Session 38

Max Sheppard

Ocean Engineering Associates, Inc.

Improved Contraction & Pier Scour Methodology

Topic Description

Improved Contraction & Pier Scour Methodology: A number of improvements in the methods for predicting local scour at complex piers and contraction scour in coastal waters have been made during the last two years as a result of additional analysis and laboratory tests. These improvements are outlined and discussed in this presentation. In particular there have been significant improvements in the prediction of scour depth at piers on spread footers or partially (or fully) buried pile caps.

Speaker Biography

Max Sheppard is President of Ocean Engineering Associates, Inc. (OEA, Inc.) and Professor Emeritus in the Civil and Coastal Engineering Department at the University of Florida. His areas of expertise include: bridge scour, coastal hydraulics, sediment transport, coastal structures, and wave loading on coastal and offshore structures.

Session 38

Rick Renna

FL. Dept. of Transportation

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Speaker Biography

Rick Renna has worked for the Department for over 32 years, the last 19 of which have been in hydraulics design. He has pursued bridge scour research improvements sine the mid-1980s and has served as the State Hydraulics Engineer since 2001.

Improved Contraction and Pier Scour Methodology

D. Max Sheppard
OEA, Inc., University of Florida

Rick Renna
FDOT

Presentation Outline

- Contraction Scour
  - Simple boundary and bathymetry - riverine flows
  - Complex boundary and/or bathymetry flows – coastal waters
  - Wind wave impact on contraction scour
- Complex Pier Scour
  - Improved methodology
  - Partially and completely buried pile caps/footers
- Improved Scour Course

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Recent Developments in Predicting Contraction Scour

Good Bridge Design is NOT Good Enough!

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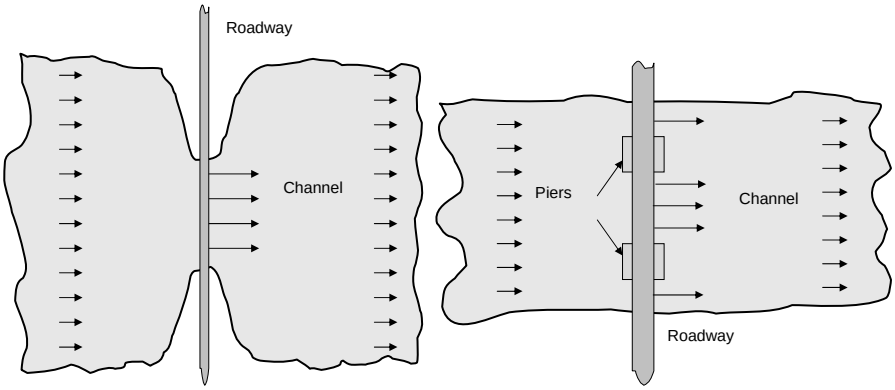
Contraction Scour



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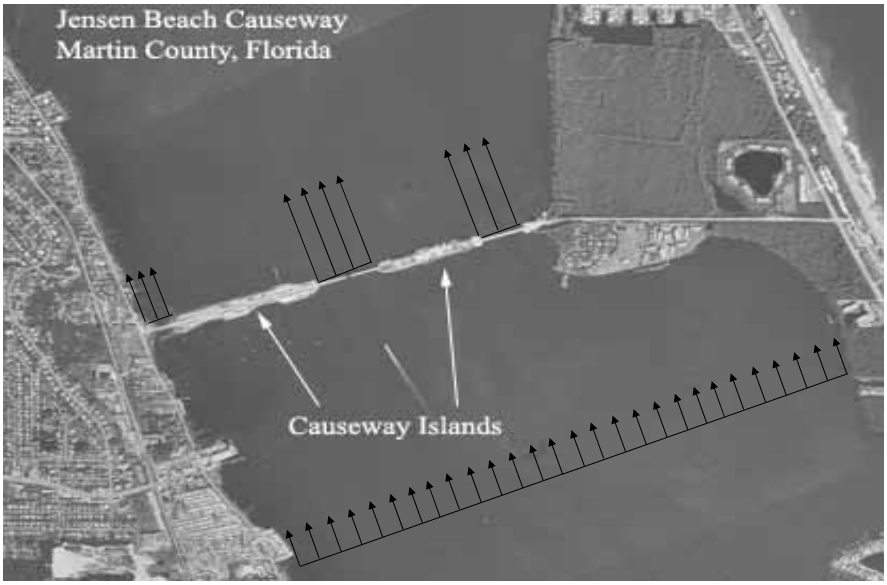
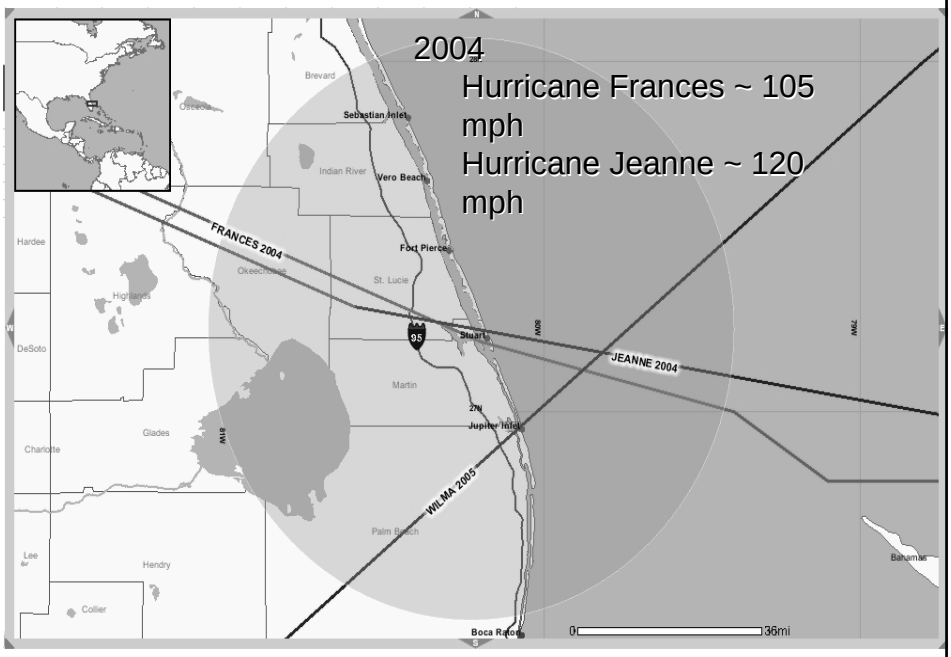
Contraction Scour



Contraction Scour Study

- Motivation – Damage from 2004 Hurricane Season
  - Availability of field data
- Compare Methodologies for Computing Contraction Scour
  - SED2D
  - Laursen equation



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2004 Hurricane Season

Hurricane Frances

Hurricane Jeanne

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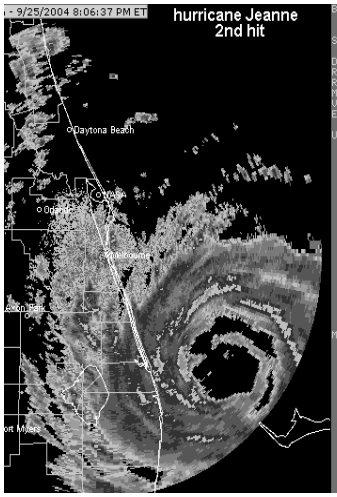
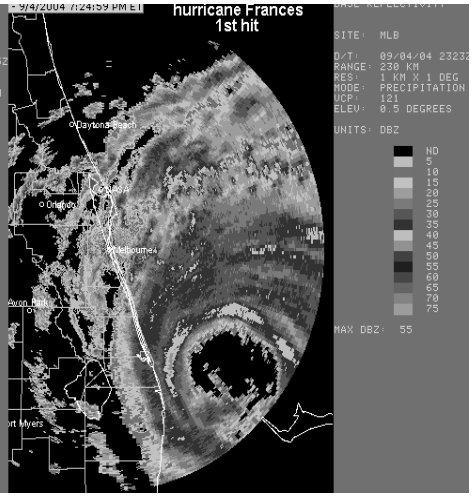
2004 Hurricane Season



Hurricane Jeanne



Hurricane Frances

After Francis

After Jeanne

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Jensen Beach Abutment

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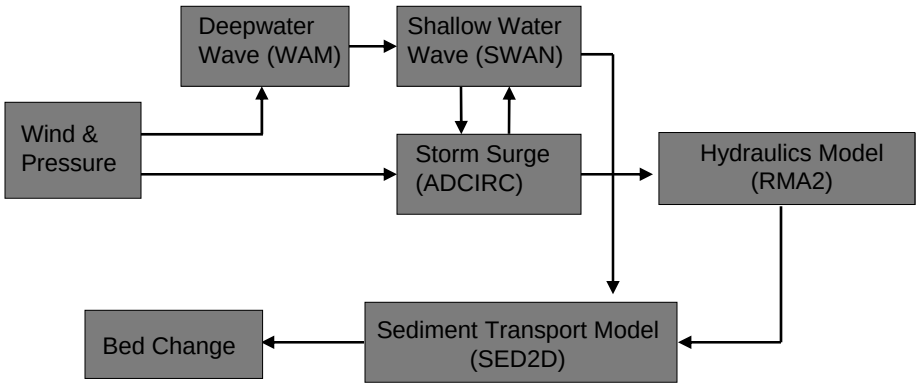
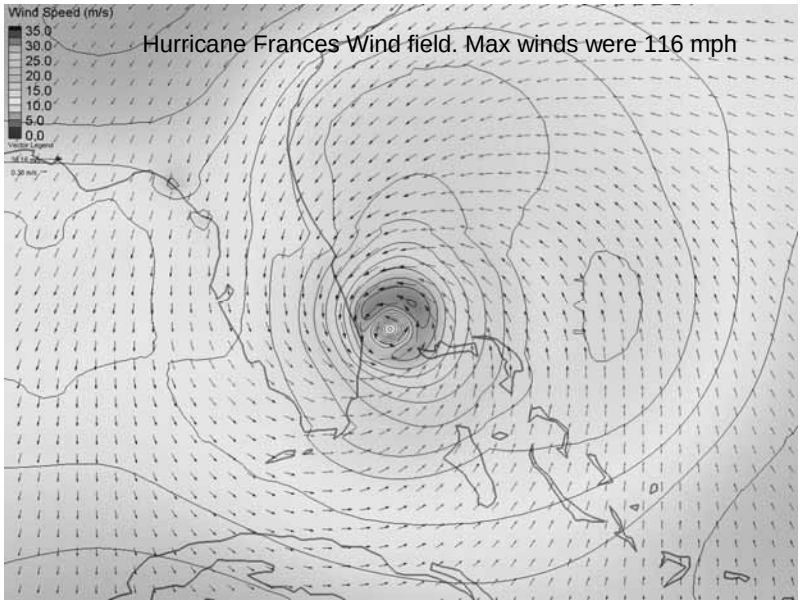
Study Procedure

- Hindcasts Storms
- Perform Sediment Transport Modeling
  - Without waves
  - With waves
- Compare with Laursen Equation

Modeling Procedure



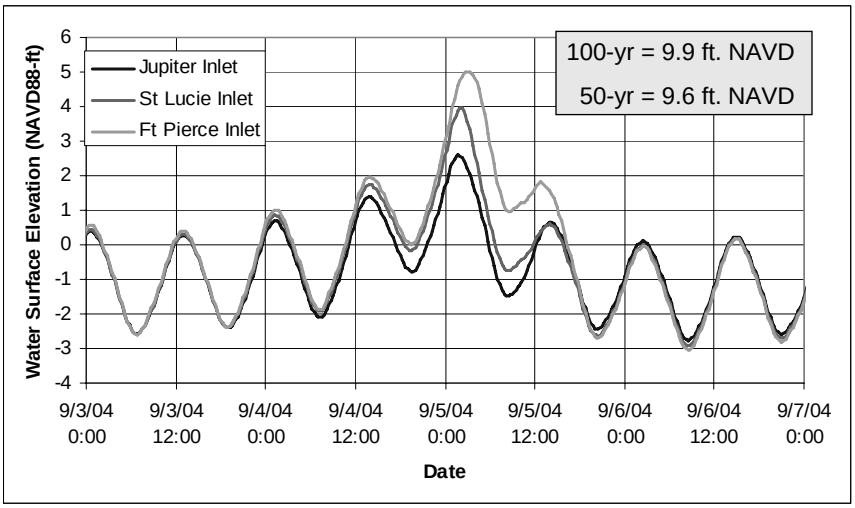


Hurricane Frances Wind field. Max winds were 116 mph

SED2D Simulations

- SED2D Modeling
  - Without Waves
  - With Waves
  - Two-way Coupling with RMA2
- SED2D with Waves Provided Best Calibration with Measured Data

Hurricane Frances Hindcast



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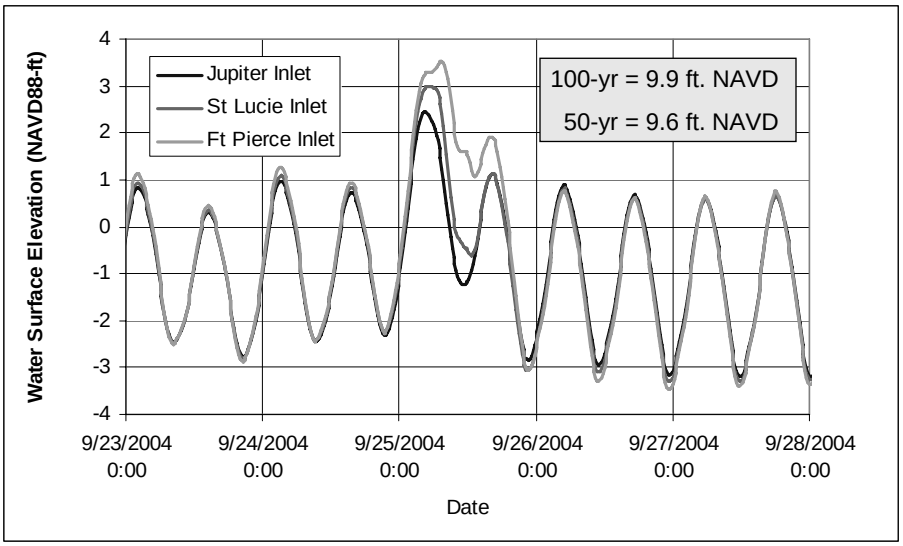
Hurricane Jeanne Hindcast



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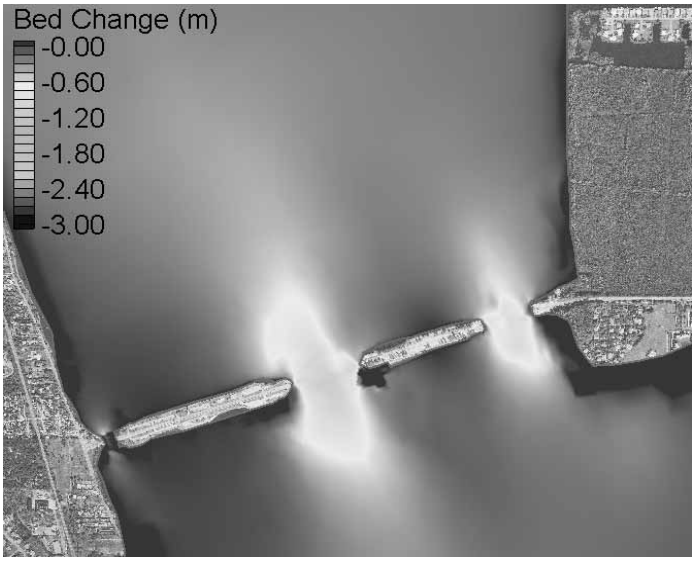
SED2D Results With Waves



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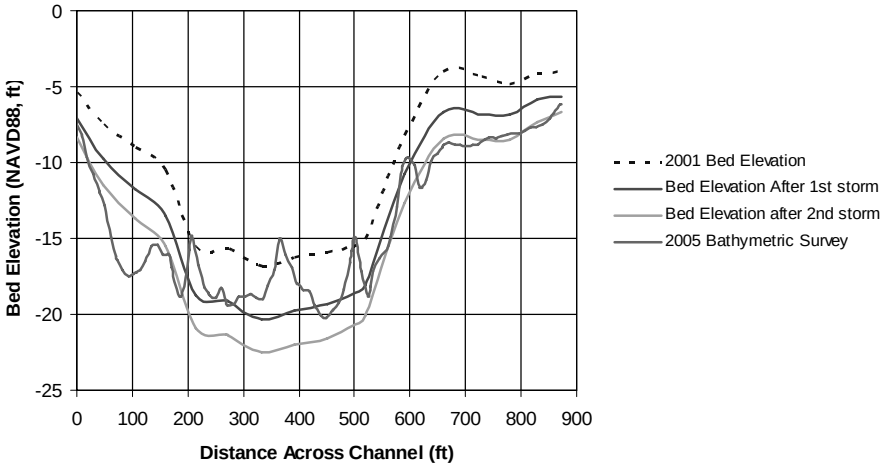
SED2D Main Channel Results with Waves



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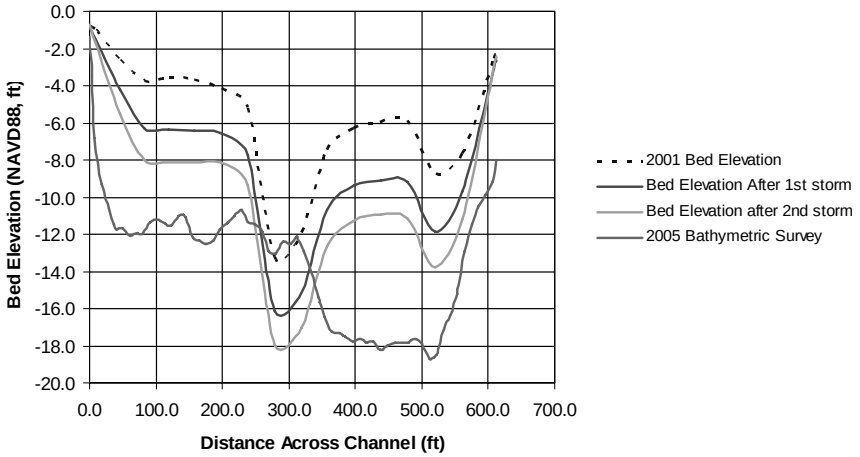
SED2D East Channel Results with Waves



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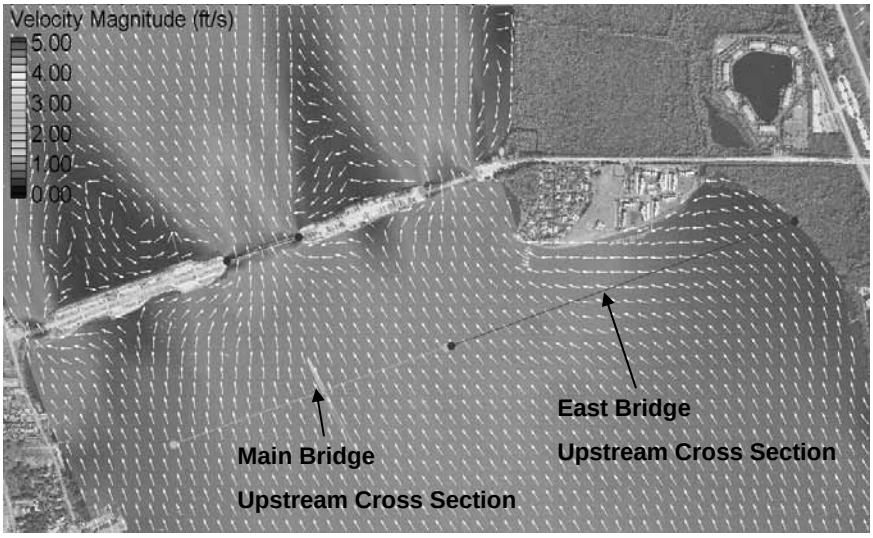
Laursen Equation



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Laursen Design Contraction Scour

- Use 100-year Storm Surge Height
- Main Bridge
  - Live Bed Contraction Scour
  - 11.4 ft
- East Bridge
  - Clearwater Contraction Scour
  - 20.8 ft

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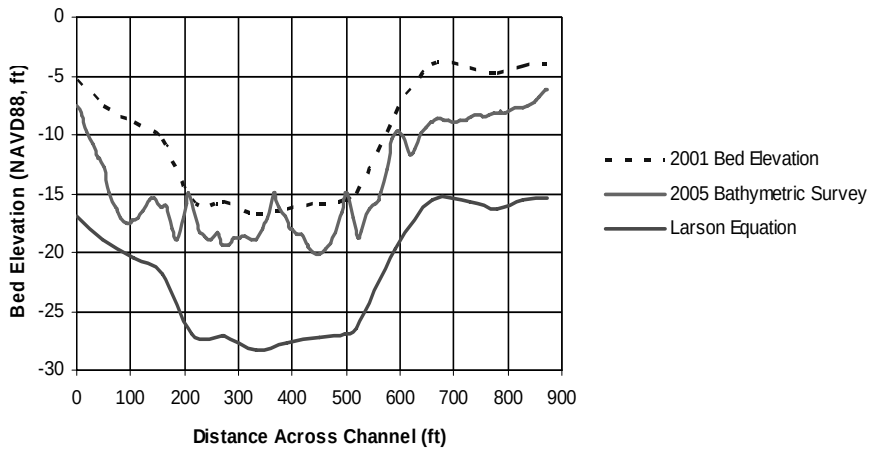
Laursen Equation – Main Channel



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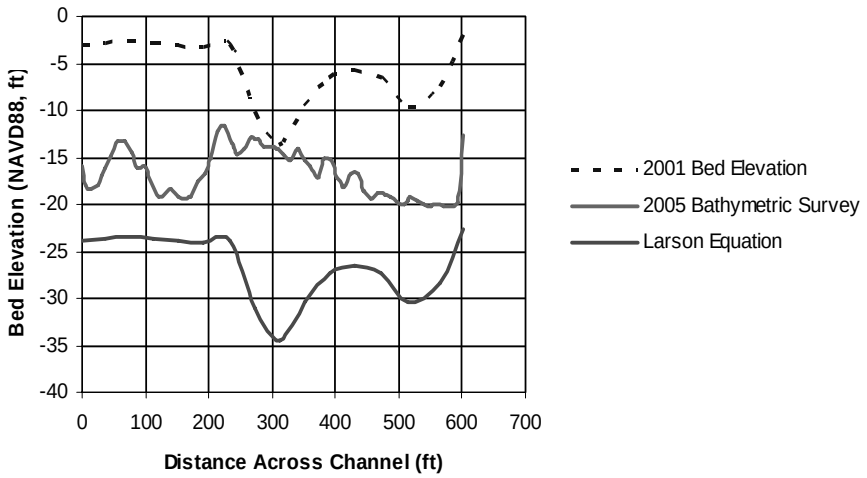
Laursen Equation - East Channel



Conclusions

- Laursen Equation Difficult to Apply for Complex Boundary/Bathymetry Flows
  - Properly applied yields conservative results
- 2D Sediment Transport Models Required for Complex Flow Situations
- Waves Can Significantly Increase Contraction Scour Depths

Improvements in Methodology for Predicting Scour at Complex Piers

Texas – April 2004

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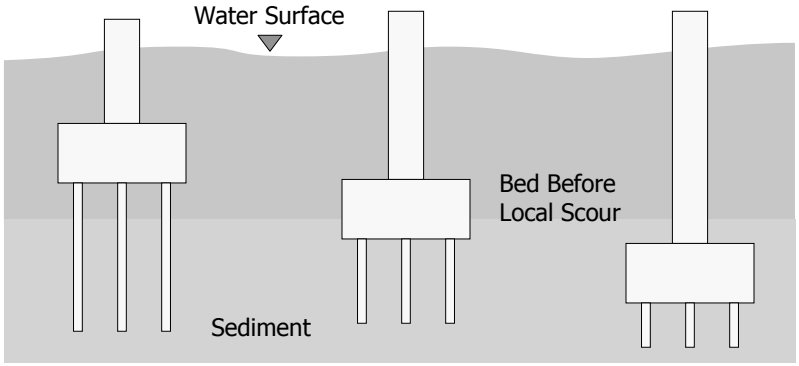
Complex Pier Classification

Case 1
Pile Cap Above the Bed

Case 2
Partially Buried Pile Cap

Case 3
Buried Pile Cap



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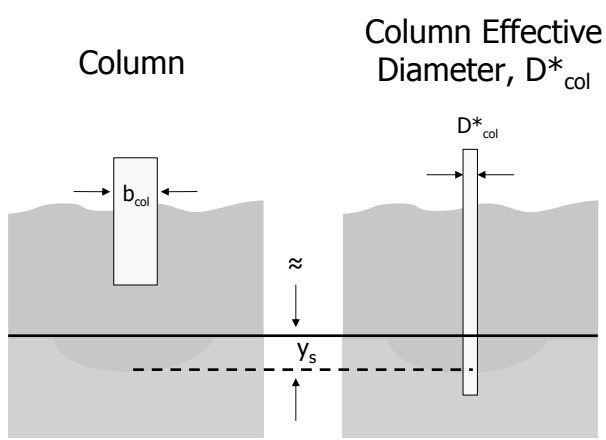
Complex Pier Scour Methodology

- Compute the effective diameter, D*, of the complex structure

where

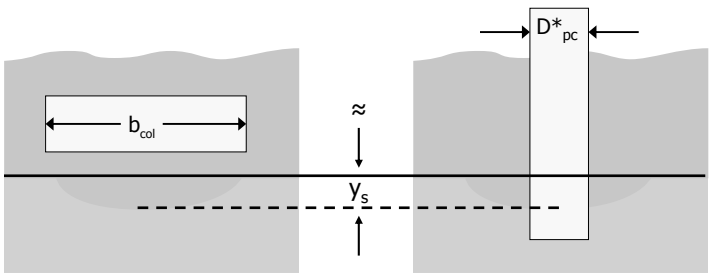
Complex Pier Scour Methodology



Complex Pier Scour Methodology

Pile Cap

Pile Cap
Effective Diameter, D^*_{pc}



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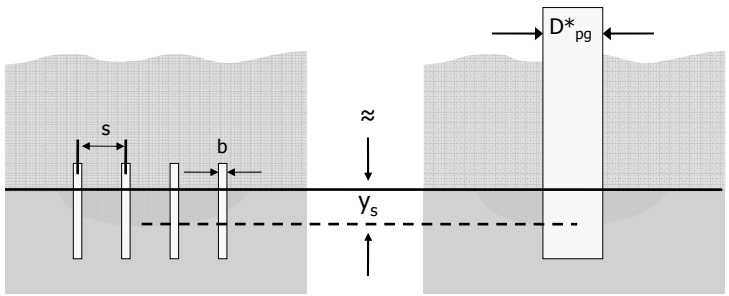
Complex Pier Scour Methodology

Pile Group

Pile Group
Effective Diameter, D^*_{pg}



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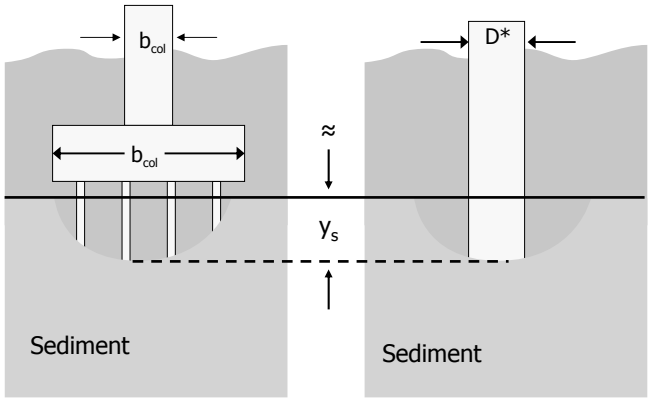
Complex Pier Scour Methodology

Complex Pier $D^* = D^*_{col} + D^*_{pc} + D^*_{pg}$



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Changes From HEC-18 Methodology

- Additional Data Available (Including Partially Buried and Buried Pile Caps)
- Compute Entire Structure Effective Diameter
- No Adjustments to Flow Velocity Required
- Flow Skew Angles Included in Effective Diameter
- Methodology Extended to Include:
  - Partially Buried Pile Caps
  - Buried Pile Caps

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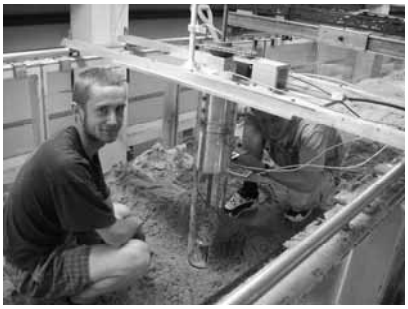
New Laboratory Data

- Max Sheppard at University of Auckland
- Sterling Jones at FHWA Lab
- Stephen Coleman at University of Auckland



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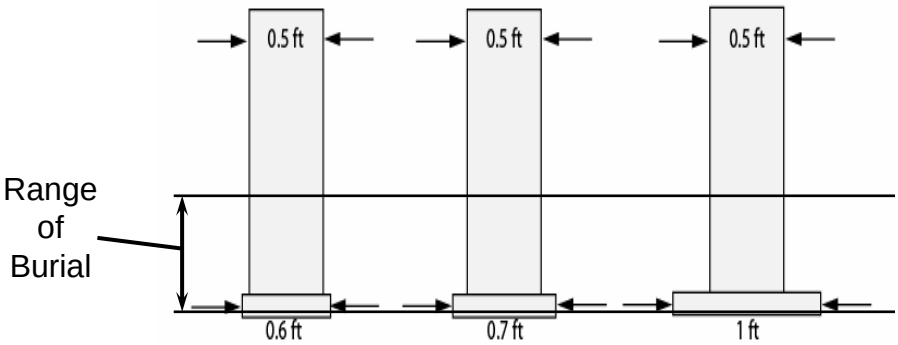
Sterling Jones' Piers



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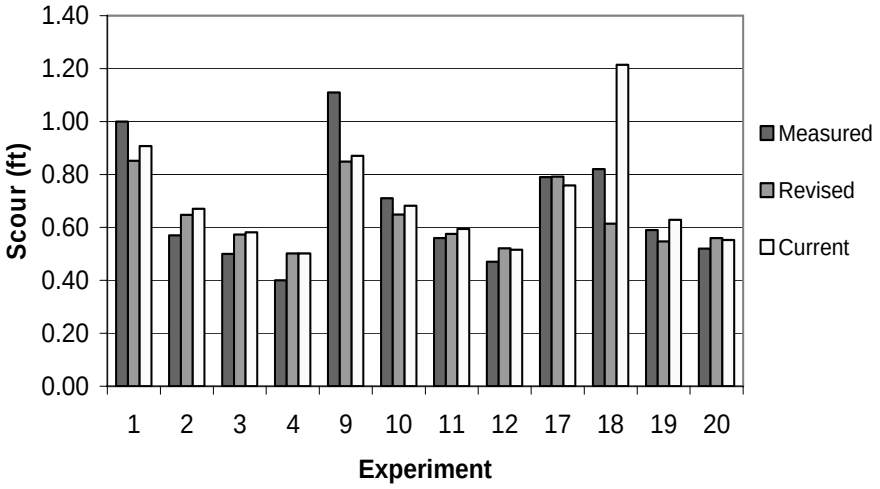
Jones' Data



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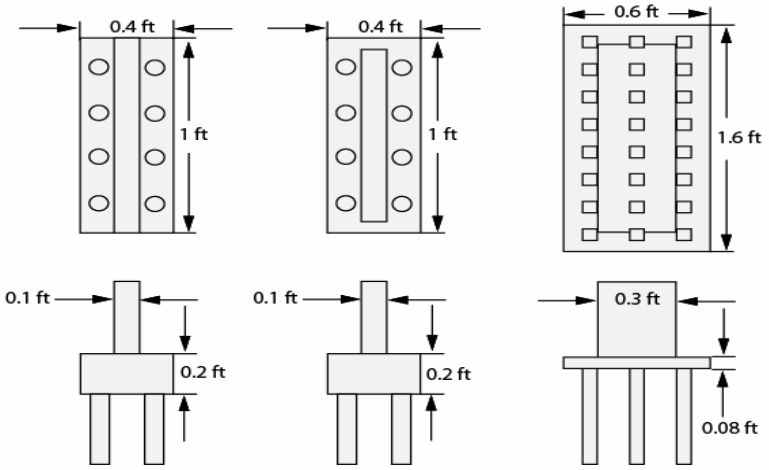
Coleman's Piers



Pier 1 Pier 2 Pier 3

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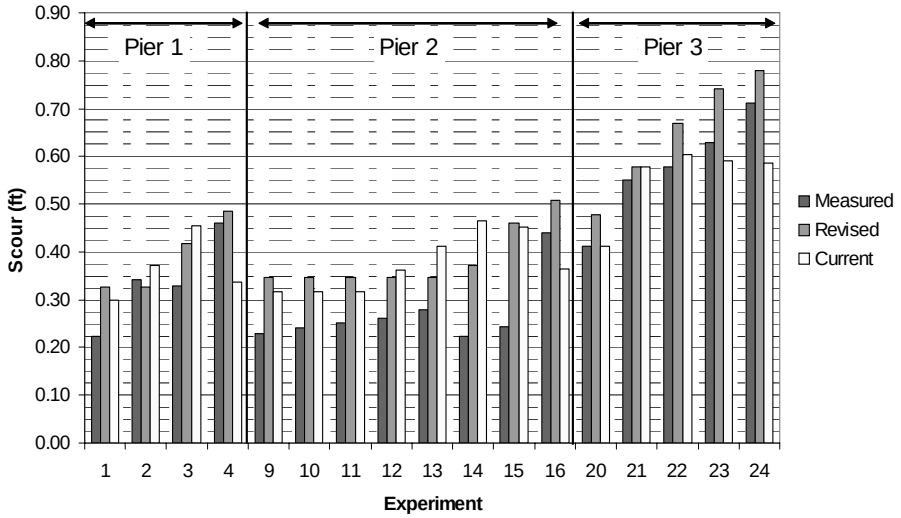
Coleman's Data



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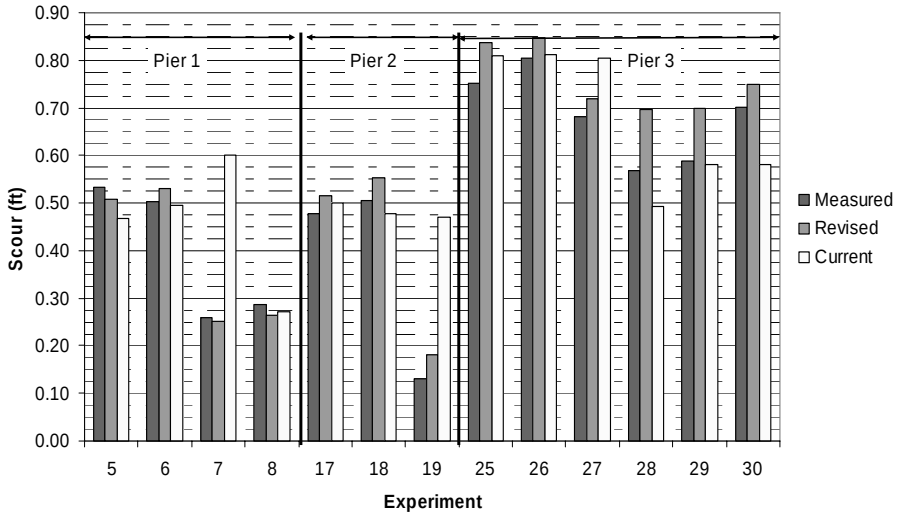
Coleman's Data



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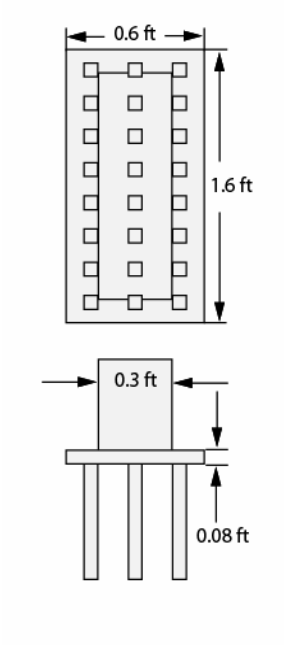
Sheppard's Pier



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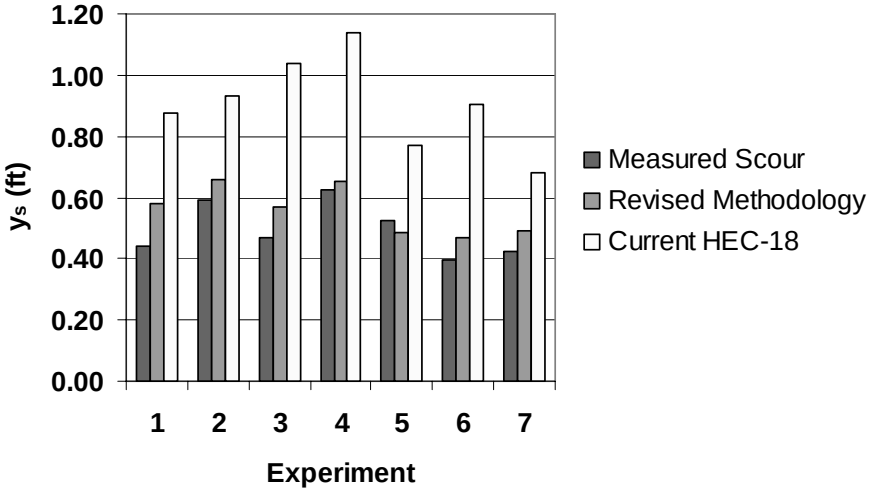
Sheppard's Data



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Improved Scour Course

- 2 Days in Length
- New Developments Included
- Spreadsheet Program
  - Complex Pier Methodology
  - Single Pier Equations
- More Discussion of Rock / Clay Scour

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Summary

- More Sophisticated Techniques Required for Complex Flows
  - 2-D hydraulics and sediment transport models
- Wind Waves Can Have Significant Impact on Contraction and Abutment Scour

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Summary

- Over-conservatism Reduced for Local Scour Prediction at Complex Piers
- Procedure Extended to Include Partially and Completely Buried Pile Caps
- Existing HEC-18 procedure can UNDER PREDICT scour depths for buried pile caps/footers

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Questions, Comments

2006
DESIGN CONFERENCE
Designing For More Than Bridges and Roads

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