NHEC 2014
National Hydraulic Engineering Conference
Designing Sustainable Infrastructure in a Changing Environment

New Directions in Scour Monitoring

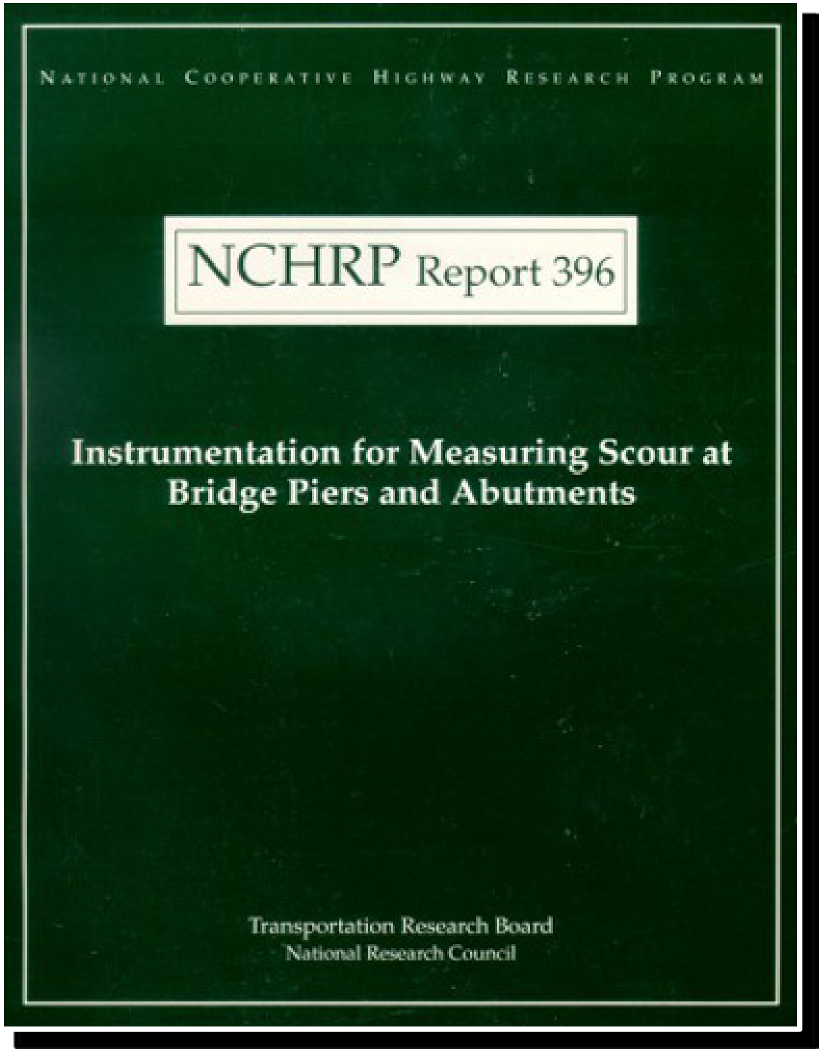
Beatrice E. Hunt, P.E., AECOM

AECOM

New Directions in Scour Bridge Scour Monitoring

- Guidance
- State-of-practice
- Research and new directions
- Conclusions

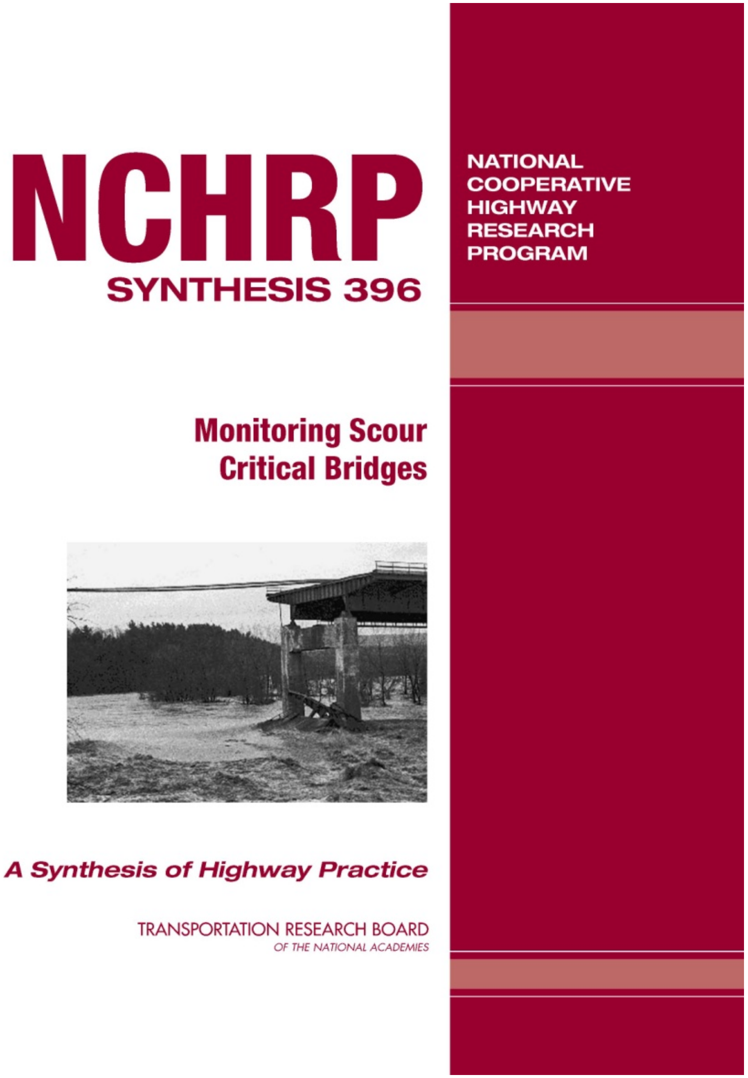
Research - NCHRP Report 396



Instrumentation for Measuring Scour at Bridge Piers and Abutments

1997

Practice Report - NCHRP Synthesis 396

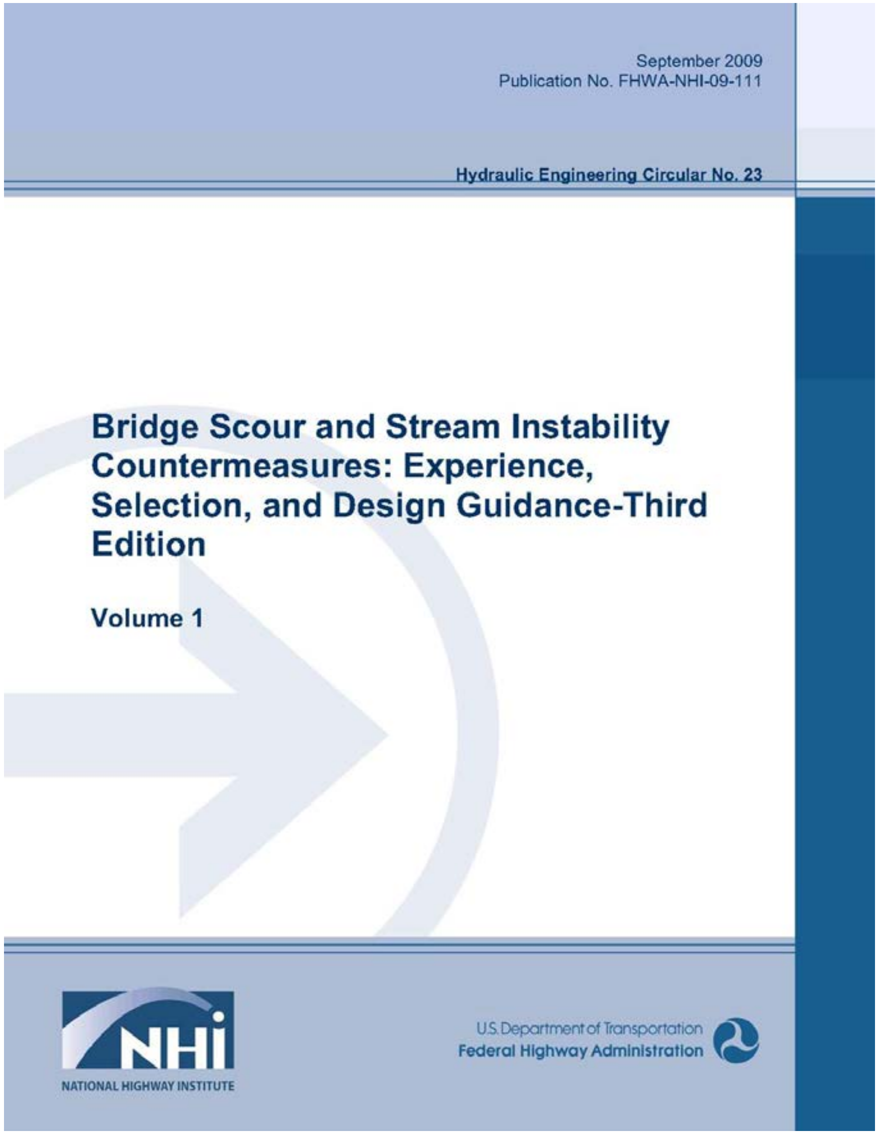


Monitoring Scour Critical Bridges

2009

*http://onlinepubs.trb.org/onlinepubs/**nchrp/nchrp**_syn_**396**.pdf*

FHWA HEC-23 Guidance


September 2009
Publication No. FHWA-NHI-09-111

Hydraulic Engineering Circular No. 23

Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition

Volume 1

NHI
NATIONAL HIGHWAY INSTITUTE

U.S. Department of Transportation
Federal Highway Administration

Bridge Scour and Stream Instability Countermeasures

New Third Edition, 2009

http://www.fhwa.dot.gov/engineering/hydraulics/pubs/09111

2012 FHWA Guidance – Risk-Based Data-Driven Process

- FHWA Scour Program
- Risk-Based, Data-Driven Decision-Making

Scour critical bridges that present lesser risk may be considered candidates for a POA with only a monitoring countermeasure component

A bridge having **unknown foundations** and low level risk may have the required POA consist of a monitoring scour countermeasure

Bridge Fixed Scour Monitoring Systems

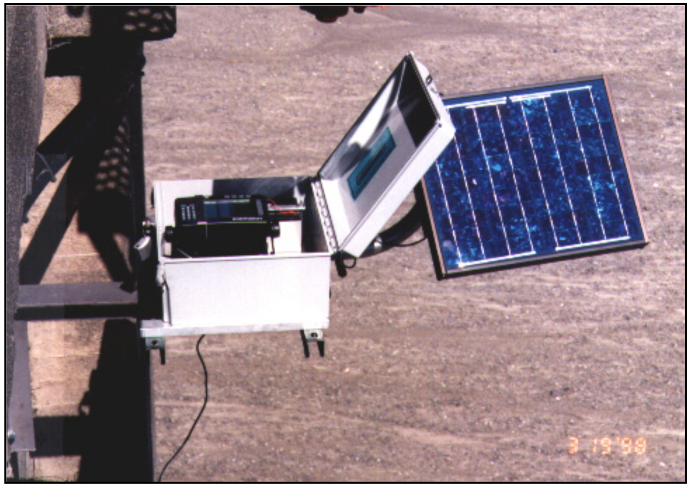
- Real time monitoring
- Remote
- Wireless
- Data loggers
- Web-based
- Automatic alerts
- SENSORS
- DATA ANALYSIS

Data Being Collected

- Streambed elevations
- Bridge movements
- Countermeasure parameters & performance
- Installation of countermeasures
- Water stage
- Velocity measurements
- Rainfall

Telemetry Options

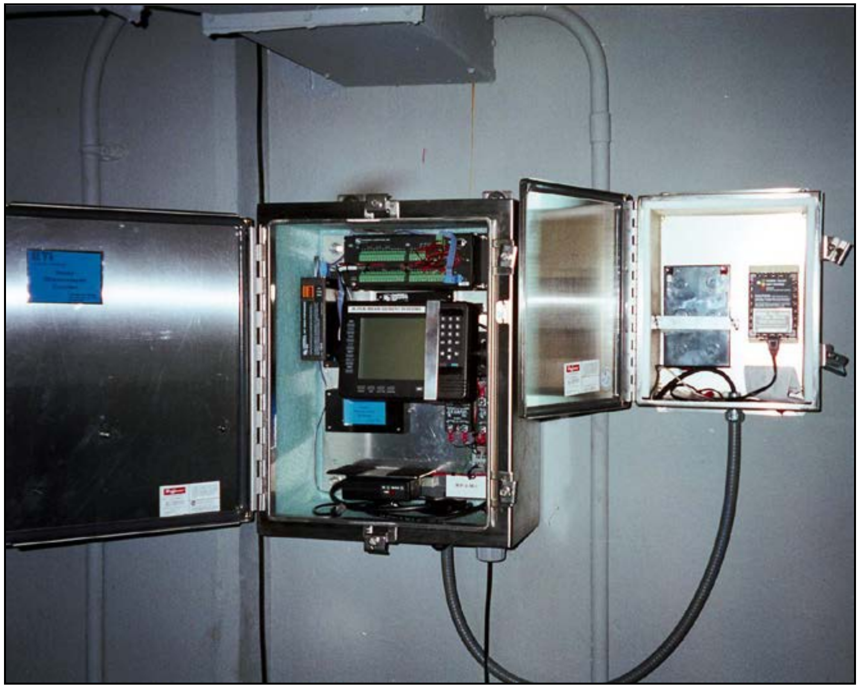
Landline



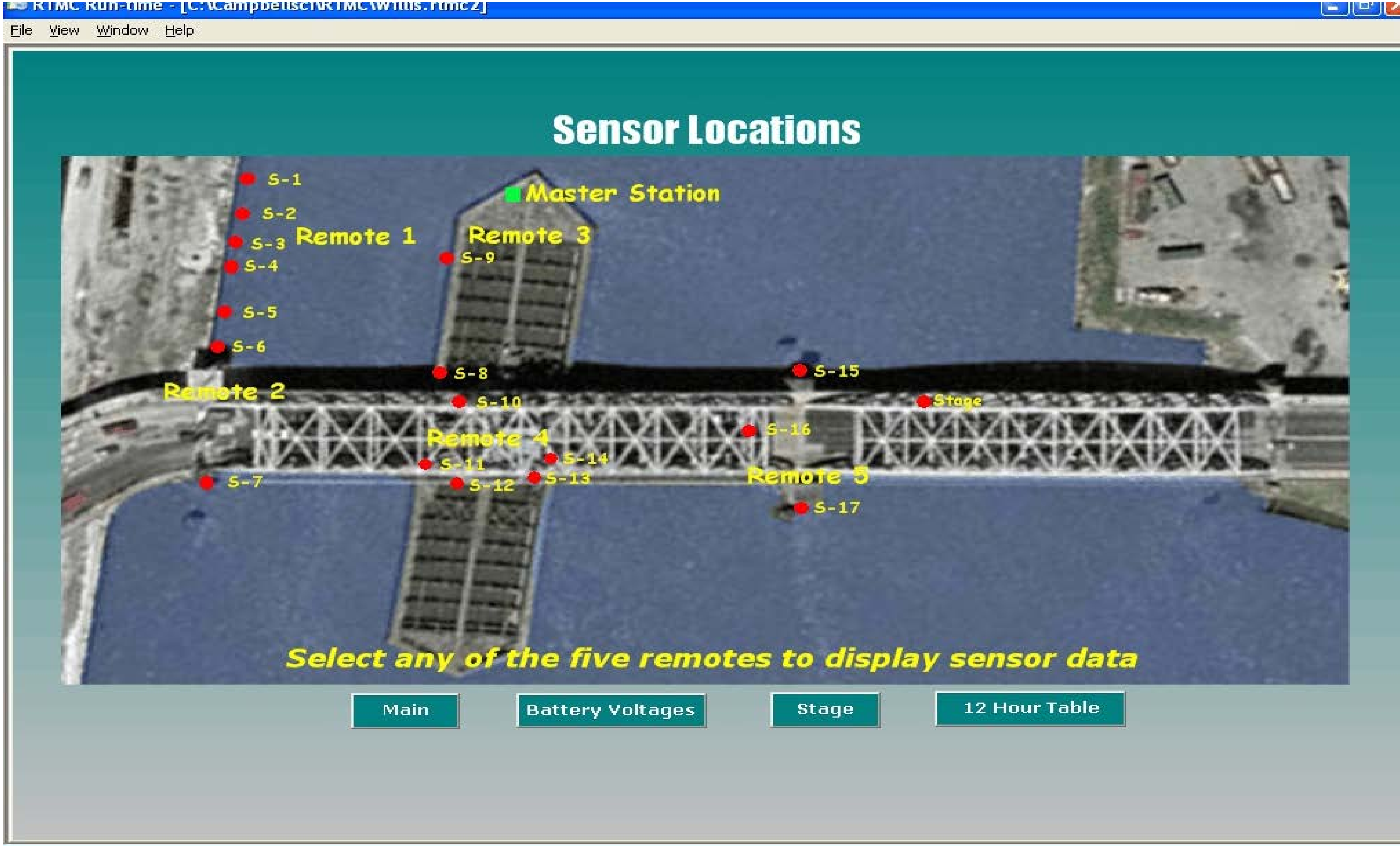
Satellite

Cellular

Data Loggers



Internet



Willis Avenue Bridge over the Harlem River / NYCDOT

AECOM

Powering the System

Solar

Commercial Power

AECOM

Types of Fixed Scour Monitors – FHWA HEC-23 (2009)

Sonar

Tilt Sensor

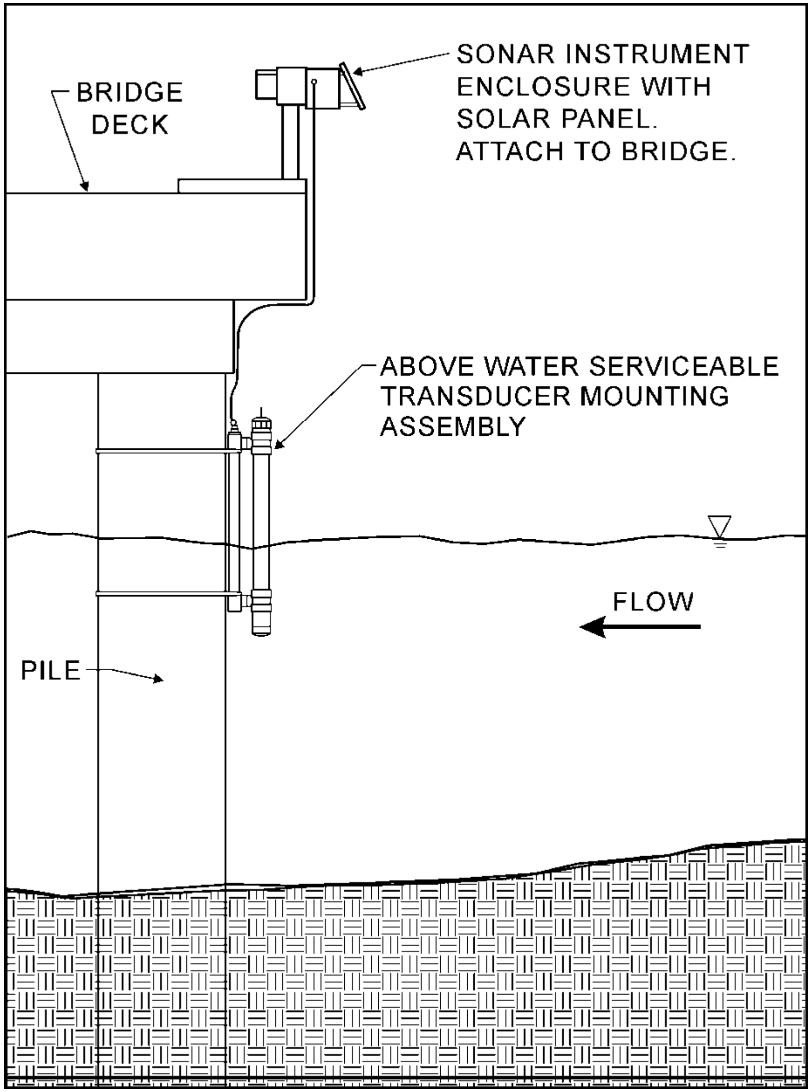
Time Domain Reflectometer

Magnetic Sliding Collar

Float-out

AECOM

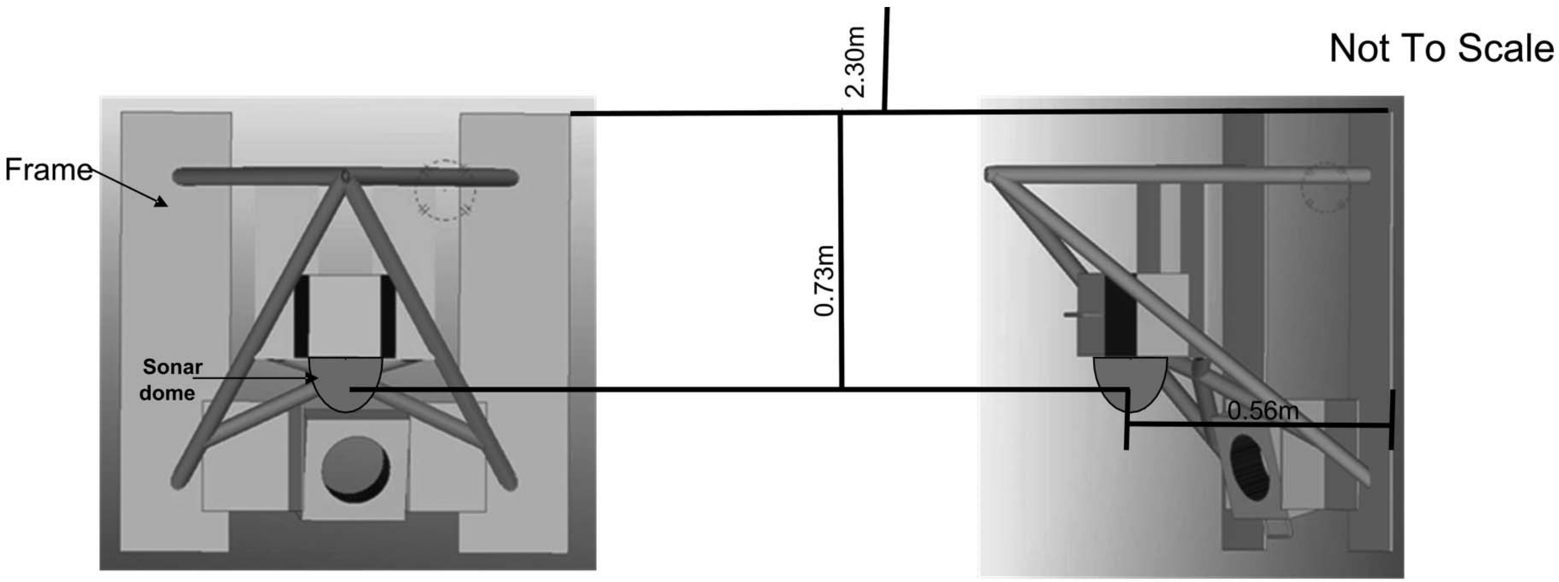
Sonar Scour Monitors

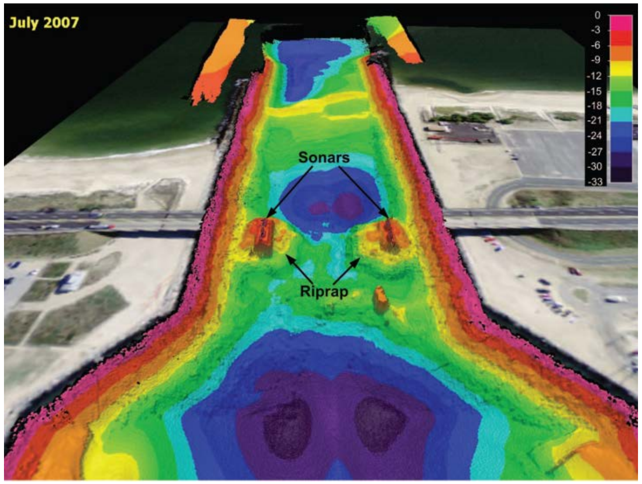


FHWA HEC-23

AECOM

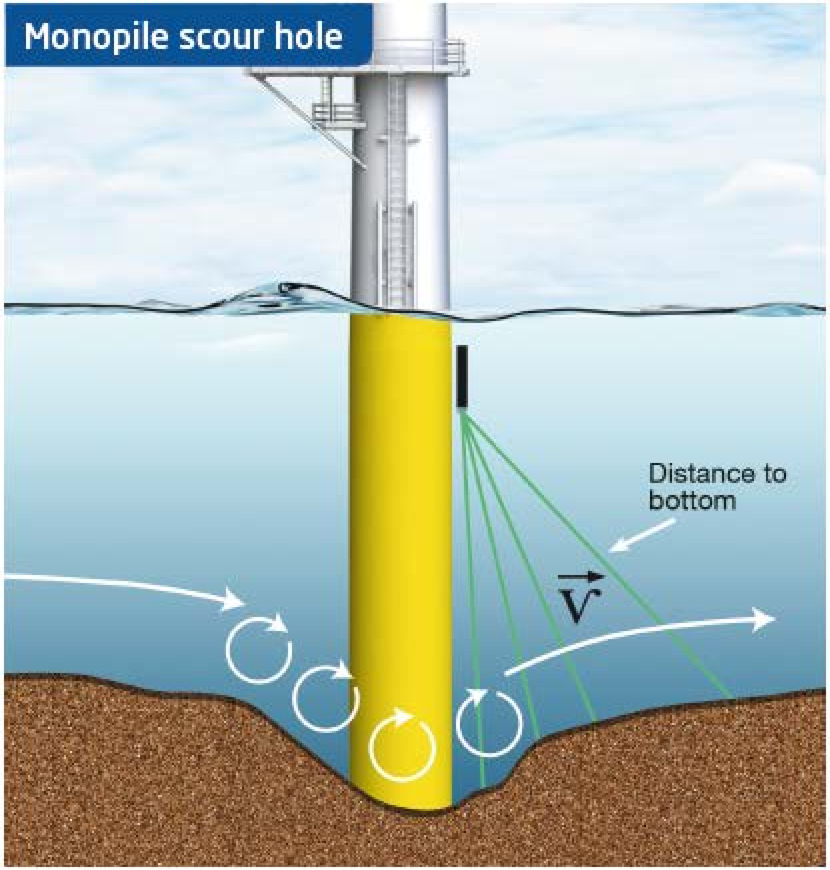
3-D Profiling Scanning Sonars





- Can observe wide areas of scour, 19,000 m^2
- Useful for monitoring armoring countermeasures

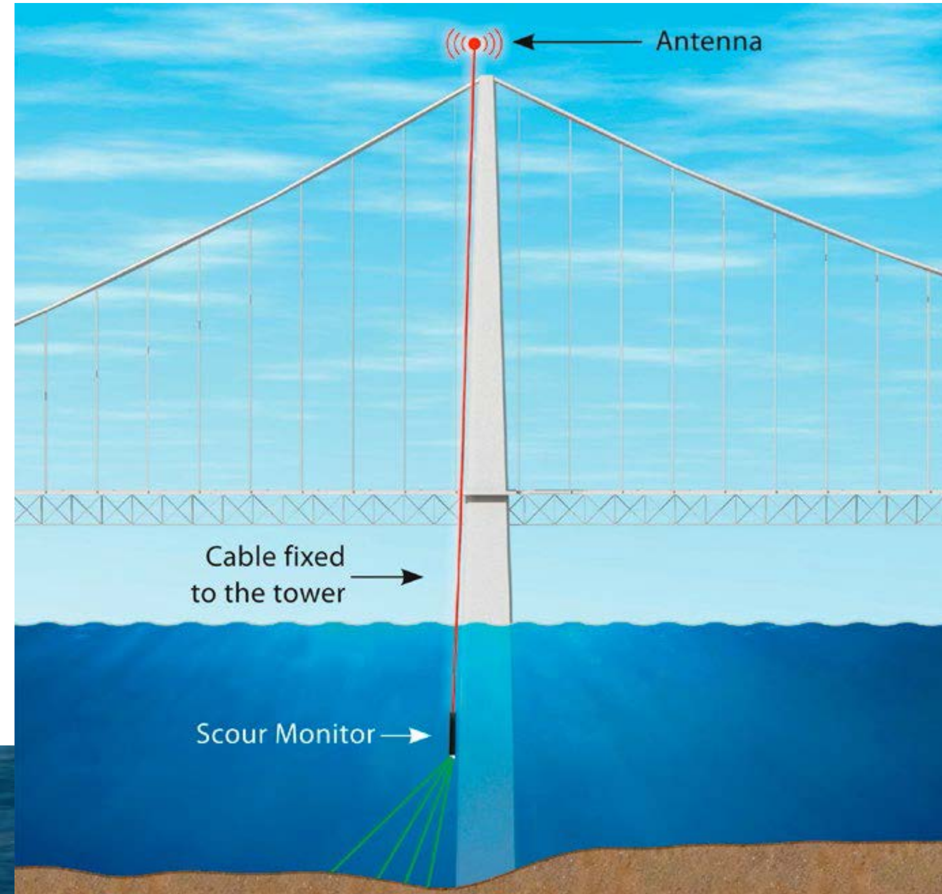
Acoustic Measurements – Four Transducers



AECOM

Acoustic Measurements – Four Transducers

Jeanette's Pier, Nag's Head, NC

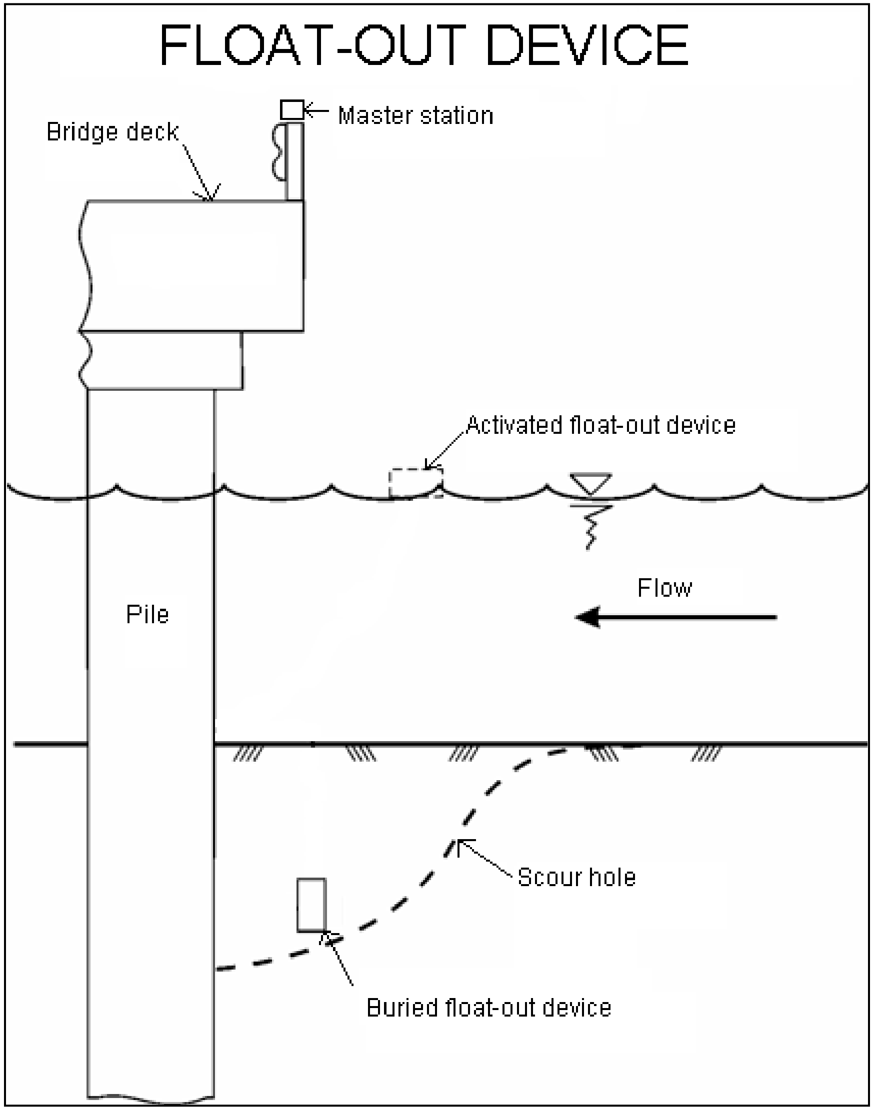


Nortek AS

North Carolina Coastal Studies Institute

AECOM

Float-out Devices



Texas A&M

TXDOT

AECOM

Tethered Buried Switches (TBS)

TTI, ETI & TXDOT

AECOM

Wireless Smart Rocks

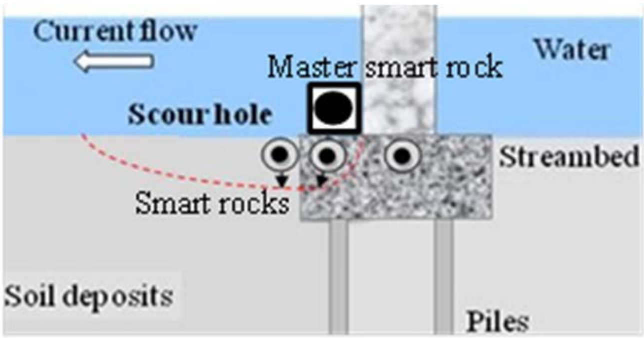


Fig. 1 Maximum Scour Depth Monitoring

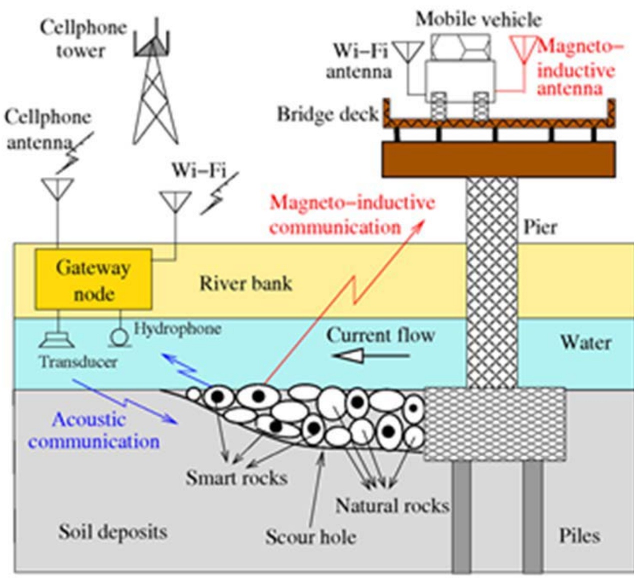


Fig. 2 Scour Countermeasure Monitoring

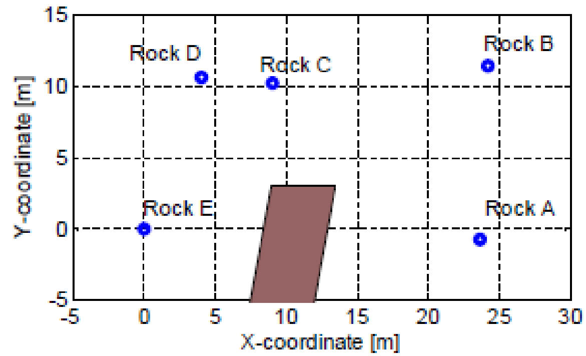
- Smart Rocks
  - Magnets or Sensors
  - Inside Rocks or Concrete
- Measurements
  - Maximum scour
  - Countermeasure performance
- Testing
  - Small-scale laboratory tests
  - Full-scale field tests
- Types
  - Passive
  - Semi-Active
  - Active

AECOM

Wireless Smart Rocks

✓ Proof-of-Concept Tests – Field Condition

- Gasconade River Bridge on 07/23/2013



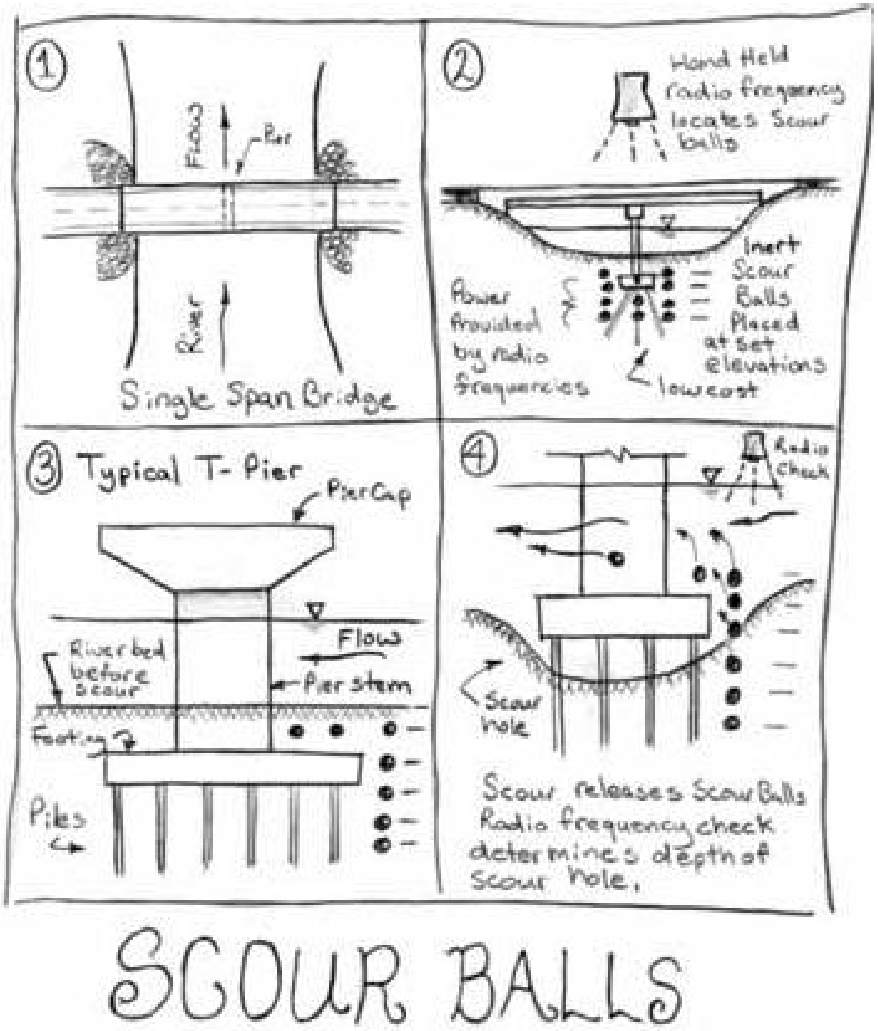
Top-View Map of the five Smart Rock installed around the pier

The rocks form a network and are capable of communicating with each other (wake up and obtain RSSI data)

- Embedded sensors/electronics
- Wireless magneto-inductive communications
- Measure individual location changes

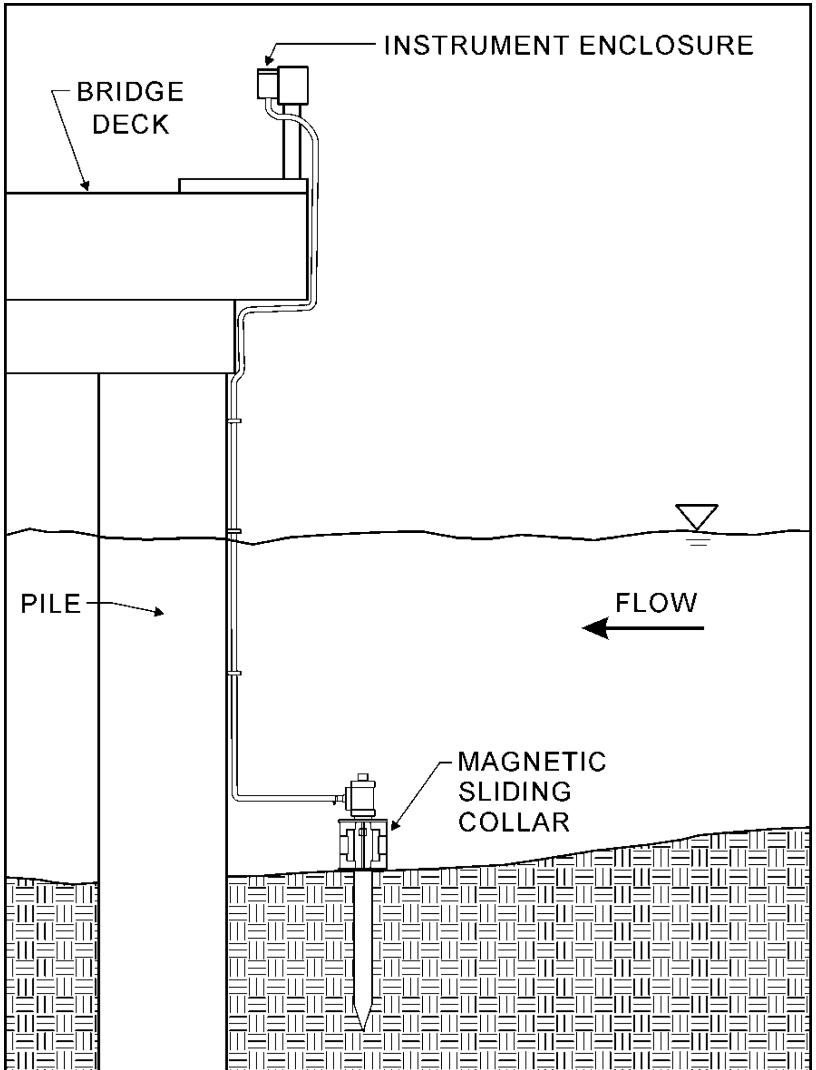
AECOM

Radio Frequency Identification (RFID) Systems



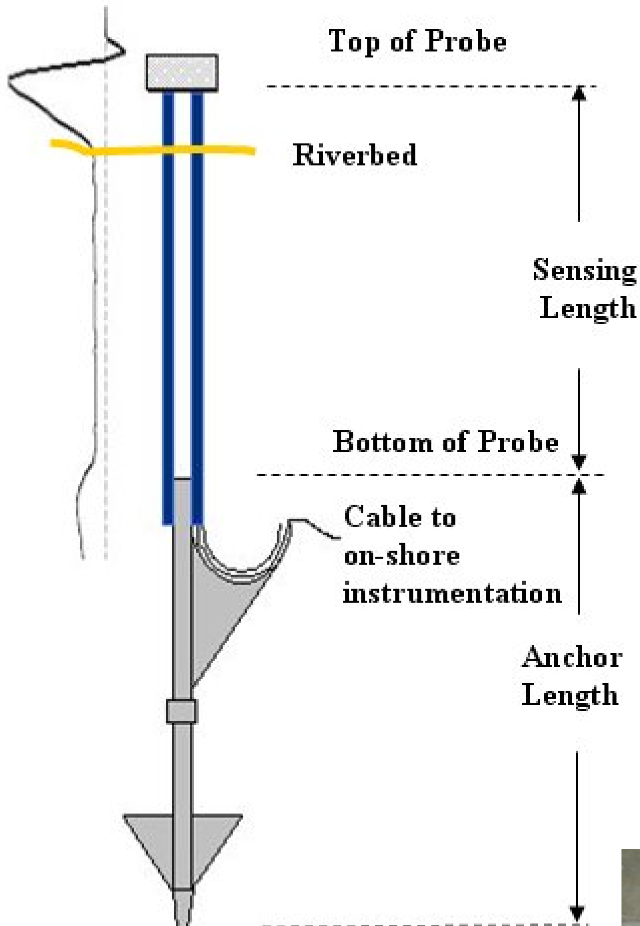
The University of Iowa and Iowa State Unversity (January 2010)

Magnetic Sliding Collars

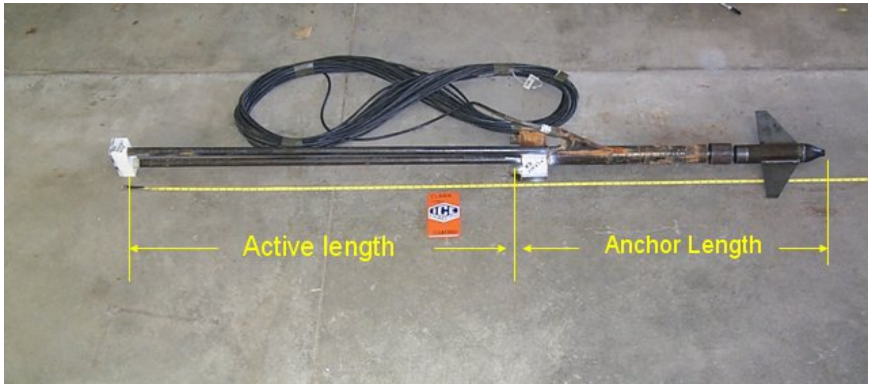


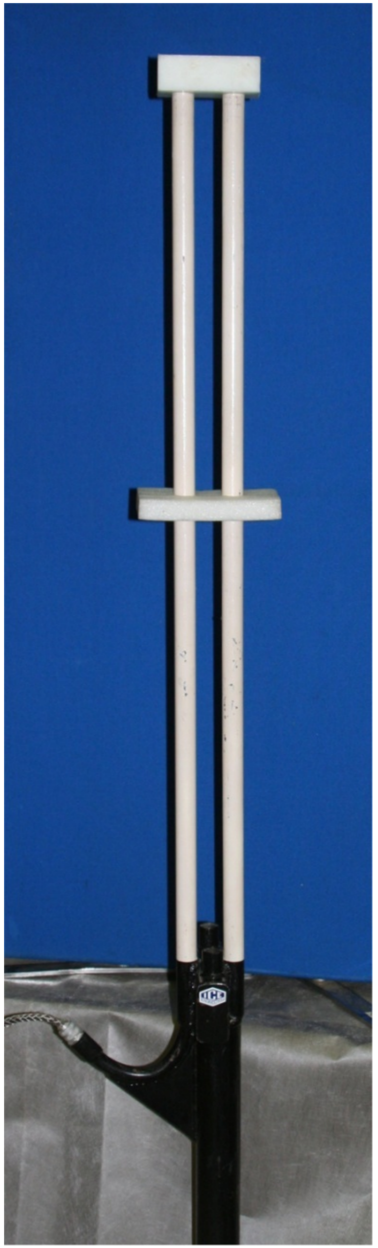
FHWA HEC-23

Time Domain Reflectometers

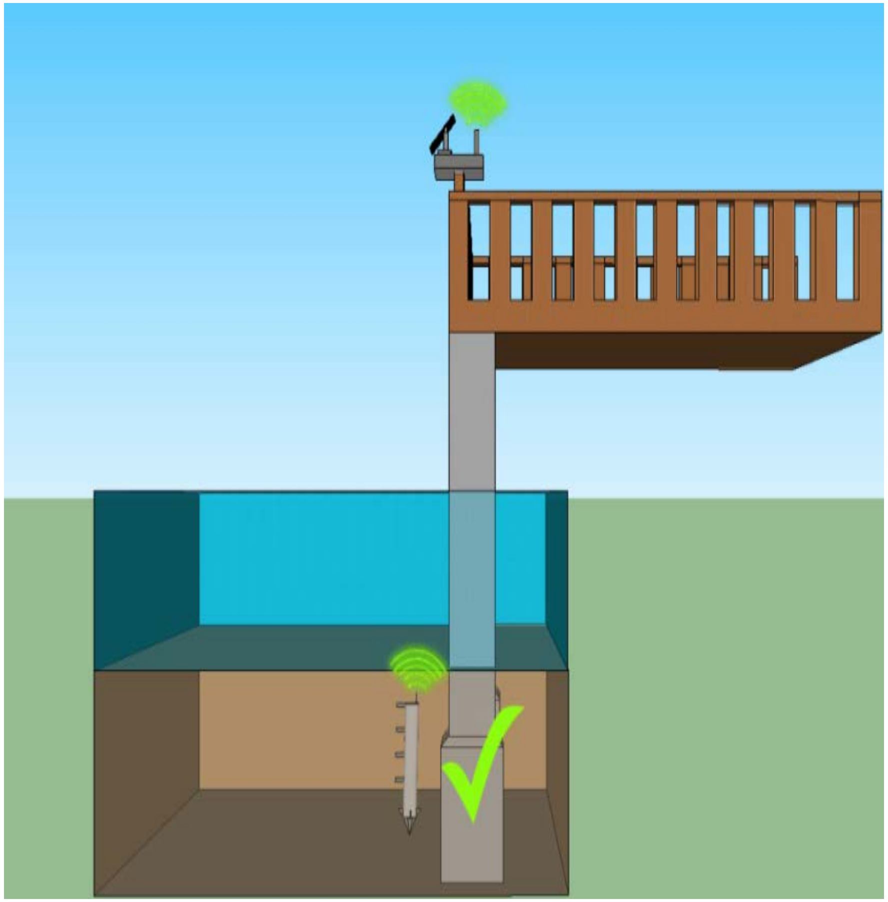


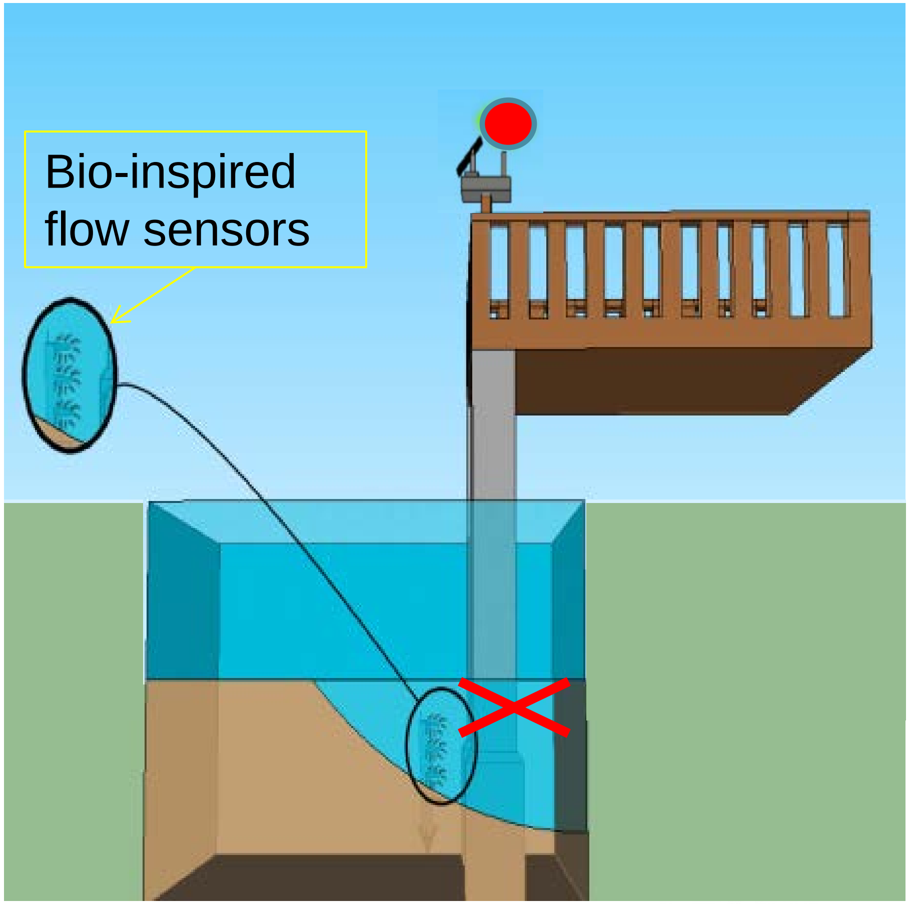
CRREL, USCOE





Whiskers - Bio-Inspired Scour Sensor Post





University of Maryland, Michigan Tech and FHWA

Scour Application

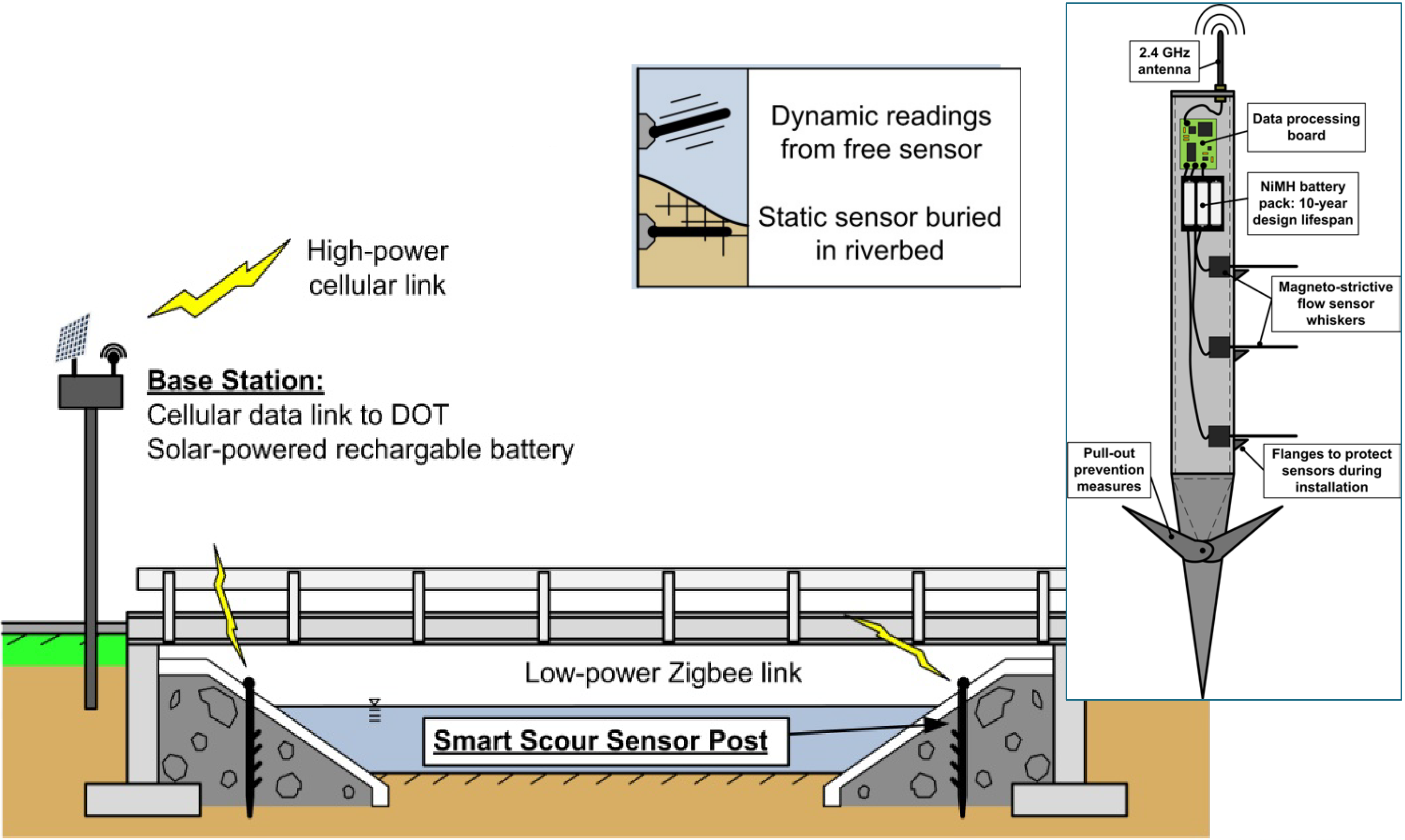
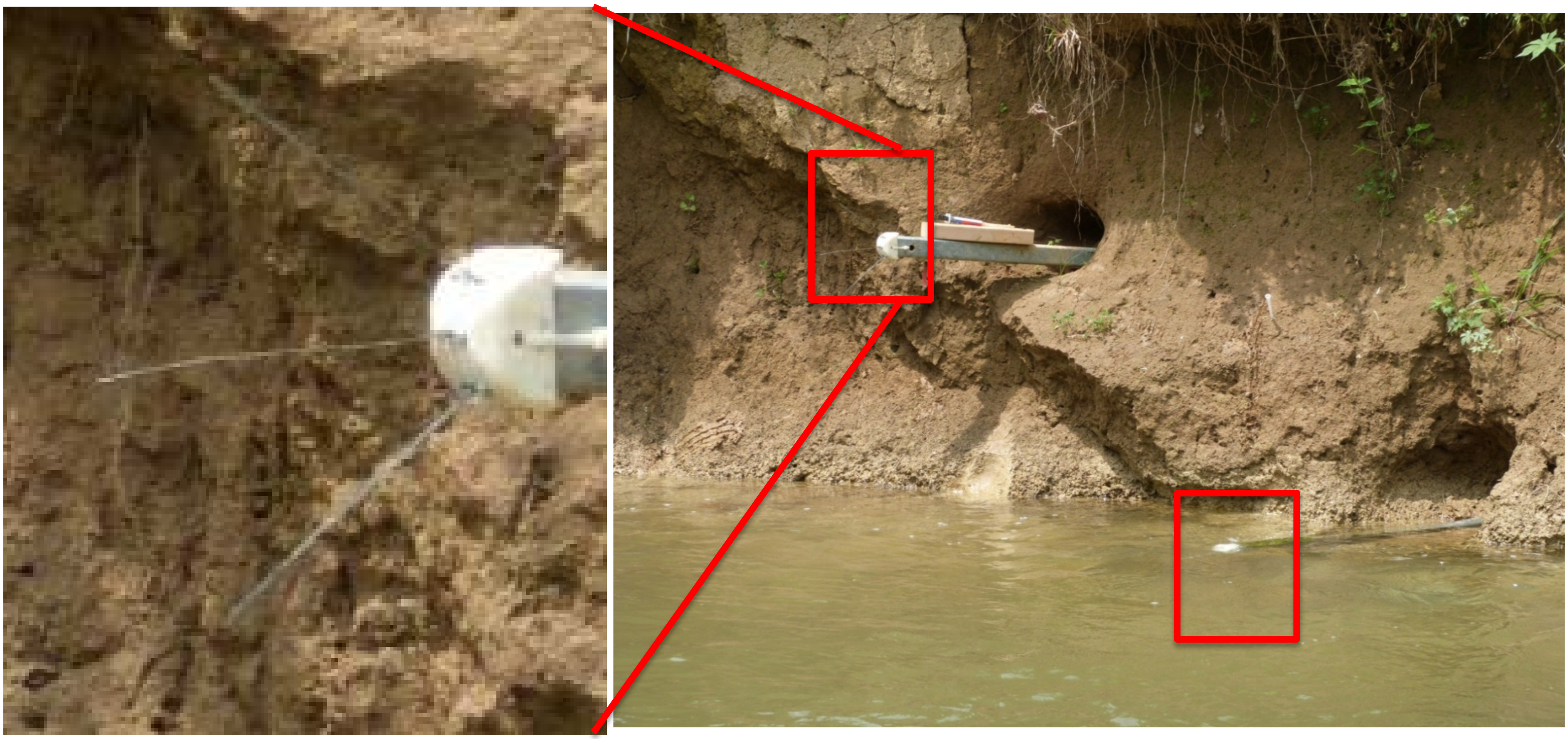
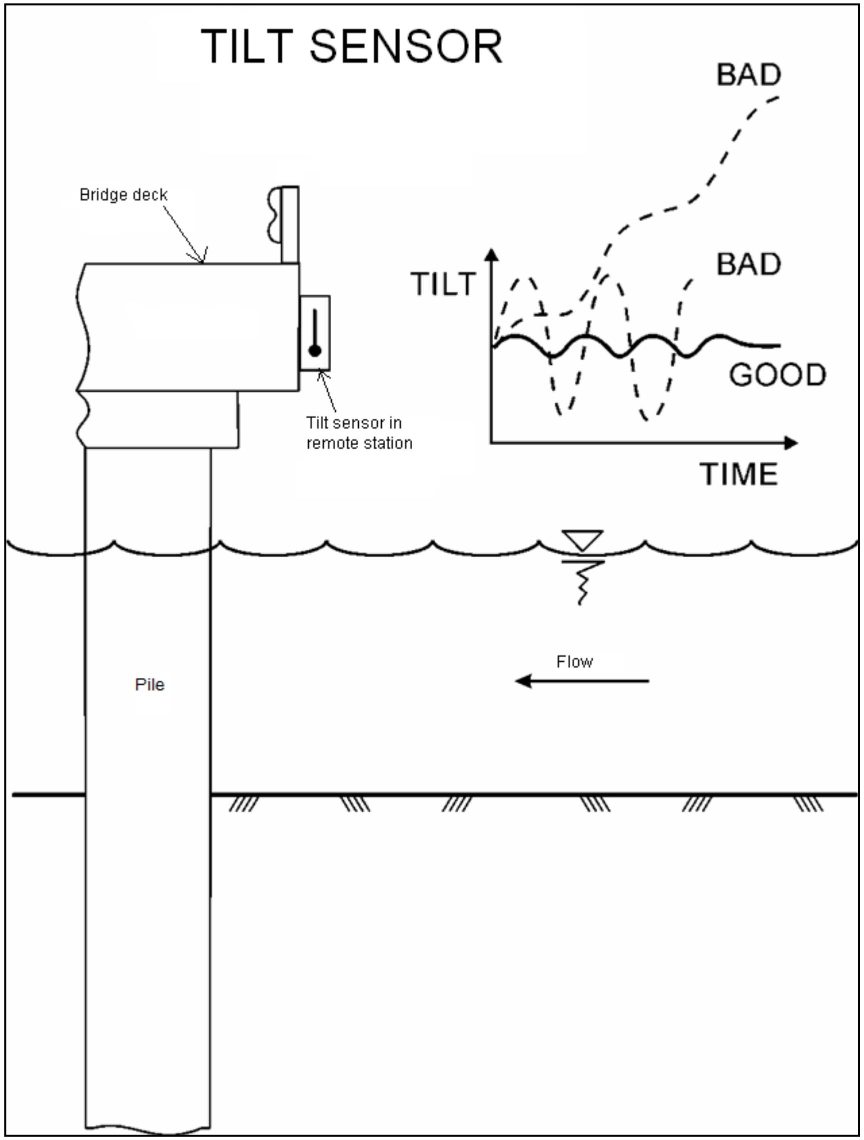


Photo of whiskers installed at the end of the in-air and in-water posts



Tilt Sensors

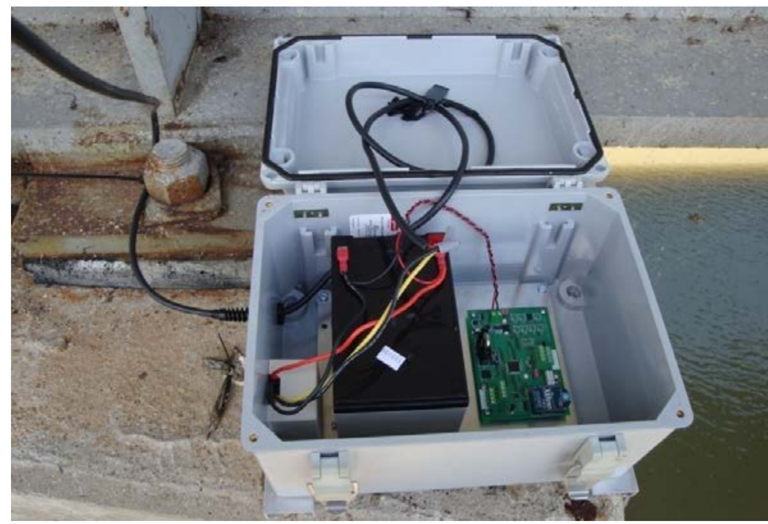


Texas A&M

Caltrans

AECOM

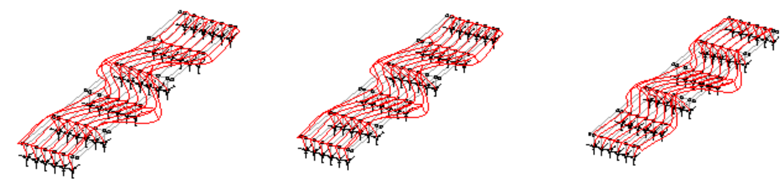
Motion Sensors / Accelerometers



TXDOT

Monitoring of 3 Bridges for Scour
New York City Department of Transportation

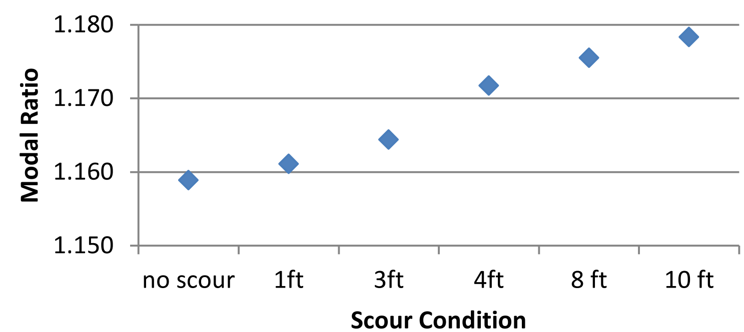
Mosholu Bridge
(4th Vibrational Mode)



No Scour 16.41 Hz.	With Scour 16.19 Hz.	With 1ft Scour on Downstream Side of Pier #3 16.35 Hz.

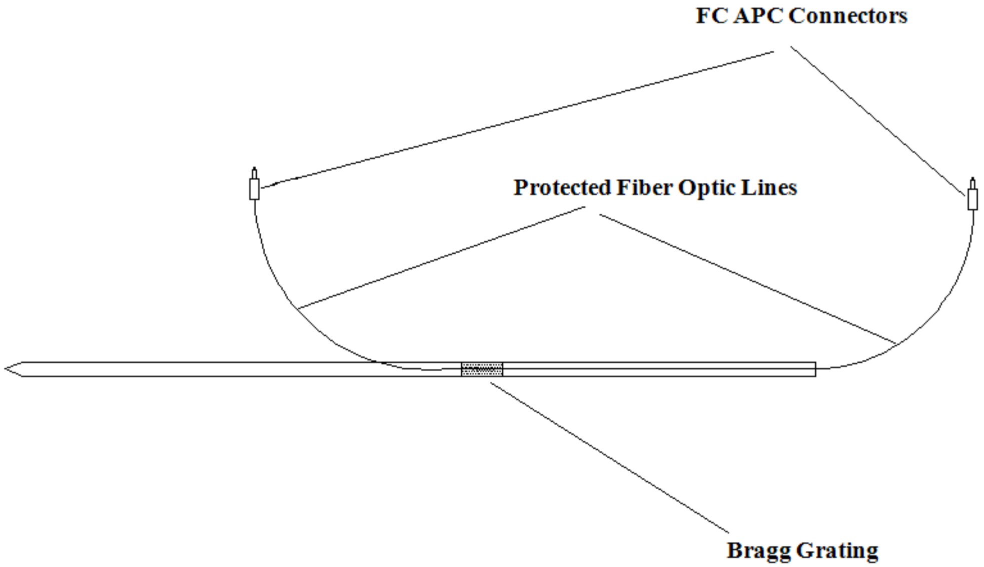
	no scour	1ft	3ft	4ft
Frequency	14.16	14.09	13.99	13.86
	14.73	14.70	14.69	14.67
	15.58	15.55	15.52	15.48
	16.41	16.36	16.29	16.24
Modal ratio				
1 to 2	1.040	1.043	1.050	1.058
2 to 3	1.058	1.058	1.057	1.055
3 to 4	1.053	1.052	1.050	1.049
1 to 4	1.159	1.161	1.164	1.172

Scour effect on modal ratio (4th to 1st)



Additional Studies

- Fiber Bragg Gratings (FBG) sensors – University of Illinois at Chicago (March 2011)



Minnesota Department of Transportation

RESEARCH SERVICES

Office of Policy Analysis, Research & Innovation

Bridge Scour Monitoring Technologies: Development of Evaluation and Selection Protocols for Application on River Bridges in Minnesota

Jeff Marr, Principal Investigator
St. Anthony Falls Laboratory
University of Minnesota

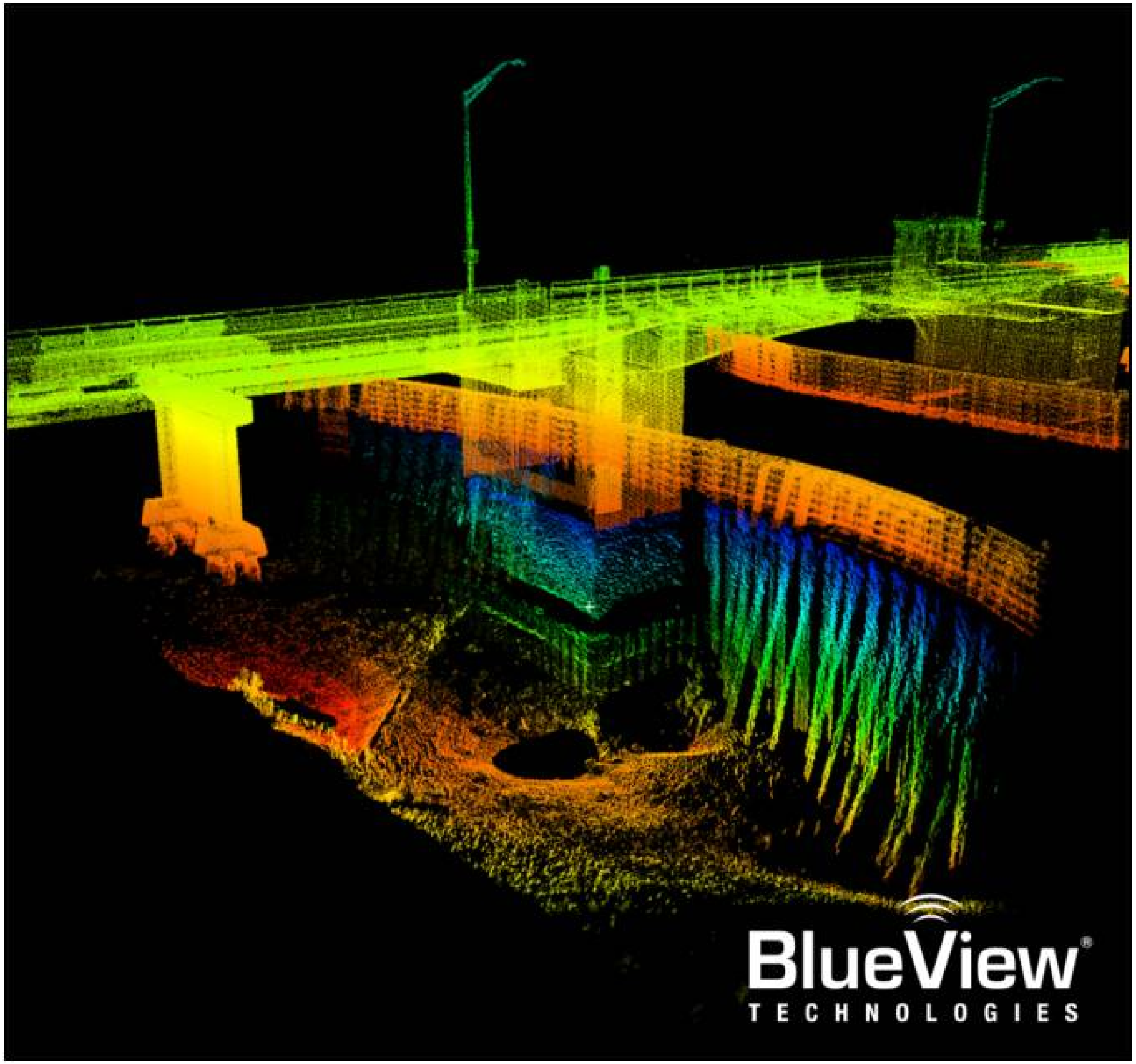
March 2010

Research Project
Final Report #2010-14

Your Destination...Our Priority

AECOM

3D Mechanical Scan

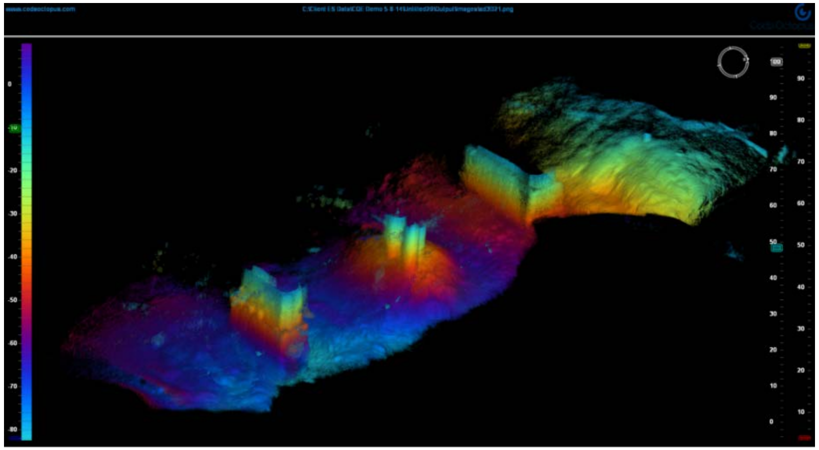


AECOM

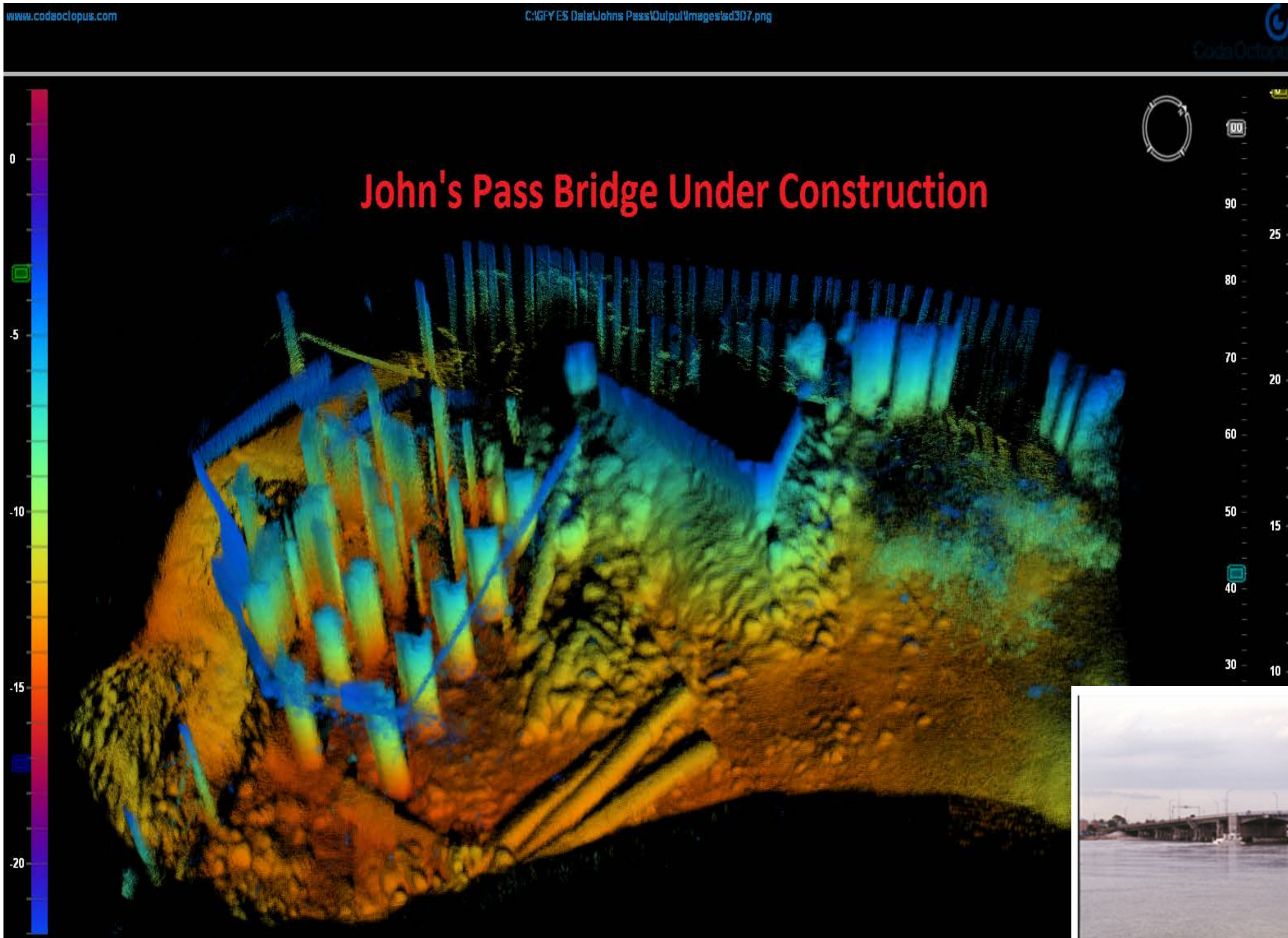
3D Volumetric Real Time Mapping

Acosta Bridge - Jacksonville, FL

Echoscope®



/Echoscope® John's Pass Bridge, Clearwater, FL



Echoscope®

Future Needs in Scour Monitoring Technology

- More robust devices - increased reliability and longevity
- Decreased costs
- Simpler installation techniques
- Less maintenance and repairs
- Better long-term power
- Longer transmission distances and through various surfaces
- Underwater wireless transmission

Future Needs in Scour Monitoring Technology

- Simplification of data analysis
- Devices more suitable for smaller and larger bridges
- Combine scour monitors with devices that measure additional hydraulic variables, structural monitors or cameras
- Funding for the scour monitoring program post-installation
- Data for scour research

AECOM

Conclusions

- Scour monitoring may be used for lower risk scour critical and unknown foundation bridges
- Several monitors available for different bridges, site conditions and data requirements
- Developments in sensors and data analysis are most needed
- Proof of concept in laboratory and fields tests are ongoing
- Portable monitors complement fixed monitors

AECOM

The University of Iowa

NHEC 2014
National Hydraulic Engineering Conference
Designing Sustainable Infrastructure in a Changing Environment

Thank you!

beatrice.hunt@aecom.com

AECOM