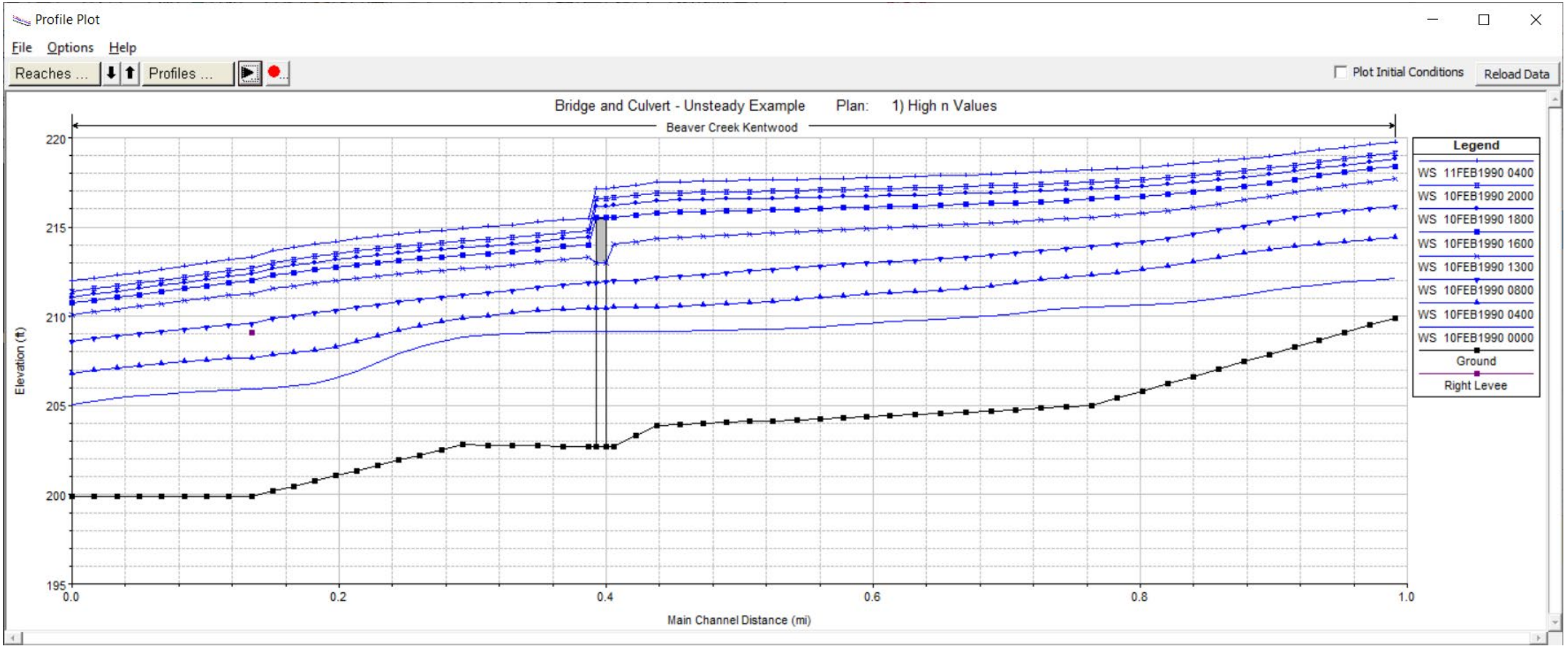


Headwater - Tailwater Stage Energy Only vs. Pressure & Weir

- The Energy Method will use overbank and channel *n* for high flows



Profile Plots with Post-processing



Bridge Comparison

Profile Output Table - Bridge Comparison

File Options Std. Tables Locations Help

HEC-RAS Plan: High n Values River: Beaver Creek Reach: Kentwood — Reload Data

Reach	River Sta	Profile	E.G. US. (ft)	W.S. US. (ft)	BR Sel Method	Energy EG (ft)	Momen. EG (ft)	Yarnell EG (ft)	WSPRO EG (ft)	Prs O EG (ft)	Prs/Wr EG (ft)	Energy/Wr EG (ft)
Kentwood	5.4	10FEB1990 0700	211.75	211.64	Energy only	211.75						
Kentwood	5.4	10FEB1990 0800	212.13	211.99	Energy only	212.14						
Kentwood	5.4	10FEB1990 0900	212.50	212.33	Energy only	212.51						
Kentwood	5.4	10FEB1990 1000	212.87	212.67	Energy only	212.89						
Kentwood	5.4	10FEB1990 1100	213.27	213.04	Press Only	213.25				213.52		
Kentwood	5.4	10FEB1990 1200	213.75	213.52	Press Only	213.81				213.79		
Kentwood	5.4	10FEB1990 1300	214.27	214.05	Press Only	214.26				214.25		
Kentwood	5.4	10FEB1990 1400	214.77	214.55	Press Only	214.75				214.74		
Kentwood	5.4	10FEB1990 1500	215.27	215.07	Press Only	215.23				215.22		
Kentwood	5.4	10FEB1990 1600	215.74	215.55	Press/Weir	215.74				215.75	215.72	
Kentwood	5.4	10FEB1990 1700	216.14	215.95	Press/Weir	216.28				216.30	216.10	
Kentwood	5.4	10FEB1990 1800	216.44	216.24	Press/Weir	216.83				216.87	216.39	
Kentwood	5.4	10FEB1990 1900	216.66	216.46	Press/Weir	217.36				217.42	216.61	
Kentwood	5.4	10FEB1990 2000	216.84	216.63	Press/Weir	218.05				217.94	216.78	
Kentwood	5.4	10FEB1990 2100	216.99	216.77	Press/Weir	218.28				218.44	216.93	
Kentwood	5.4	10FEB1990 2200	217.11	216.89	Press/Weir	218.43				218.90	217.05	
Kentwood	5.4	10FEB1990 2300	217.21	216.98	Press/Weir	218.57				219.32	217.15	
Kentwood	5.4	11FEB1990 0000	217.29	217.05	Press/Weir	218.73				219.68	217.23	
Kentwood	5.4	11FEB1990 0100	217.36	217.11	Press/Weir	218.89				220.00	217.30	
Kentwood	5.4	11FEB1990 0200	217.41	217.15	Press/Weir	219.04				220.25	217.35	
Kentwood	5.4	11FEB1990 0300	217.44	217.18	Press/Weir	219.16				220.44	217.38	
Kentwood	5.4	11FEB1990 0400	217.46	217.20	Press/Weir	219.23				220.56	217.41	
Kentwood	5.4	11FEB1990 0500	217.47	217.21	Press/Weir	219.26				220.61	217.41	
Kentwood	5.4	11FEB1990 0600	217.47	217.21	Press/Weir	219.25				220.59	217.41	
Kentwood	5.4	11FEB1990 0700	217.45	217.19	Press/Weir	219.20				220.50	217.40	
Kentwood	5.4	11FEB1990 0800	217.42	217.17	Press/Weir	219.10				220.34	217.37	

Upstream energy grade elevation at bridge or culvert (specific to that opening, not necessarily the weighted average).

Bridge Only

Profile Output Table - Bridge Only

File Options Std. Tables Locations Help

HEC-RAS Plan: High n Values River: Beaver Creek Reach: Kentwood

Reload Data

Reach	River Sta	Profile	E.G. US. (ft)	Min El Prs (ft)	BR Open Area (sq ft)	Prs O WS (ft)	Q Total (cfs)	Min El Weir Flow (ft)	Q Weir (cfs)	Delta EG (ft)	BR Sluice Coef
Kentwood	5.4	10FEB1990 0800	212.13	213.00	1100.93		2928.90	215.51		0.15	
Kentwood	5.4	10FEB1990 0900	212.50	213.00	1100.93		3506.92	215.51		0.19	
Kentwood	5.4	10FEB1990 1000	212.87	213.00	1100.93		4121.97	215.51		0.24	
Kentwood	5.4	10FEB1990 1100	213.27	213.00	1100.93	213.32	4760.63	215.51		0.56	0.28
Kentwood	5.4	10FEB1990 1200	213.75	213.00	1100.93	213.56	5425.69	215.51		0.53	
Kentwood	5.4	10FEB1990 1300	214.27	213.00	1100.93	214.01	6090.76	215.51		0.71	
Kentwood	5.4	10FEB1990 1400	214.77	213.00	1100.93	214.51	6800.55	215.51		0.92	
Kentwood	5.4	10FEB1990 1500	215.27	213.00	1100.93	215.01	7484.75	215.51		1.16	
Kentwood	5.4	10FEB1990 1600	215.74	213.00	1100.93		8209.77	215.51	69.24	1.41	
Kentwood	5.4	10FEB1990 1700	216.14	213.00	1100.93		8948.39	215.51	446.20	1.55	
Kentwood	5.4	10FEB1990 1800	216.44	213.00	1100.93		9676.73	215.51	999.78	1.61	
Kentwood	5.4	10FEB1990 1900	216.66	213.00	1100.93		10364.32	215.51	1616.86	1.63	
Kentwood	5.4	10FEB1990 2000	216.84	213.00	1100.93		10994.37	215.51	2231.20	1.62	
Kentwood	5.4	10FEB1990 2100	216.99	213.00	1100.93		11577.11	215.51	2838.82	1.60	
Kentwood	5.4	10FEB1990 2200	217.11	213.00	1100.93		12106.24	215.51	3396.04	1.58	
Kentwood	5.4	10FEB1990 2300	217.21	213.00	1100.93		12583.11	215.51	3900.14	1.56	
Kentwood	5.4	11FEB1990 0000	217.29	213.00	1100.93		12991.06	215.51	4328.13	1.54	
Kentwood	5.4	11FEB1990 0100	217.36	213.00	1100.93		13334.06	215.51	4688.46	1.52	
Kentwood	5.4	11FEB1990 0200	217.41	213.00	1100.93		13608.04	215.51	4988.08	1.51	
Kentwood	5.4	11FEB1990 0300	217.44	213.00	1100.93		13811.02	215.51	5200.51	1.49	
Kentwood	5.4	11FEB1990 0400	217.46	213.00	1100.93		13938.92	215.51	5344.61	1.49	
Kentwood	5.4	11FEB1990 0500	217.47	213.00	1100.93		13992.14	215.51	5392.92	1.48	
Kentwood	5.4	11FEB1990 0600	217.47	213.00	1100.93		13970.26	215.51	5371.07	1.48	
Kentwood	5.4	11FEB1990 0700	217.45	213.00	1100.93		13873.50	215.51	5280.76	1.49	
Kentwood	5.4	11FEB1990 0800	217.42	213.00	1100.93		13703.95	215.51	5107.60	1.50	

Upstream energy grade elevation at bridge or culvert (specific to that opening, not necessarily the weighted average).

6 XS Bridge

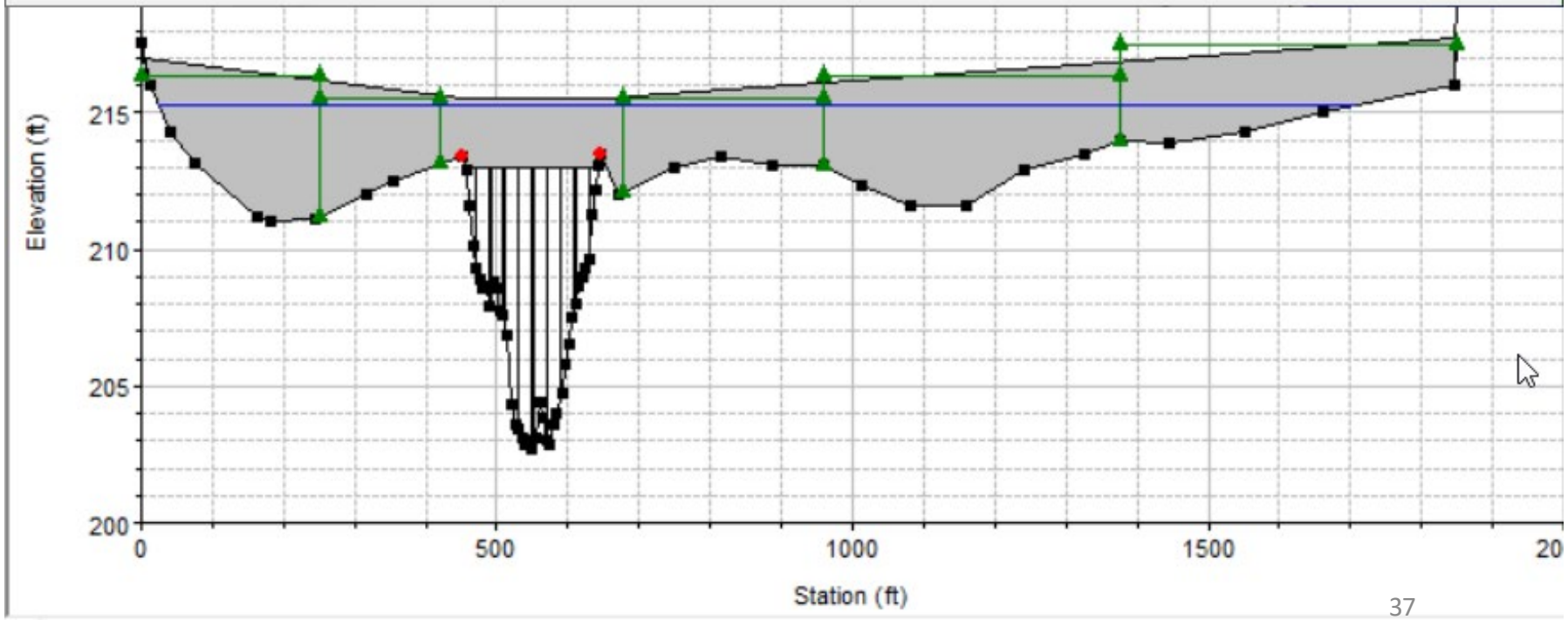
Profile Output Table - Six XS Bridge

File Options Std. Tables Locations Help

HEC-RAS Plan: Bridge - Multiple Ineffective River: Beaver Creek Reach: Kentwood Profile: 10FEB1990 1600 Reload Data

Reach	River Sta	Profile	E.G. Elev (ft)	W.S. Elev (ft)	Crit W.S. (ft)	Frctn Loss (ft)	C & E Loss (ft)	Top Width (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Vel Chnl (ft/s)
Kentwood	5.425	10FEB1990 1600	215.80	215.60	211.15	0.10		1710.17	1030.15	5677.66	1559.12	4.34
Kentwood	5.41	10FEB1990 1600	215.72	215.33	210.33			1699.14	19.97	8160.31	53.07	4.99
Kentwood	5.4 BR U	10FEB1990 1600	215.66	215.26	210.53				2.62	8227.21	4.73	7.47
Kentwood	5.4 BR D	10FEB1990 1600	215.66	215.26	210.54				2.62	8227.21	4.73	7.47
Kentwood	5.39	10FEB1990 1600	214.47	213.90	210.33	0.17		1497.46	22.41	8208.37	2.58	6.07
Kentwood	5.37	10FEB1990 1600	214.17	213.90	211.67	0.15		1464.31	1296.46	5675.02	1250.71	4.97

Energy gradeline for given WSEL.



6 XS Bridge

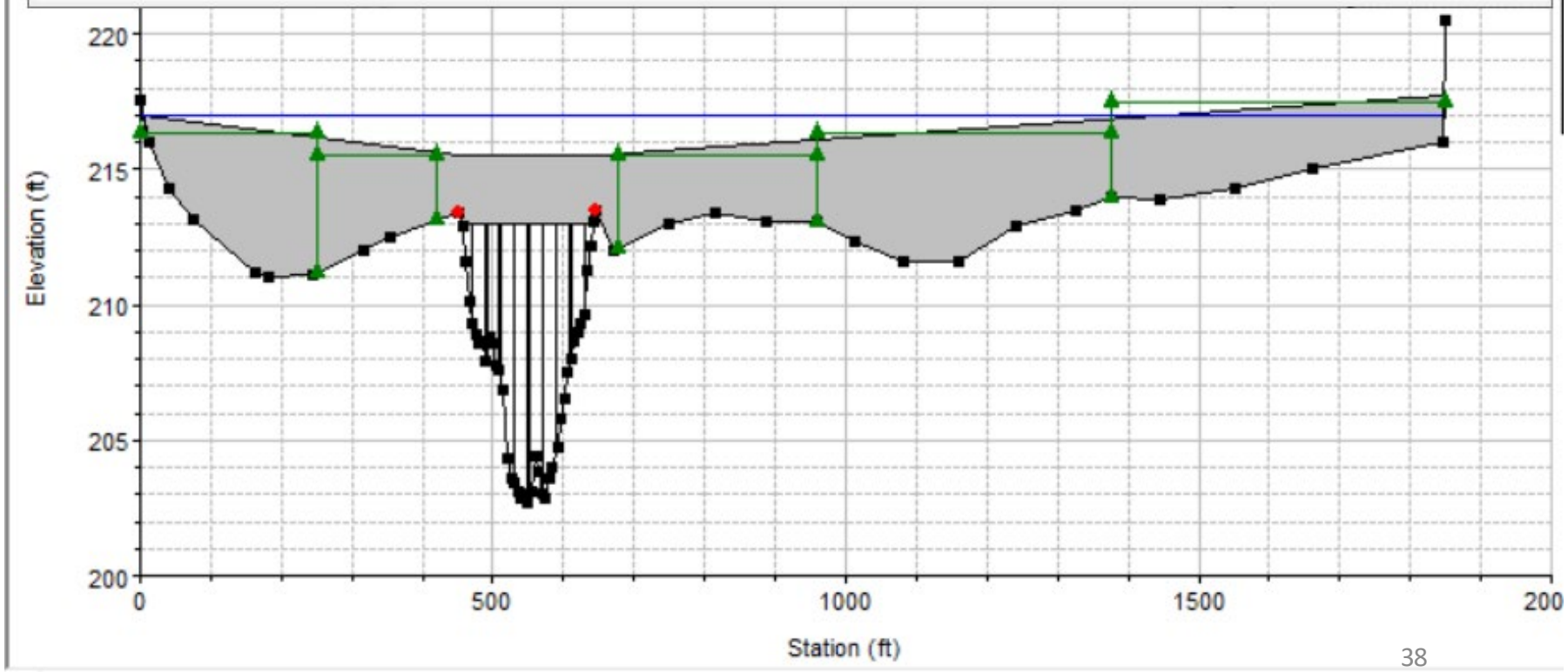
Profile Output Table - Six XS Bridge

File Options Std. Tables Locations Help

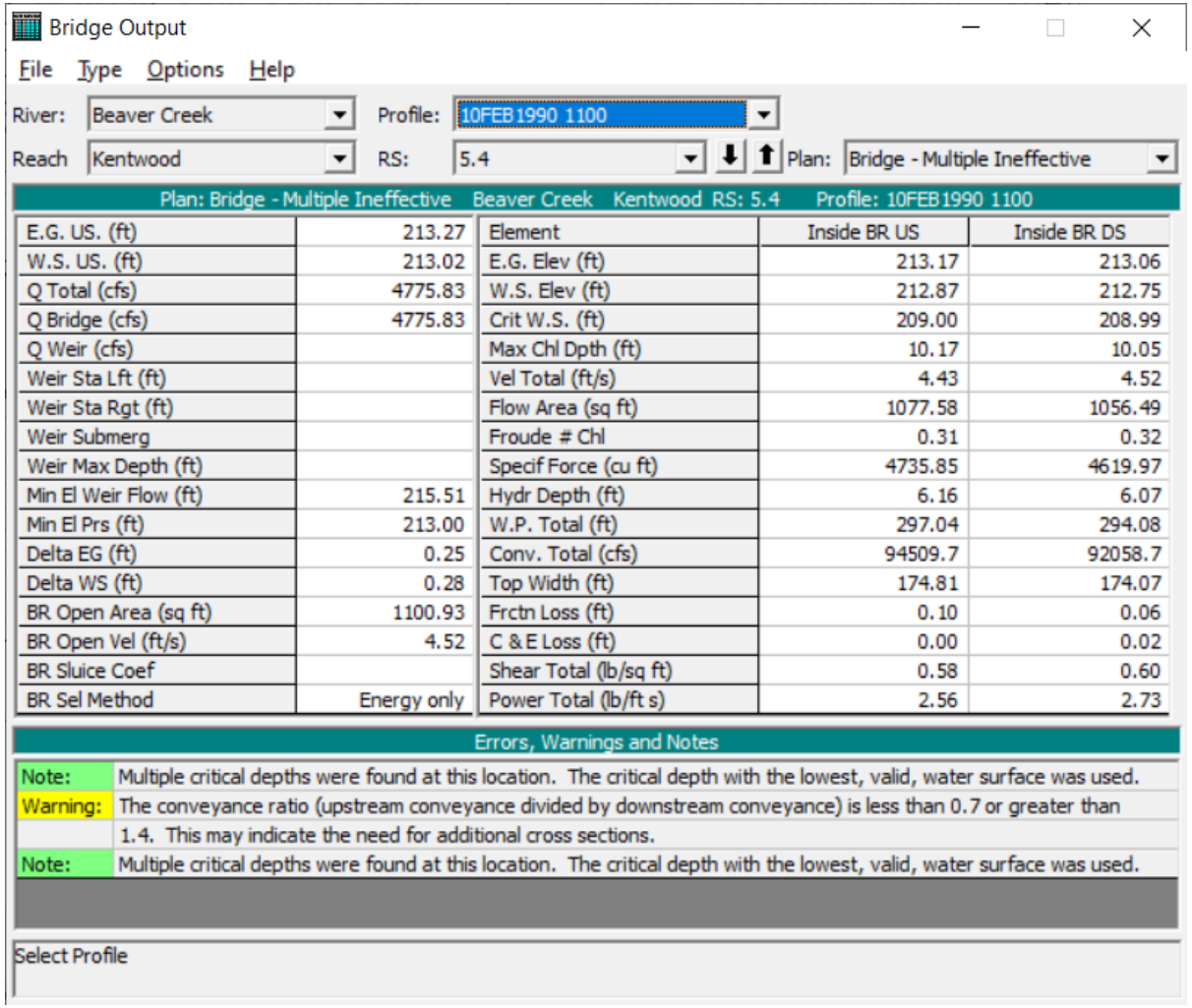
HEC-RAS Plan: Bridge - Multiple Ineffective River: Beaver Creek Reach: Kentwood Profile: 11FEB1990 0100 Reload Data

Reach	River Sta	Profile	E.G. Elev (ft)	W.S. Elev (ft)	Crit W.S. (ft)	Frctn Loss (ft)	C & E Loss (ft)	Top Width (ft)	Q Left (cfs)	Q Channel (cfs)	Q Right (cfs)	Vel Chnl (ft/s)
Kentwood	5.425	11FEB1990 0100	217.46	217.25	213.79	0.10		1844.07	1894.85	7505.06	3955.58	4.85
Kentwood	5.41	11FEB1990 0100	217.35	217.08	212.03			1843.92	1163.62	9760.80	2428.15	4.94
Kentwood	5.4 BR U	11FEB1990 0100	217.29	217.00	212.33			1456.57	1298.31	9864.67	2236.09	7.06
Kentwood	5.4 BR D	11FEB1990 0100	217.29	217.00	212.32			1460.94	1298.31	9864.67	2236.09	7.06
Kentwood	5.39	11FEB1990 0100	215.79	215.33	212.05	0.16		1676.22	990.26	10163.97	2198.34	6.22
Kentwood	5.37	11FEB1990 0100	215.58	215.26	213.03	0.16		1660.96	2528.84	7910.67	2910.14	5.77

Energy gradeline for given WSEL.



Detailed Bridge Output



Bridge Output

File Type Options Help

River: Beaver Creek Profile: 10FEB1990 1100

Reach: Kentwood RS: 5.4 Plan: Bridge - Multiple Ineffective

Plan: Bridge - Multiple Ineffective Beaver Creek Kentwood RS: 5.4 Profile: 10FEB1990 1100

		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	213.27	E.G. Elev (ft)	213.17	213.06
W.S. US. (ft)	213.02	W.S. Elev (ft)	212.87	212.75
Q Total (cfs)	4775.83	Crit W.S. (ft)	209.00	208.99
Q Bridge (cfs)	4775.83	Max Chl Dpth (ft)	10.17	10.05
Q Weir (cfs)		Vel Total (ft/s)	4.43	4.52
Weir Sta Lft (ft)		Flow Area (sq ft)	1077.58	1056.49
Weir Sta Rgt (ft)		Froude # Chl	0.31	0.32
Weir Submerg		Specif Force (cu ft)	4735.85	4619.97
Weir Max Depth (ft)		Hydr Depth (ft)	6.16	6.07
Min El Weir Flow (ft)	215.51	W.P. Total (ft)	297.04	294.08
Min El Prs (ft)	213.00	Conv. Total (cfs)	94509.7	92058.7
Delta EG (ft)	0.25	Top Width (ft)	174.81	174.07
Delta WS (ft)	0.28	Frctn Loss (ft)	0.10	0.06
BR Open Area (sq ft)	1100.93	C & E Loss (ft)	0.00	0.02
BR Open Vel (ft/s)	4.52	Shear Total (lb/sq ft)	0.58	0.60
BR Sluice Coef		Power Total (lb/ft s)	2.56	2.73
BR Sel Method	Energy only			

Errors, Warnings and Notes

Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, water surface was used.
Warning:	The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than
	1.4. This may indicate the need for additional cross sections.
Note:	Multiple critical depths were found at this location. The critical depth with the lowest, valid, water surface was used.

Select Profile

- Post processing provides Interior Bridge Data and Energies
- Notes & Warnings give solution information
- Use summary tables to get overview
- Detailed for problems

Getting to a Bridge Solution

1. Use steady-flow profiles in initial analysis!

2. Figure out which profile begins to overtop bridge using Profile Plot and XS Plot.
3. Evaluate ineffective areas and determine that they turn off at the bounding cross sections at the same time.
4. Adjust Ineffective Areas until solution is in sync.

Getting to a Bridge Solution

- Use Bridge Only or Detailed Bridge table to identify total weir flow.
- Use Six XS Bridge table to evaluate flow in the Left/Right Overbanks.
- Does conveyance match weir flow?
    - QWeirTotal - QWeirChannel = QLeftOB + QRightOB
- Adjust n values to balance flow in bounding sections with weir flow.

Questions?

US Army Corps of Engineers