Scour Modeling and Analysis

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Water Resources Solutions

UMKC School of Computing & Engineering

Objectives

- Advocate for more common usage of advanced modeling for Bridge Scour analysis.

- Outline a strategy for efficient reduction of uncertainty in hydraulic design using the three-level approach

- List advantages to integrated physical/numeric modeling

John Weeks Bridge Greenville MS US 82/287

Level 3 Analysis Tools

- Two-Dimensional hydraulic models
- Physical models
- 3-dimensional and Sediment Transport models

Why are these not used more?

Common beliefs:

- Expensive
- Requires special equipment
- Requires a large laboratory

Hec-18-20 Three-level approach

More emphasis on using 2-dimensional models as the technology has matured. Also guidelines on when to use have been developed:

FHWA HDS 7 –"Design of Safe Bridges"

- Improved guidance for 2-D modeling
  - Complex flow patterns
  - One-dimensional model assumptions are violated
  - Difficulty in visualizing the flow

Criteria for Selecting Hydraulic Models (Web- Only Document 106, NCHRP 2006).

- Improved guidance for 2-D modeling
- Provides for a selection worksheet.

Table 4.1. Bridge Hydraulic Modeling Selection.

Bridge Hydraulic Condition	Hydraulic Analysis Method	
	One-Dimensional	Two-Dimensional
Small streams	●	◗
In-channel flows	●	◗
Narrow to moderate-width floodplains	●	◗
Wide floodplains	◗	●
Minor floodplain constriction	●	◗
Highly variable floodplain roughness	◗	●
Highly sinuous channels	◗	●
Multiple embankment openings	◗/○	●
Unmatched multiple openings in series	◗/○	●
Low skew roadway alignment (<20˚)	●	◗
Moderately skewed roadway alignment (>20˚ and <30˚)	◗	●
Highly skewed roadway alignment (>30˚)	○	●
Detailed analysis of bends, confluences and angle of attack	○	●
Multiple channels	◗	●
Small tidal streams and rivers	●	◗
Large tidal waterways and wind-influenced conditions	○	●
Detailed flow distribution at bridges	◗	●
Significant roadway overtopping	◗	●
Upstream controls	○	●
Countermeasure design	◗	●

● well suited or primary use
◗ possible application or secondary use
○ unsuitable or rarely used
◗/○ possibly unsuitable depending on application

Other level 3 methods:

Physical Models

- Froude Scale
- Rigid Bed
- Moveable Bed

3-Dimensional Models

Sediment Transport models

Currently there is little additional guidance to recommend These techniques.

“Physical First” Strategy

Step 1: Build and Test
physical model
Determine optimal project conditions

↓

Step 2 : Two-dimensional modeling
Prototype Hydraulic Parameters
Sizes quantities and hydraulic specifications

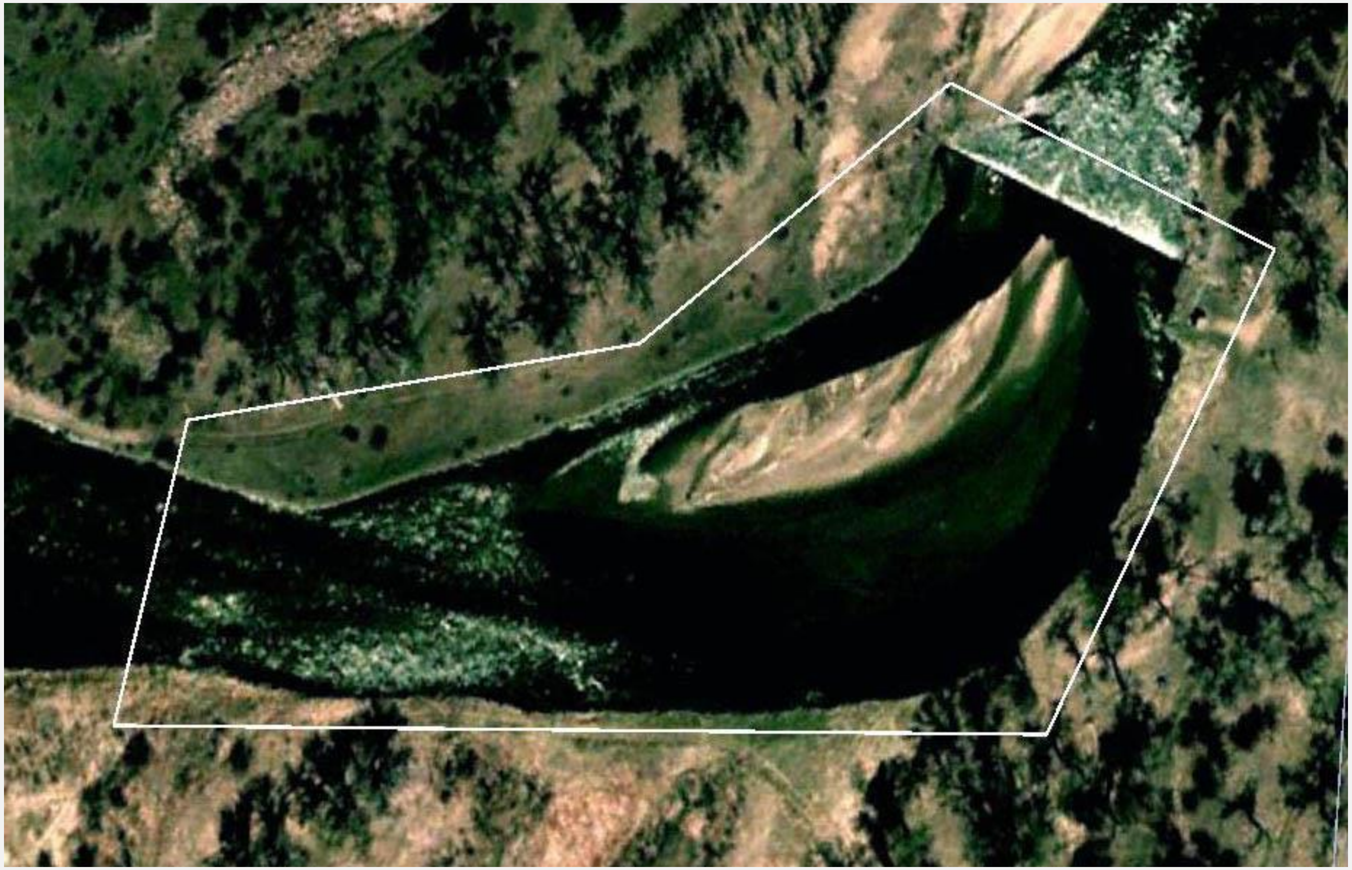
↓

Step 3: Finalize Design
Sizes quantities and
hydraulic specifications

Physical First Advantages

- Economics
- Client “ buy in”
- Unanticipated findings
- Not just for large projects

North Platte River at State Line Weir



Physical Model Scaling

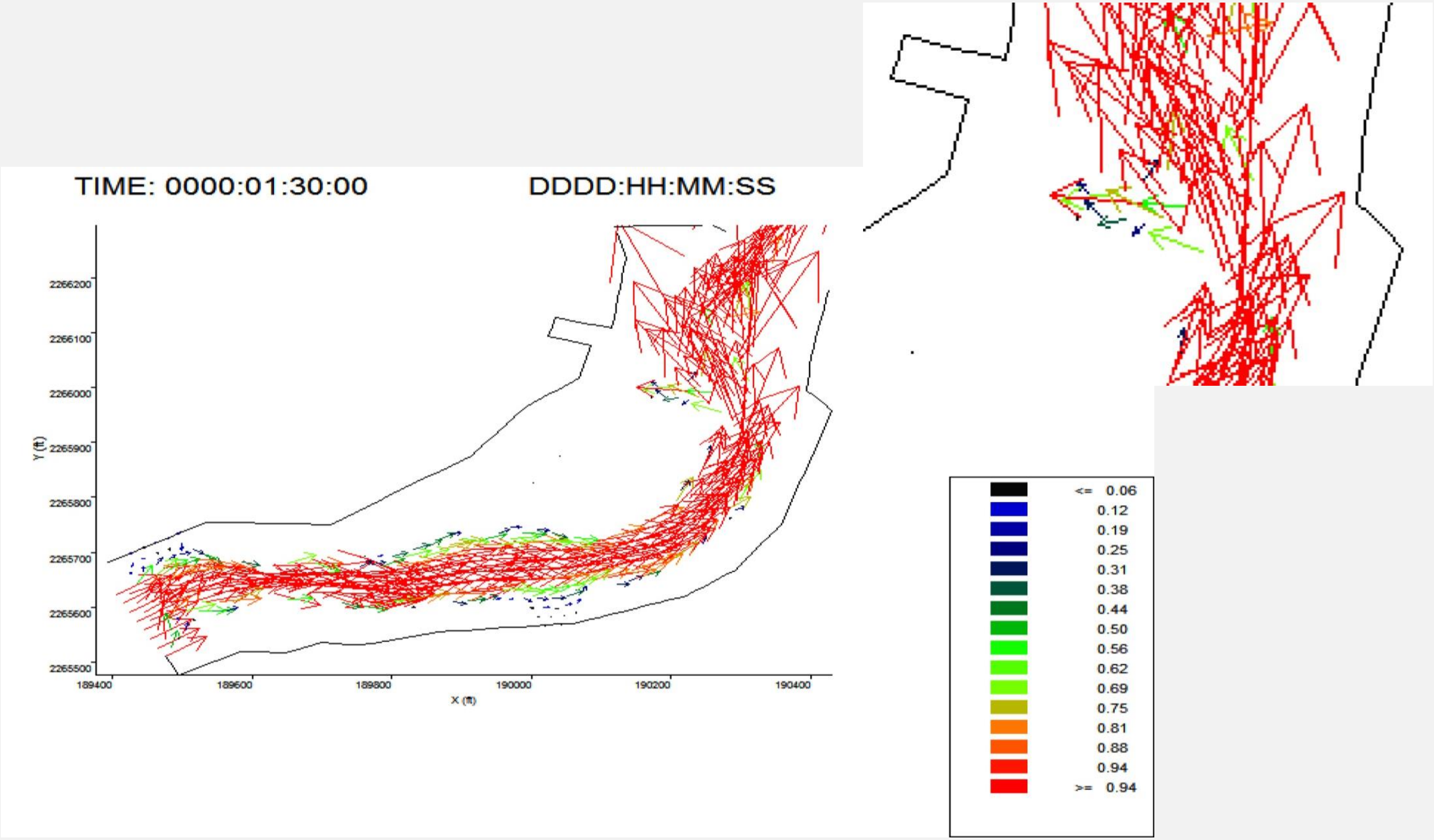
Parameter	Prototype to Model Scale Ratio
Vertical length	20:1
Horizontal Length	70:1
Time (hydraulic)	16.3:1
Time (sediment)	1,444:1
Velocity	4.5:1
Flow Rate	6300:1
Froude No.	1:1
Slope	1:3.5

Step 1: Existing conditions

Unintended findings: the Ah ha moment

Step 1: Refined Design Conditions

Step 2:Two-dimensional model



Step 3: Final Design and construction

Wow: Hydraulics were insensitive to bridge geometry.

63rd Street Bridge over Brush Creek
\$3 to \$1.5 million

Physical First Advantages

- Economics

  60 % cost reductions

- Client “ buy in”

  Tactile observable

- Unanticipated findings

  The Ah- ha moment

Other Applications

- Scour conditions during construction.
  - Large obstructions such as work platforms and coffer dams can have significant scour during construction.

Other Applications

- Parallel bridges

Conclusions

- Significantly more hydraulic tools available.
- 2-dimensional modeling should be commonly used as a part of level 2.
- More robust analysis decreases cost by reducing uncertainty.
- Integrated physical/numeric often yields significant cost savings.

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