Two Quick Scour Reminders…

1. Scour Knowledge, Application, & Consistency

- Know HEC-18 equations and input parameters
- Watch and/or review FHWA scour training on ProjectWise
- Use SMS scour coverage tools with HT
- Refer to the Scour Q&A on ProjectWise (will be updated for 8/16, 8/23, and 8/30 discussions)
- Make use of the Prime OTS reviews

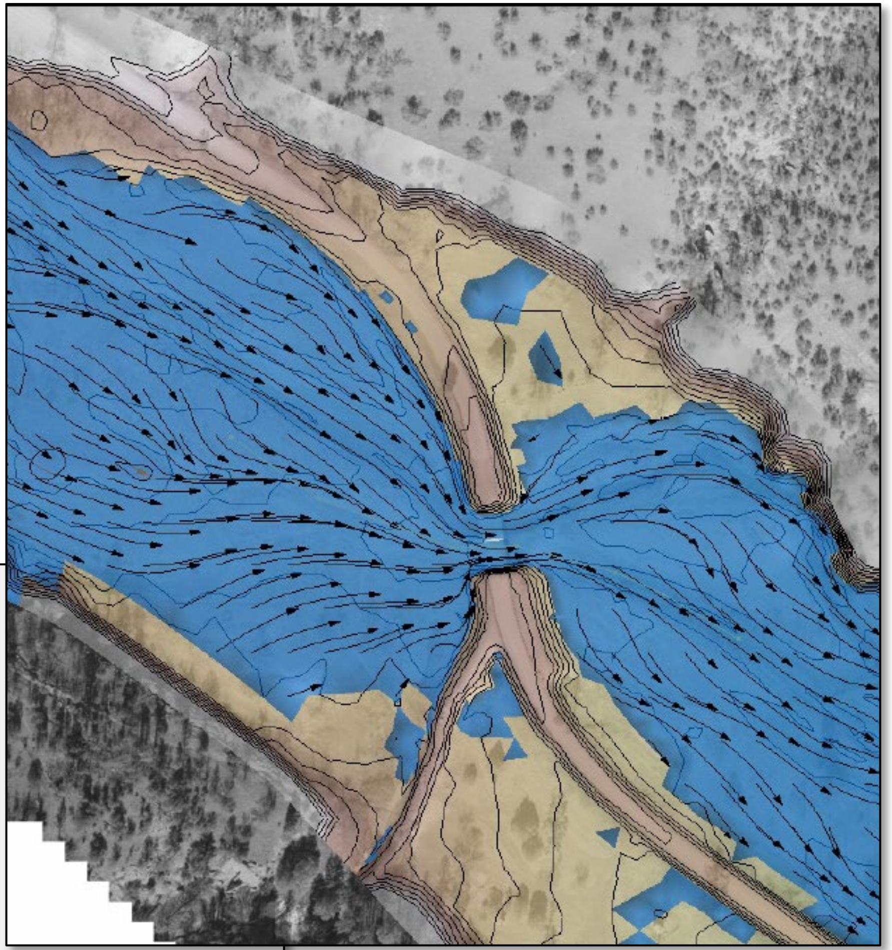
2. Scour Accuracy and Sensitivity

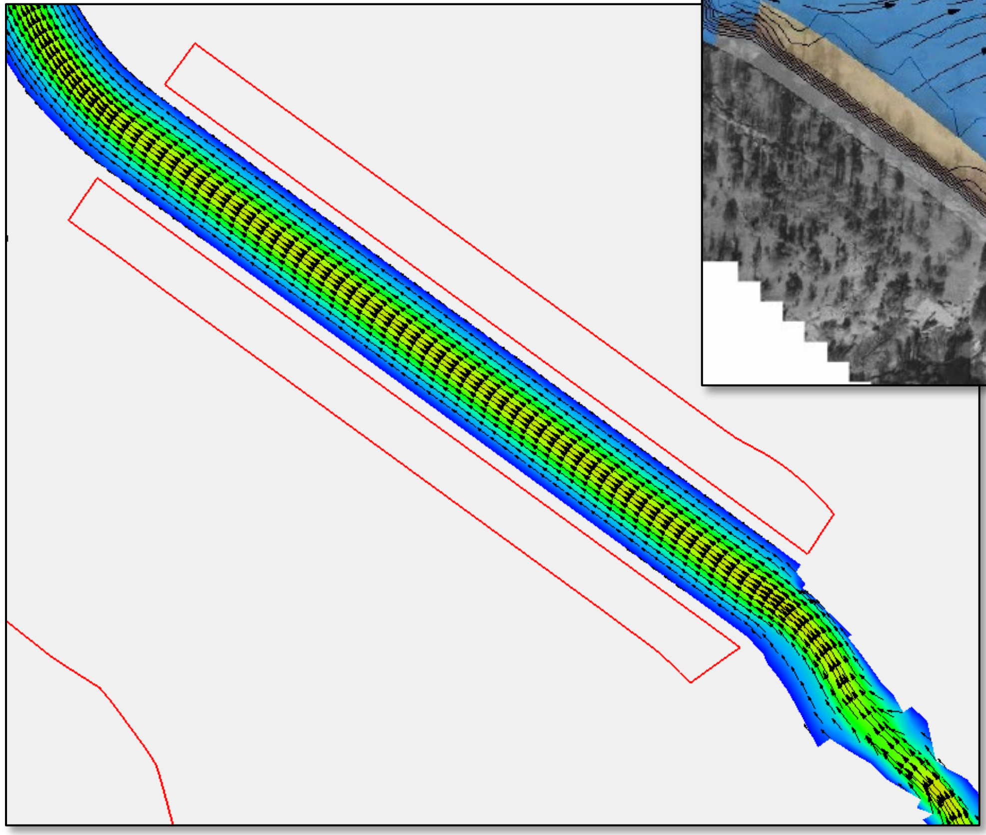
- Preliminary nature of PHD to help determine structure types
- Follow procedures and best practices, but don’t overthink it or get in circular loops
- Scour not accurate to 0.000000001 ft – keep things meaningful and in perspective

Contraction Scour

3. Contraction? What contraction?

- Textbook equations often show narrow bridge openings against a wide upstream floodplain
- Nature of WSDOT crossing spans vs. flow widths means bridge openings may not be causing a dramatic contraction
- Contraction results may be minimal
- **Do your best with contraction scour….try a few things for sensitivity…don't overthink**
- **Abutment scour is related to contraction scour, and computing it may not be needed at some crossings where flow width is less than span (think about the abutment flow obstruction, lateral migration, and whether or not an amplified scour depth is meaningful)**

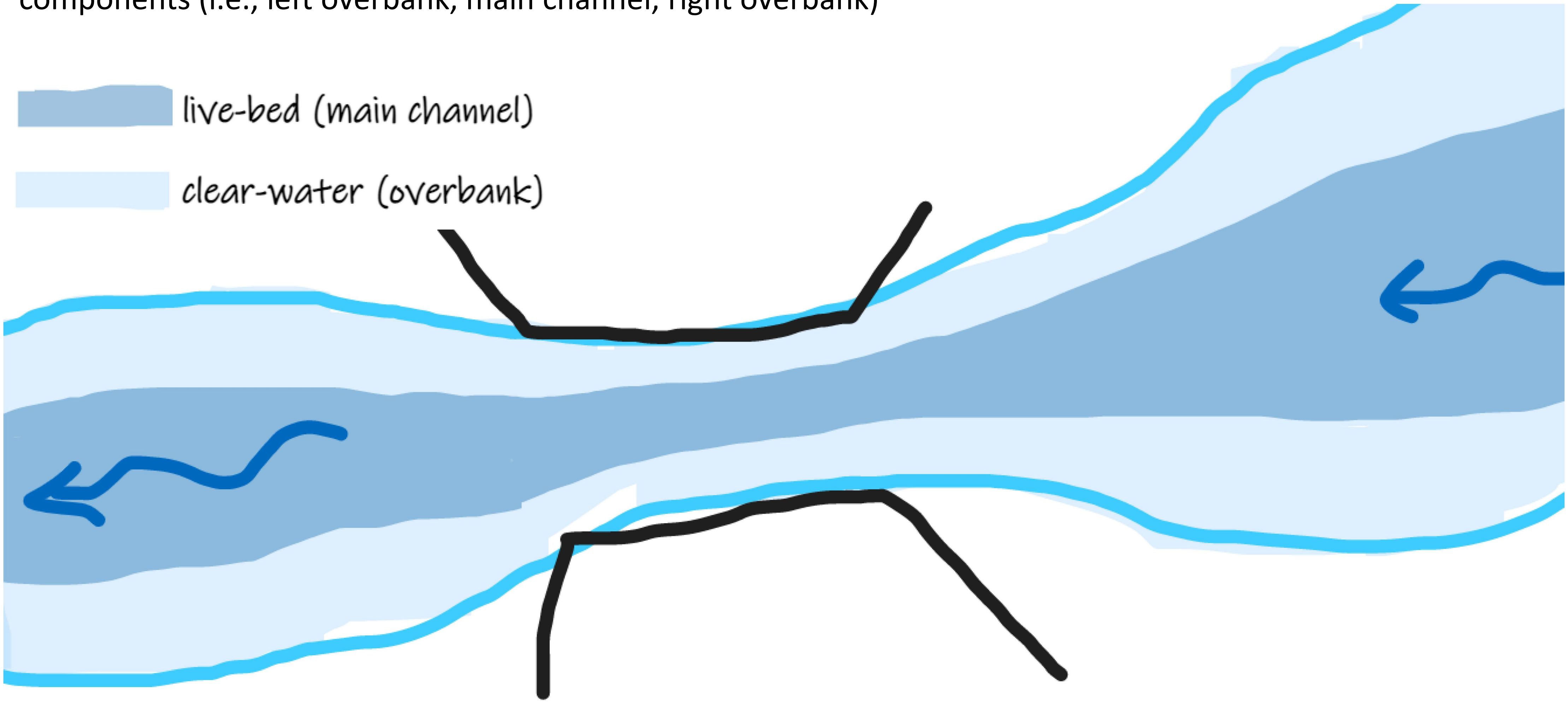




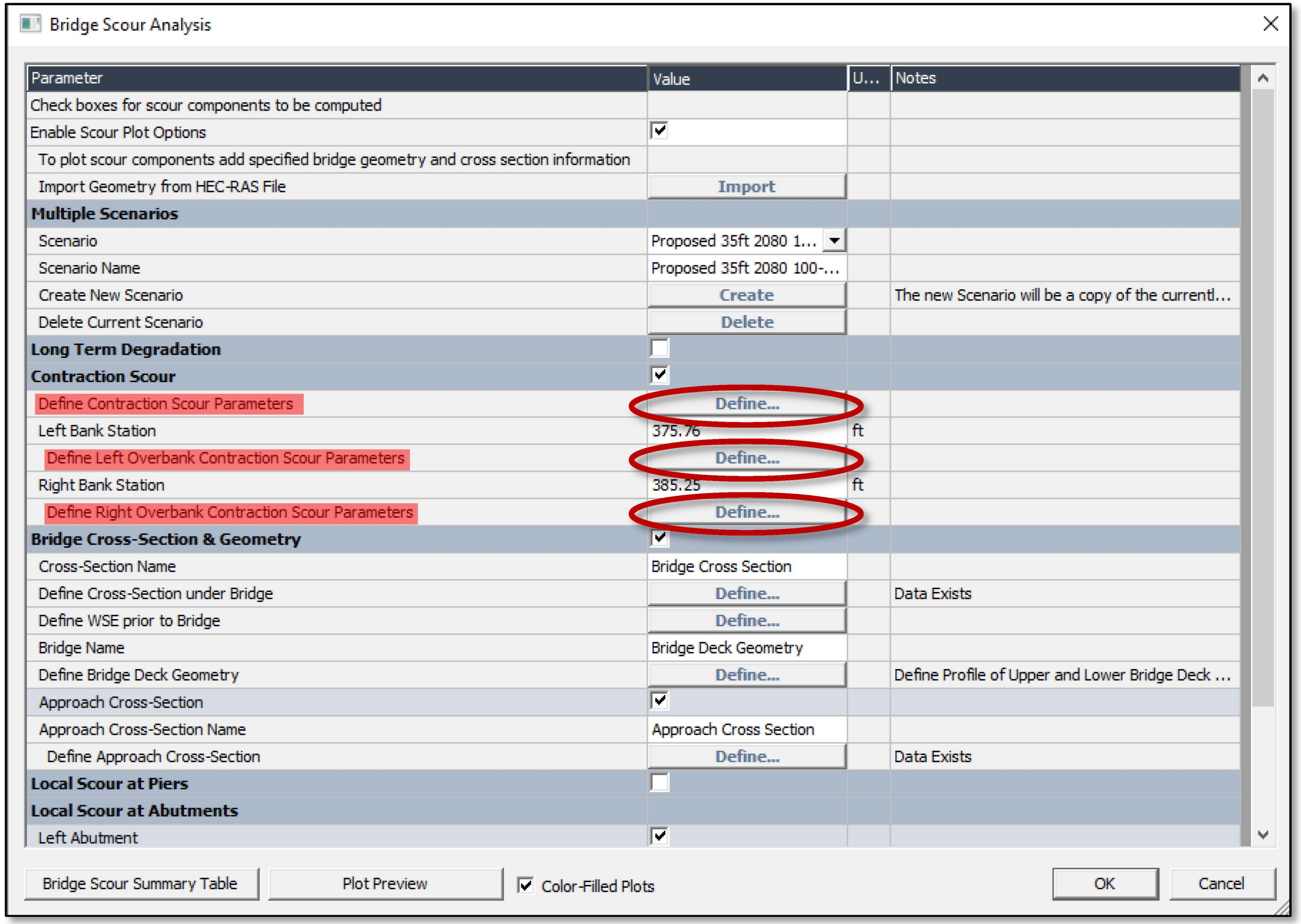
4. Evaluating Contraction Scour for Clear-Water Overbanks

- Some crossings may have live-bed main channel areas with clear-water overbanks that persist through the crossing (referred to by HEC-18 as “Case 1C”)

- Per HEC-18, SMS and HT are set up to evaluate contraction scour separately for all three channel components (i.e., left overbank, main channel, right overbank)

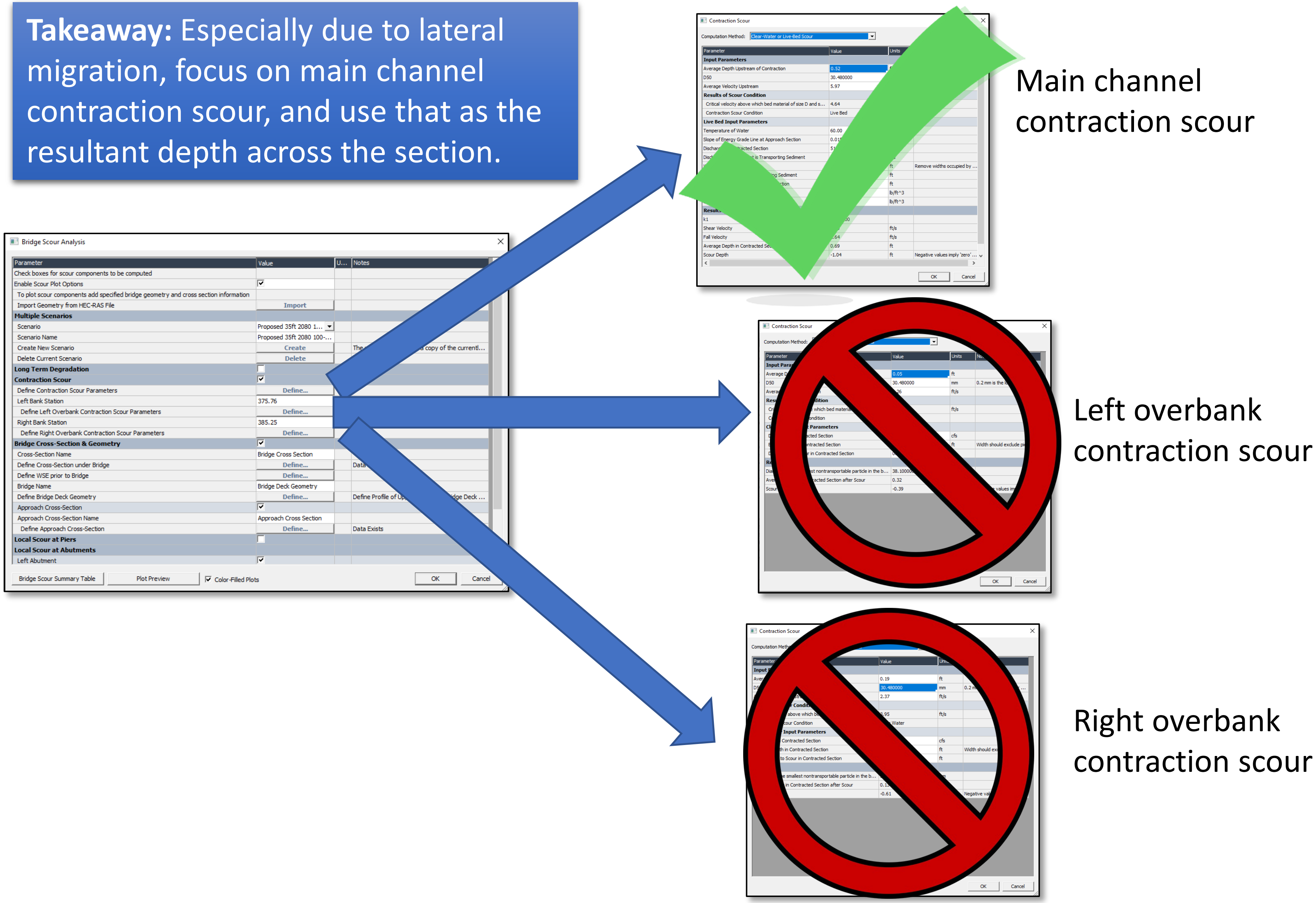


4. Evaluating Contraction Scour for Clear-Water Overbanks (cont…)



4. Evaluating Contraction Scour for Clear-Water Overbanks (cont…)

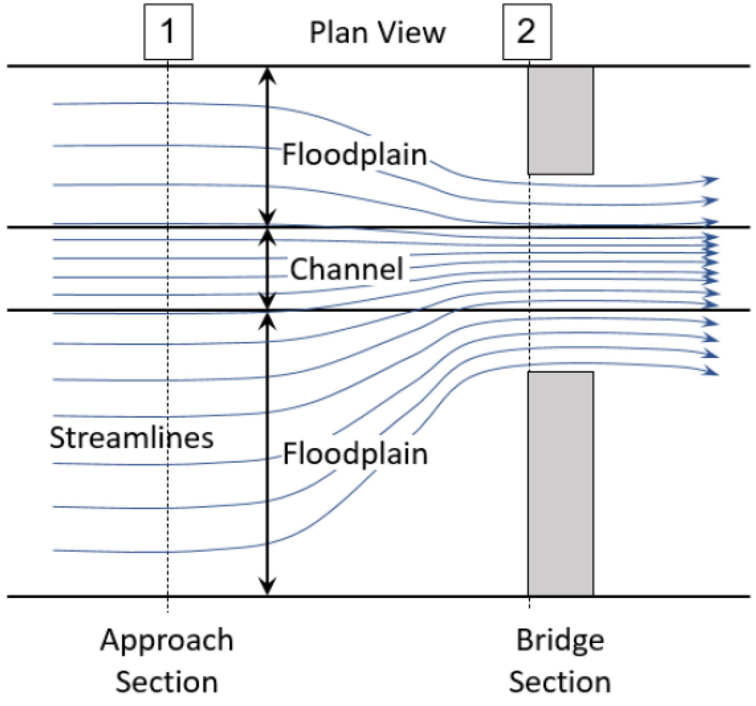
Takeaway: Especially due to lateral migration, focus on main channel contraction scour, and use that as the resultant depth across the section.



4. Evaluating Contraction Scour for Clear-Water Overbanks (cont…)

Computing Contraction Scour

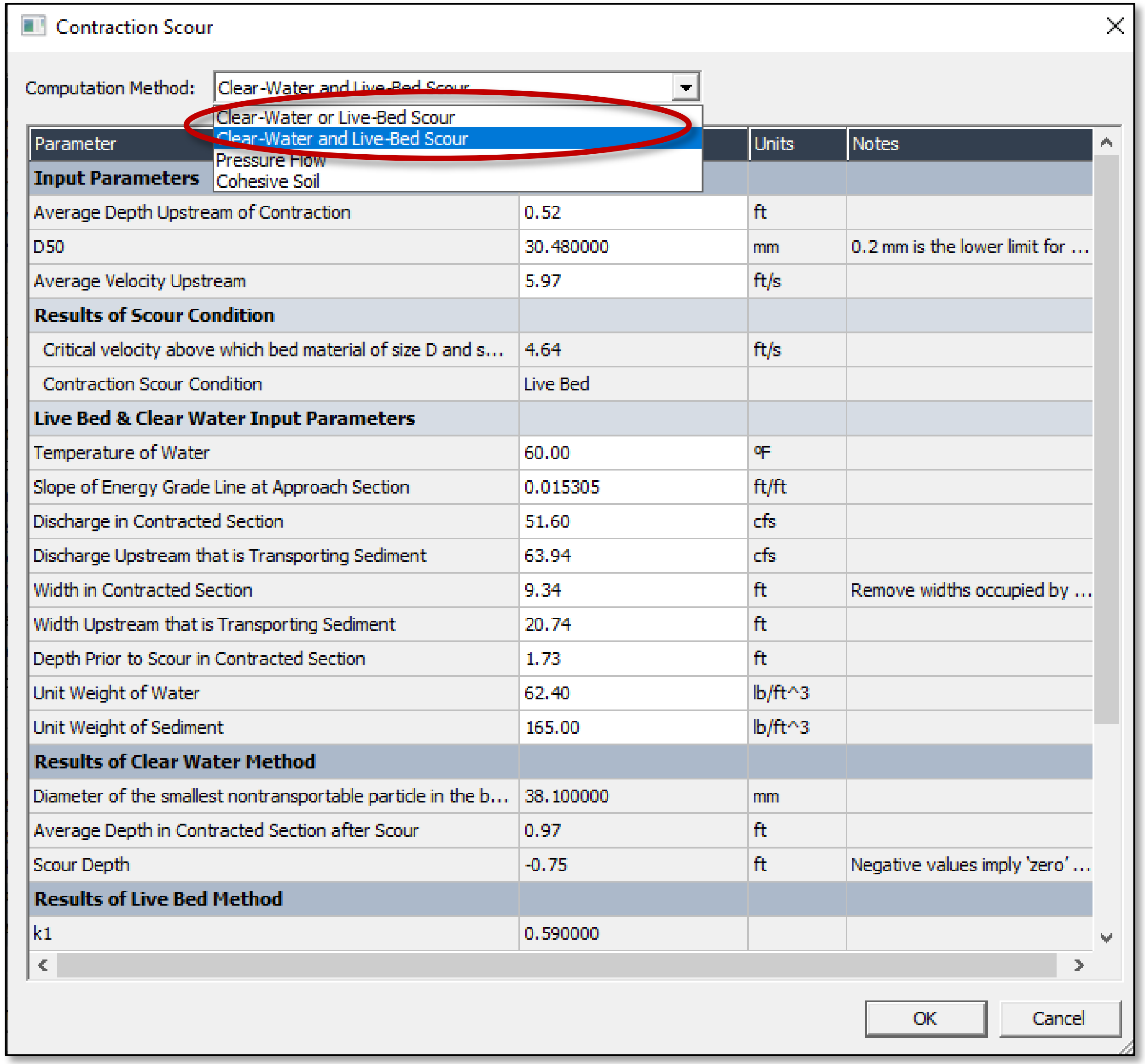
- **Main channel vs overbank contraction scour:**
  - Separate processes / separate computations
  - If the main channel can migrate to either abutment, the channel scour is used and the floodplain contraction scour is typically ignored.
  - Main channel contraction scour is likely live-bed scour, but clear-water scour may occur
  - Overbank contraction scour is predominantly clear-water scour when the overbanks are vegetated (i.e. secondary and relief structures)



5. Live-Bed vs. Clear-Water Contraction Scour

- With course sediments, live-bed conditions should be computed using BOTH live-bed and clear-water scour approaches....**use the lesser (smaller) of the two result values (use “and” pulldown in HT).** HEC-18 p. 6.11, Note 8

- Where clear-water conditions prevail everywhere near crossing, **okay to use just clear-water equation (ok to use “or” pulldown in HT)**

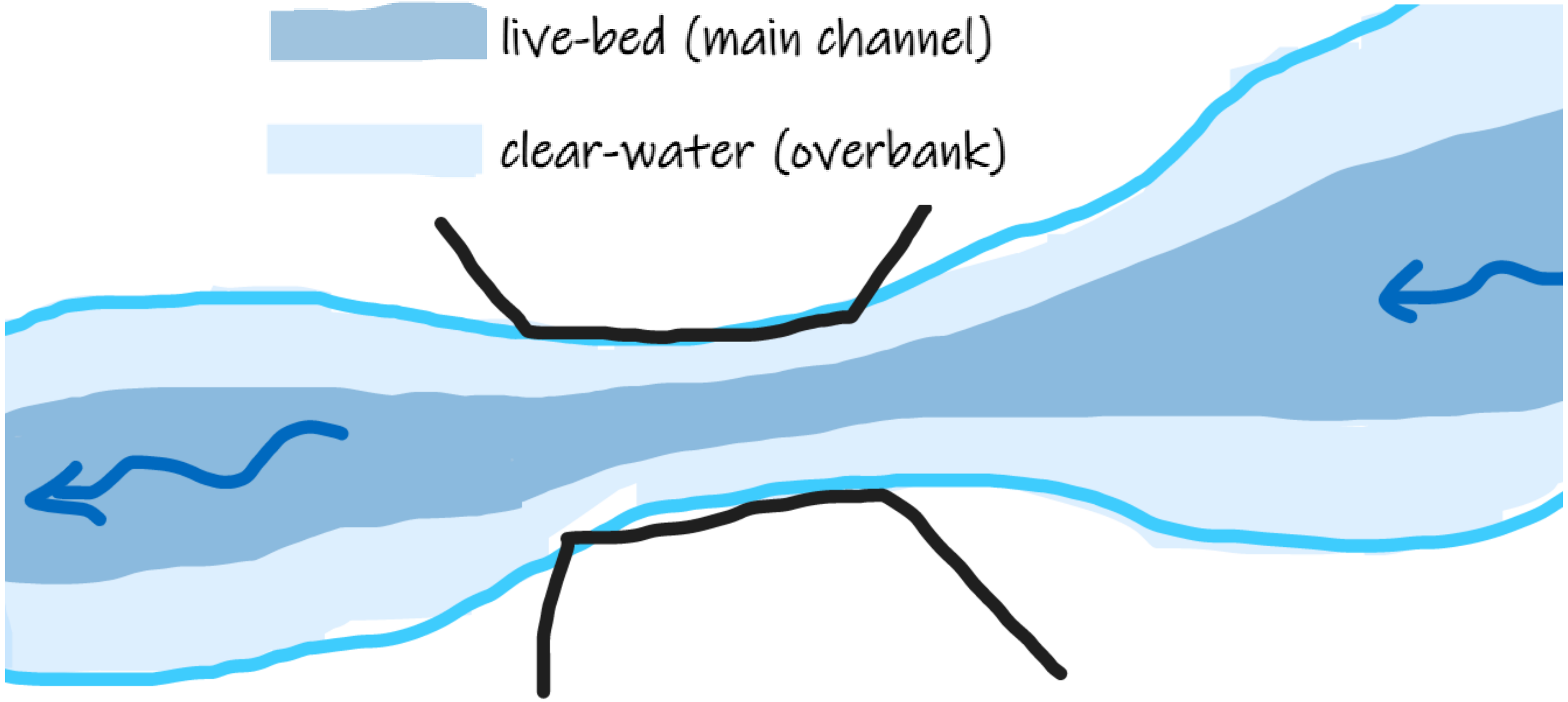


Abutment Scour

6. NCHRP abutment scour – Live-Bed vs. Clear-Water

- Designer to determine if <u>abutment toes</u> are in live-bed or clear-water portion of flow.
- Traditionally narrow bridge with wide floodplains often mean the live-bed prevails everywhere through crossing.
- Wider crossings may have clear-water overbanks.

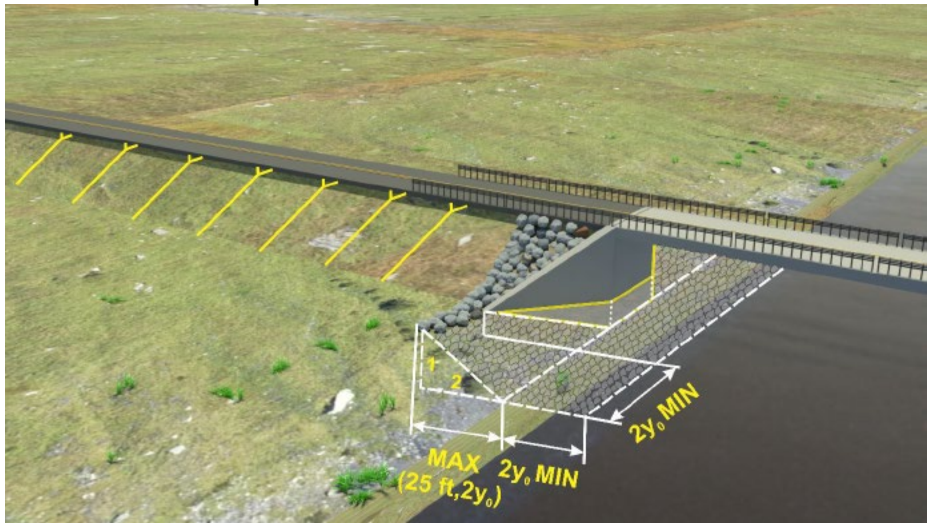
Takeaway: Unless clear-water conditions prevail everywhere, lateral migration potential dictates that you use live-bed NCHRP equation.



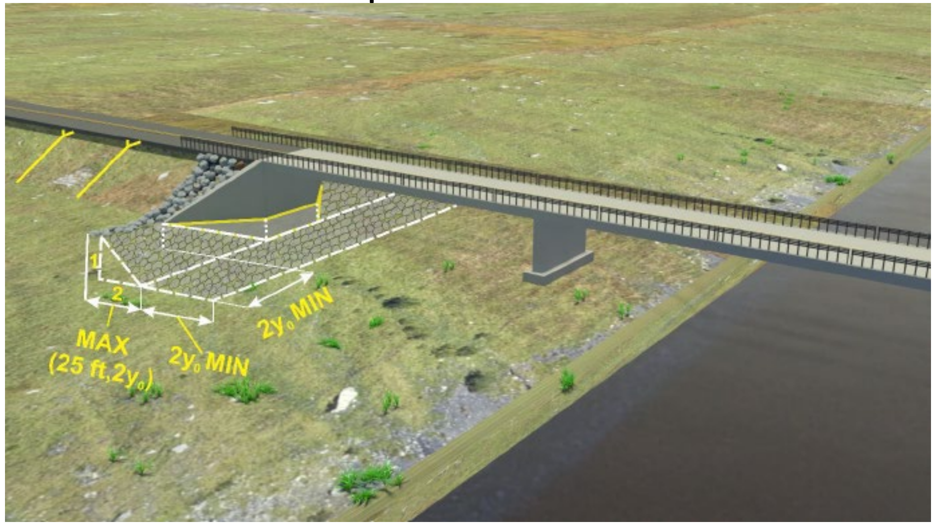
7. NCHRP Abutment Scour – Scour Condition A or B

- Scour Condition relates to how close the abutment toes are to the main channel.
- Some language in HEC-18 on how to determine Scour Condition (i.e., L/B_f ratio) – don't worry too much about this language.
- Selection of Scour Condition guides input parameters and amplification factors
- Scour Condition is independent from sediment transport regime (i.e., live-bed or clear-water).

Scour Condition A uses main channel hydraulic values to compute abutment scour depths.



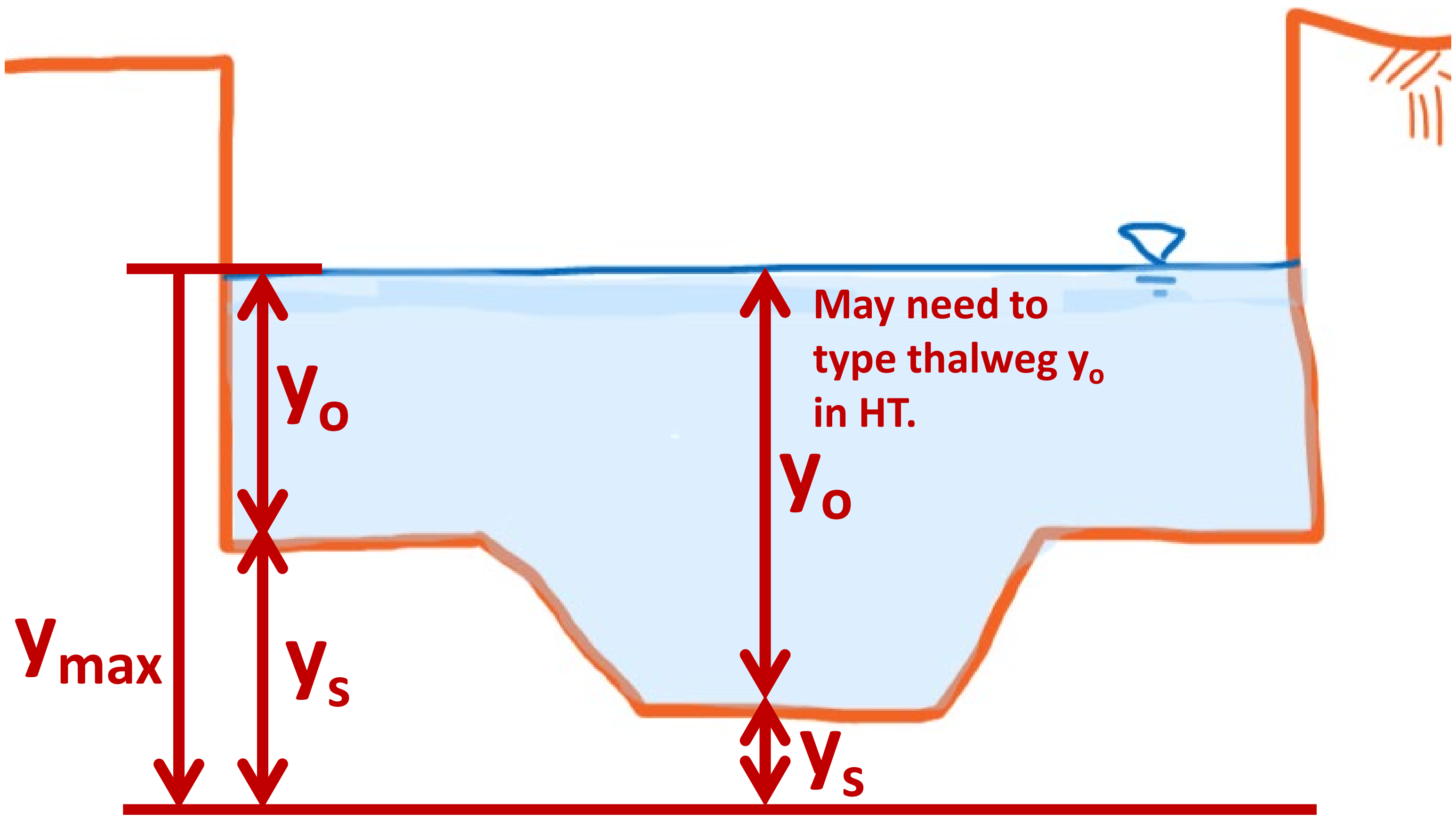
Scour Condition B uses overbank channel hydraulic values to compute abutment scour depths.

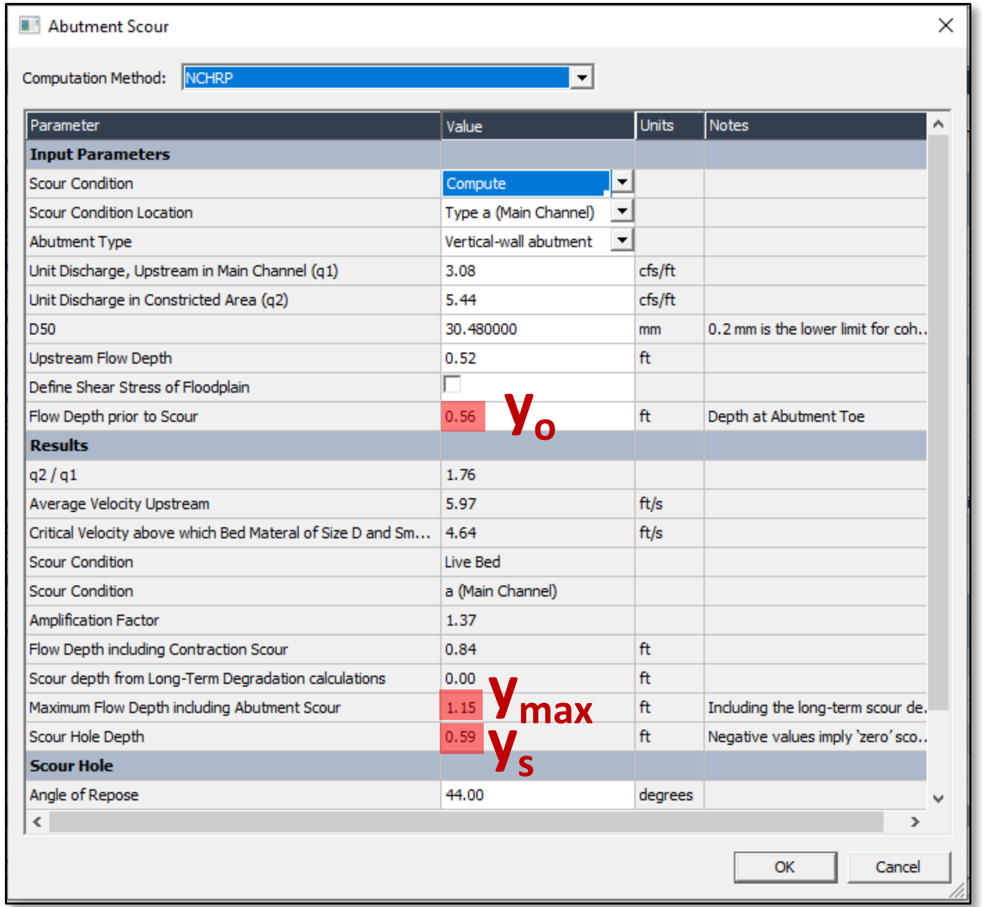


Takeaway: For crossings with abutment toes near to the main channel and/or if the crossing is likely to experience lateral migration, Scour Condition A should be used and selected in both SMS and HT.

8. NCHRP Abutment Scour - Elevations vs. Depths

- Depths and elevations are related
- Depth requires a carefully-communicated reference point
- PHD tables use thalweg as a reference point for reported scour depths
- Delivery teams need to understand NCHRP result terms (y_{max} and y_s)
  - y_o is the before-scour flow depth at the location in which you drew your SMS abutment arcs.
  - $y_{max} = \alpha_A \, y_c$ is the maximum after-scour equilibrium depth, measured down from water surface. **Use this value!**
  - y_s is the additional scour hole depth at the location in which you drew your SMS abutment arcs.

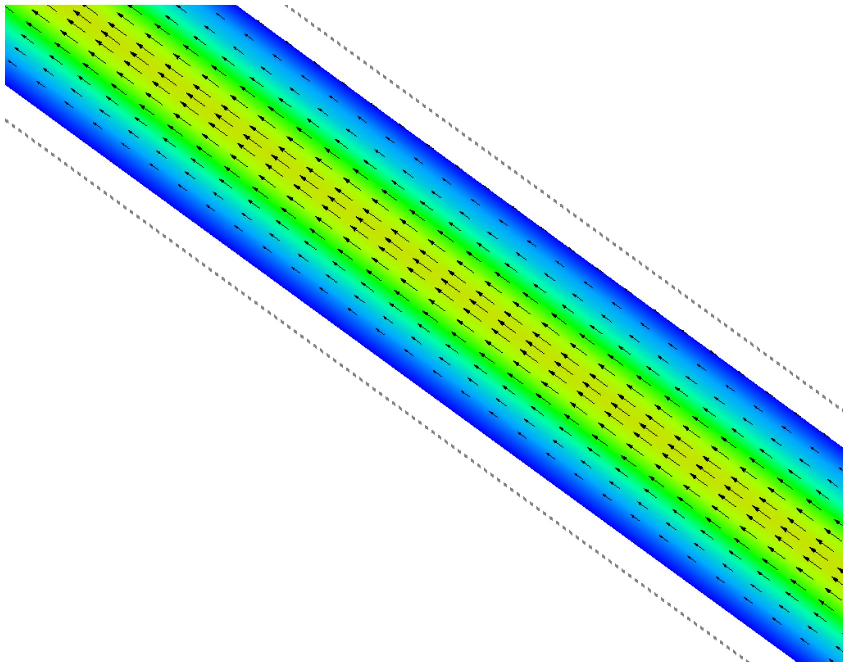


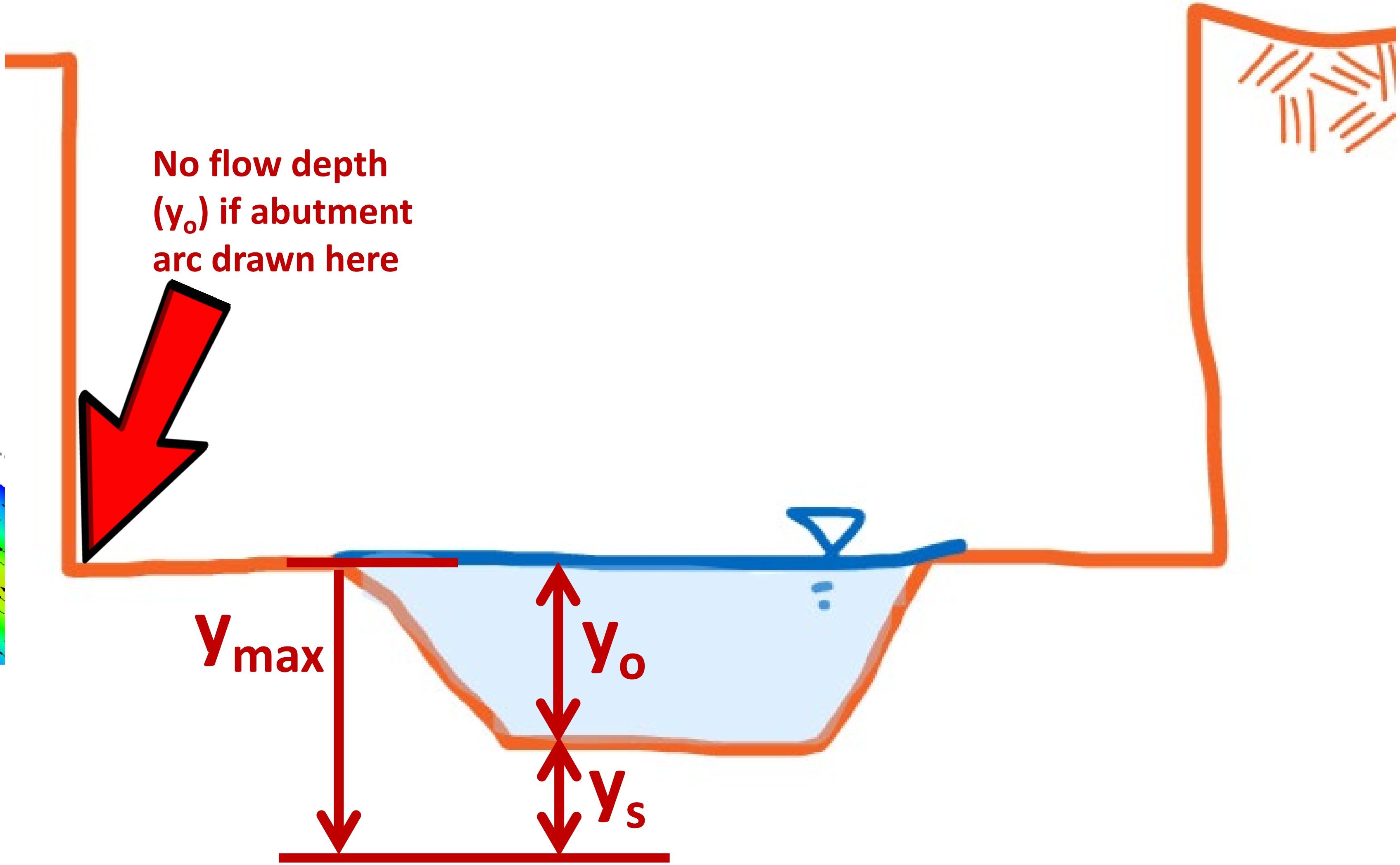


Parameter	Value	Units	Notes
Input Parameters			
Scour Condition	Compute		
Scour Condition Location	Type a (Main Channel)		
Abutment Type	Vertical-wall abutment		
Unit Discharge, Upstream in Main Channel (q1)	3.08	cfs/ft	
Unit Discharge in Constricted Area (q2)	5.44	cfs/ft	
D50	30.480000	mm	0.2 mm is the lower limit for coh..
Upstream Flow Depth	0.52	ft	
Define Shear Stress of Floodplain	☐		
Flow Depth prior to Scour	0.56	ft	Depth at Abutment Toe
Results			
q2 / q1	1.76		
Average Velocity Upstream	5.97	ft/s	
Critical Velocity above which Bed Materal of Size D and Sm...	4.64	ft/s	
Scour Condition	Live Bed		
Scour Condition	a (Main Channel)		
Amplification Factor	1.37		
Flow Depth including Contraction Scour	0.84	ft	
Scour depth from Long-Term Degradation calculations	0.00	ft	
Maximum Flow Depth including Abutment Scour	1.15	ft	Including the long-term scour de.
Scour Hole Depth	0.59	ft	Negative values imply 'zero' sco..
Scour Hole			
Angle of Repose	44.00	degrees	

8. NCHRP Abutment Scour - Elevations vs. Depths (cont…)

- SMS abutment arcs are <u>only</u> used to obtain a flow depth y_o, yield a scour hole depth y_s, and draw a graphical scour hole on the SMS plot
- HT requires a non-zero value for y_o to compute abutment scour y_{max} and y_s
- <u>If you decide you need to compute abutment scour</u>, manually type in y_o value at thalweg in HT to get computed results, including y_s relative to thalweg

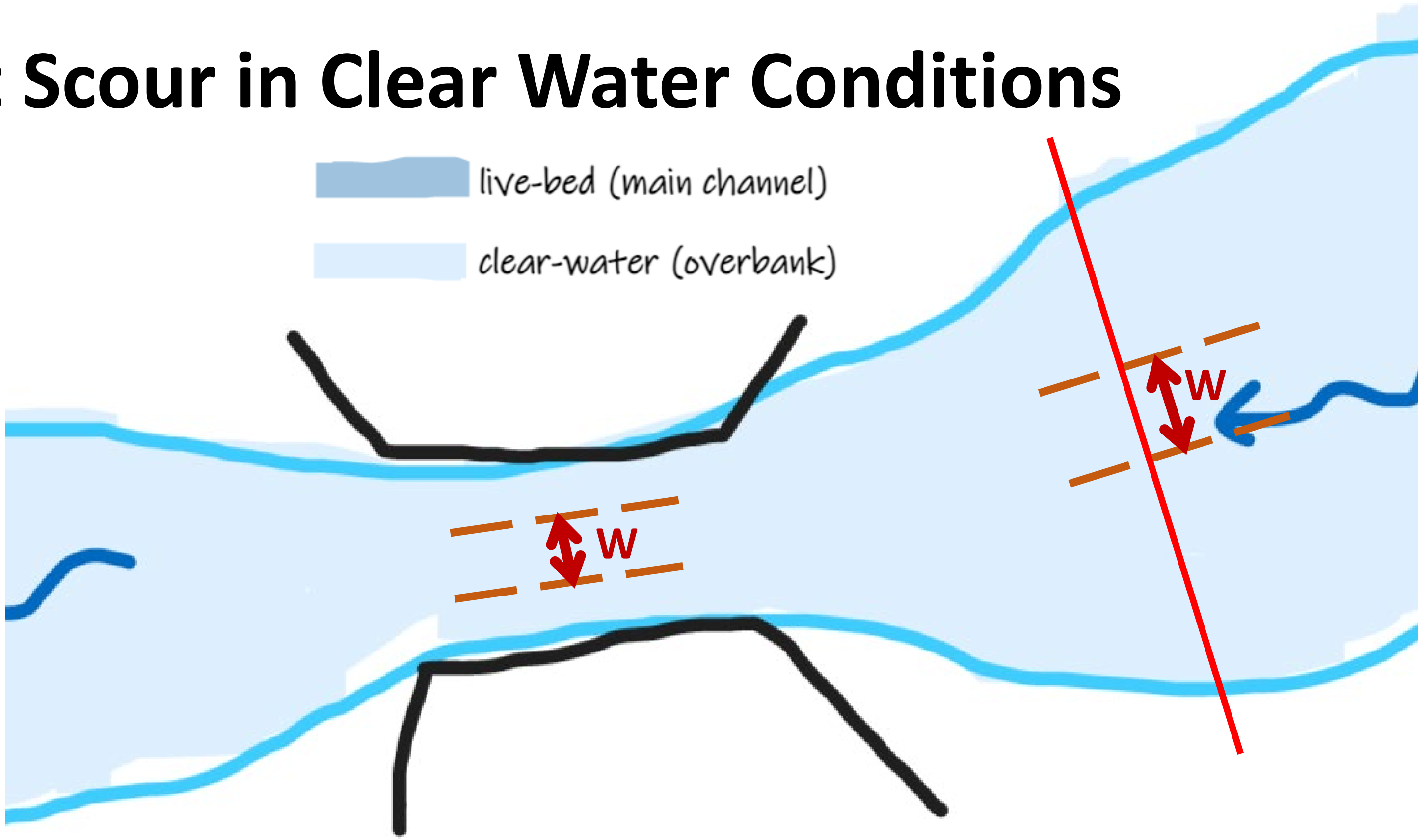




SMS Scour Arcs

9. Contraction and Abutment Scour in Clear Water Conditions

- In some crossings, larger D_{50} values combined with lower flows and velocities may result in clear-water conditions that prevail everywhere in the crossing
- Per the 2012 (5th) edition of HEC-18, contraction scour equation 6.4 states to use the full flow width or bridge span as width parameter "W"
  - This is aging guidance – **do not do this**.
  - Instead, establish main channel bank arcs using topobathymetry (top or toe of bank to same on opposite side) – SMS/HT will take care of the rest
  - Establish these main channel bank arcs beneath the bridge, but also at upstream approach (for NCHRP abutment needs…see #10)



10. NCHRP Abutment Scour – Unit Discharges

- Unit discharges in SMS are also currently based on flow divided by a width parameter
  - Contracted-section unit discharge (q_2)
  - Upstream unit discharge (q_1)
- Again, SMS bank arcs are drawn by the designer to delineate the "main channel" area both beneath the bridge and at the upstream approach
- Use consistent methods to locate your contracted and upstream bank arcs
- 2012 (5^{th})edition of HEC-18 includes some aging guidance (e.g., for Scour Condition A, HEC-18 equations 8.5 and 8.6 state to use full bridge span or full flow width)
  - **Don't do this**….current guidance for Scour Condition A is handled by SMS, and uses the width inside of the SMS bank arcs you've drawn
  - Again, SMS bank arcs to be developed based on an assessment of topobathymetry, field knowledge, vegetation, and live-bed areas.

10. NCHRP Abutment Scour – Unit Discharges (cont…)

Guidance for Unit Discharges for NCHRP 24-20 Abutment Scour				
Sediment Transport Regime at Abutment Toe	Scour Condition	Unit Discharge Parameter	How the 2012 5th edition of HEC-18 says to compute unit discharge	What SMS/HT do
live-bed	**A**	Contracted section (q_2)	Total discharge beneath bridge divided by lesser of flow width or bridge span (excluding overtopped flows). NOTE: This guidance is outdated per more recent FHWA guidance.	If interior bank arcs are drawn, SMS does not use bridge span width per older 2012 guidance. Instead, SMS uses flow and width under bridge inside of bank arcs (**main channel**). Designer to verify that main channel hydraulic values are being used.
		Upstream approach section (q_1)	Upstream **main channel** width divided by associated upstream main channel flow	If interior bank arcs are drawn, SMS follows HEC-18 guidance. SMS uses upstream flow and width inside of bank arcs (**main channel**). Designer to verify that main channel hydraulic values are being used.
	B	Contracted section (q_2)	Left or right **overbank** discharge under bridge divided by associated overbank width under bridge (excluding overtopped flows)	By virtue of correctly-drawn bank arcs, SMS uses HEC-18 guidance. SMS uses left or right **overbank** flow and width under bridge. Designer to verify that overbank hydraulic values are being used.
		Upstream approach section (q_1)	Left or right upstream **overbank** discharge divided by associated upstream overbank width	By virtue of correctly-drawn bank arcs, SMS uses HEC-18 guidance. SMS uses left or right **overbank** flow and width at upstream approach. Designer to verify that overbank hydraulic values are being used.
clear-water*	**A**	Contracted section (q_2)	Total discharge beneath bridge divided by lesser of flow width or bridge span (excluding overtopped flows). NOTE: This guidance is outdated per more recent FHWA guidance.	If interior bank arcs are drawn, SMS does not use bridge span width per older 2012 guidance. Instead, SMS uses flow and width under bridge inside of bank arcs (**main channel**). Designer to verify that main channel hydraulic values are being used.
		Upstream approach section (q_1)	**No clear written guidance in HEC-18.** Likely should use upstream **main channel** width divided by associated upstream main channel flow. No clear guidance if entire approach cross-section is clear-water.	If interior bank arcs are drawn, SMS uses upstream flow and width inside of bank arcs (**main channel**). Designer to verify that main channel hydraulic values are being used.
	B	Contracted section (q_2)	Left or right **overbank** discharge under bridge divided by associated overbank width under bridge. No clear guidance if entire bridge cross-section is clear-water.	If interior bank arcs are drawn, SMS follows HEC-18 guidance. SMS uses flow and width of left or right **overbank** under bridge. Designer to verify that overbank hydraulic values are being used.
		Upstream approach section (q_1)	**No clear written guidance in HEC-18**. Likely should use left or right **overbank** discharge at upstream approach divided by associated upstream overbank width.	If interior bank arcs are drawn, SMS uses upstream flow and width of left or right **overbank**. Designer to verify that overbank hydraulic values are being used.

*Abutments may be located in clear-water overbanks. In the event that clear-water conditions prevail across the entire river section, a main channel should still be delineated both upstream and in the contracted section via SMS bank arcs based on topobathymetry (e.g., top of bank to top of bank, or bank toe to bank toe).