TEXAS TECH UNIVERSITY
Multidisciplinary Research in Transportation

PROJECT SUMMARY

Texas Department of Transportation

0-6841: Modeling a Change in Flowrate through Detention or Additional Pavement on the Receiving Stream

Background

The synthesis project developed guidance to identify distances relative to some common metric where model boundaries should be established—beyond these distances, hydraulic calculations based on the simpler slope-area method would apply; within these distances, hydraulic modeling using HEC-RAS, WSPRO, or similar tools would be appropriate for precise description of water surface elevations and force calculations. The principal research question was: "What would be the minimum required upstream and downstream model extents required for hydraulic modeling of bridge crossings on rivers and wide creeks?"

What the Researchers Did

A literature review and a generic modeling study were conducted to address the question posed above by scenario modeling several conditions. The results of the HEC-RAS modeling study were used to develop a tool to estimate model boundary distances in conjunction with similar guidance from the literature. The tool itself reports distances from four rules—three from literature interpretation and one for the study-specific modeling.

Figure 1 is a screen capture of the estimation interface tool that implements the rule(s)-of-thumb for a minimal description of the channel hydraulics.

What They Found

The literature review identified three broad categories of guidance ranging from a vague "far enough" to a prescriptive 200 meters. An intermediate category based on 20-30 characteristic lengths (the bankfull width) was also found. The generic modeling study conducted as part of the study produced results in reasonable agreement with the literature guidance, although the numerical values differ.

The estimation tool will return four distance estimates:

(a) An estimate based on the modeling study in this document;

(b) An estimate based on Wildland Hydrology Inc. (2013);

(c) An estimate based on Nebraska Department of Roads (2015); and

(d) An estimate based on Samuels (1989), Castellarin et al. (2009), and a rule-of-thumb for physical models that approximately 40 characteristic lengths is sufficient for full flow development. The characteristic length used was channel width.

What This Means

A designer can support their judgment on modeling boundary distances using rules-of-thumb derived from the literature and a targeted modeling study.

If the flow addition or change occurs within the smallest distances supplied by the estimation tool, then a hydraulic model of the structure and surrounding stream is indicated—and the distances to the model boundaries can be specified.

If the flow addition or change occurs beyond the largest distances supplied by the estimation tool, then simplified hydraulics, if otherwise applicable, are sufficient.

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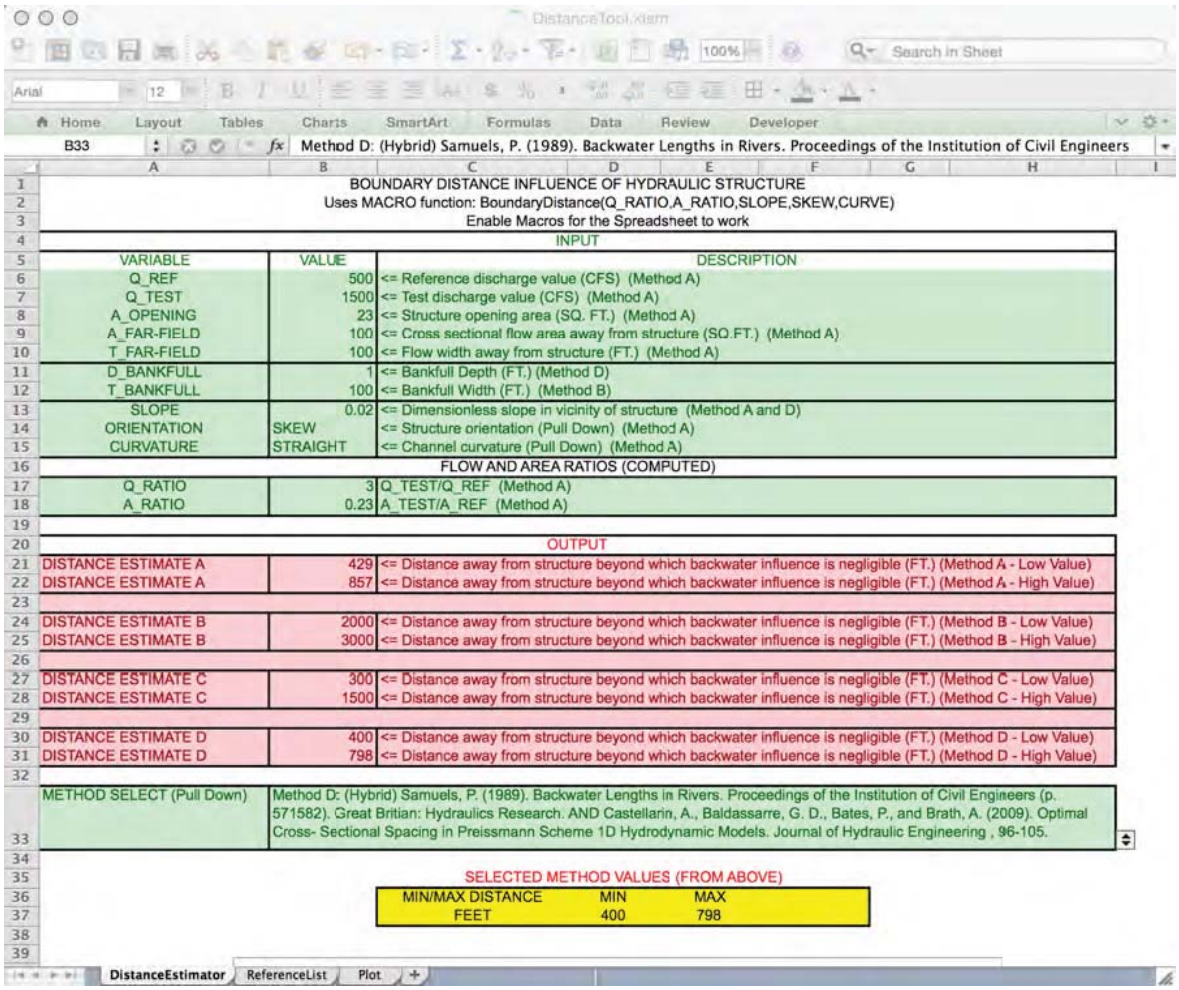

	A	B	C
1	BOUNDARY DISTANCE INFLUENCE OF HYDRAULIC STRUCTURE		
2	Uses MACRO function: BoundaryDistance(Q_RATIO,A_RATIO,SLOPE,SKEW,CURVE)		
3	Enable Macros for the Spreadsheet to work		
4	INPUT		
5	VARIABLE	VALUE	DESCRIPTION
6	Q_REF	500	<= Reference discharge value (CFS) (Method A)
7	Q_TEST	1500	<= Test discharge value (CFS) (Method A)
8	A_OPENING	23	<= Structure opening area (SQ. FT.) (Method A)
9	A_FAR-FIELD	100	<= Cross sectional flow area away from structure (SQ.FT.) (Method A)
10	T_FAR-FIELD	100	<= Flow width away from structure (FT.) (Method A)
11	D_BANKFULL	1	<= Bankfull Depth (FT.) (Method D)
12	T_BANKFULL	100	<= Bankfull Width (FT.) (Method B)
13	SLOPE	0.02	<= Dimensionless slope in vicinity of structure (Method A and D)
14	ORIENTATION	SKEW	<= Structure orientation (Pull Down) (Method A)
15	CURVATURE	STRAIGHT	<= Channel curvature (Pull Down) (Method A)
16	FLOW AND AREA RATIOS (COMPUTED)		
17	Q_RATIO	3	Q_TEST/Q_REF (Method A)
18	A_RATIO	0.23	A_TEST/A_REF (Method A)
19			
20	OUTPUT		
21	DISTANCE ESTIMATE A	429	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method A - Low Value)
22	DISTANCE ESTIMATE A	857	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method A - High Value)
23			
24	DISTANCE ESTIMATE B	2000	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method B - Low Value)
25	DISTANCE ESTIMATE B	3000	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method B - High Value)
26			
27	DISTANCE ESTIMATE C	300	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method C - Low Value)
28	DISTANCE ESTIMATE C	1500	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method C - High Value)
29			
30	DISTANCE ESTIMATE D	400	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method D - Low Value)
31	DISTANCE ESTIMATE D	798	<= Distance away from structure beyond which backwater influence is negligible (FT.) (Method D - High Value)
32			
33	METHOD SELECT (Pull Down)	Method D: (Hybrid) Samuels, P. (1989). Backwater Lengths in Rivers. Proceedings of the Institution of Civil Engineers (p. 571582). Great Britian: Hydraulics Research. AND Castellarin, A., Baldassarre, G. D., Bates, P., and Brath, A. (2009). Optimal Cross- Sectional Spacing in Preissmann Scheme 1D Hydrodynamic Models. Journal of Hydraulic Engineering , 96-105.	
34			
35	SELECTED METHOD VALUES (FROM ABOVE)		
36	MIN/MAX DISTANCE	MIN	MAX
37	FEET	400	798
38			
39			

Figure 1. Screen capture of boundary distance estimation tool.

For More Information

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