TRANSPORTATION POOLED FUND PROGRAM
QUARTERLY PROGRESS REPORT

Lead Agency (FHWA or State DOT): __FHWA____

INSTRUCTIONS:
Project Managers and/or research project investigators should complete a quarterly progress report for each calendar quarter during which the projects are active. Please provide a project schedule status of the research activities tied to each task that is defined in the proposal; a percentage completion of each task; a concise discussion (2 or 3 sentences) of the current status, including accomplishments and problems encountered, if any. List all tasks, even if no work was done during this period.

Transportation Pooled Fund Program Project #	**Transportation Pooled Fund Program - Report Period:**
TPF-5(279)	☐Quarter 1 (January 1 – March 31) 2016 ☐Quarter 2 (April 1 – June 30) 2016 ☑Quarter 3 (July 1 – September 30) 2016 ☐Quarter 4 (October 1 – December 31) 2016

Project Title:
High Performance Computational Fluid Dynamics (CFD) Modeling Services for Highway Hydraulics

Name of Project Manager(s): *Kornel Kerenyi*	**Phone Number:** *(202) 493-3142*	**E-Mail** *kornel.kerenyi@fhwa.dot.gov*
Lead Agency Project ID:	**Other Project ID (i.e., contract #):**	**Project Start Date:**
Original Project End Date:	**Current Project End Date:**	**Number of Extensions:**

Project schedule status:

☑ On schedule ☐ On revised schedule ☐ Ahead of schedule ☐ Behind schedule

Overall Project Statistics:

Total Project Budget	**Total Cost to Date for Project**	**Percentage of Work Completed to Date**

Quarterly Project Statistics:

Total Project Expenses and Percentage This Quarter	**Total Amount of Funds Expended This Quarter**	**Total Percentage of Time Used to Date**

Project Description:

The Federal Highway Administration established an Inter-Agency Agreement (IAA) with the Department of Energy's (DOE) Argonne National Laboratory (ANL) Transportation Analysis Research Computing Center (TRACC) to get access and support for High Performance Computational Fluid Dynamics (CFD) modeling for highway hydraulics research conducted at the Turner-Fairbank Highway Research Center (TFHRC) Hydraulics Laboratory. TRACC was established in October 2006 to serve as a high-performance computing center for use by U.S. Department of Transportation (USDOT) research teams, including those from Argonne and their university partners. The objective of this cooperative project is to:

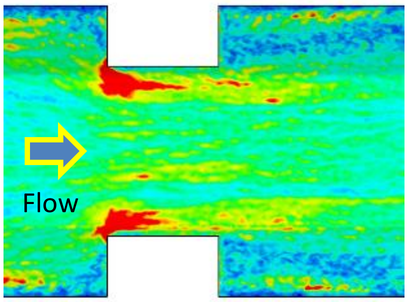
- Provide research and analysis for a variety of highway hydraulics projects managed or coordinated by State DOTs
- Provide and maintain a high performance Computational Fluid Dynamics (CFD) computing environment for application to highway hydraulics infrastructure and related projects
- Support and seek to broaden the use of CFD among State Department of Transportation employees.

The work includes:

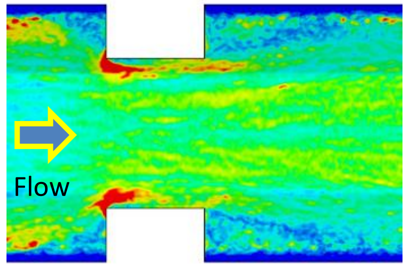
- Computational Mechanics Research on a Variety of Projects: The TRACC scientific staff in the computational mechanics focus area will perform research, analysis, and parametric computations as required for projects managed or coordinated by State DOTs.
- Computational Mechanics Research Support: The TRACC support team consisting of highly qualified engineers in the CFD focus areas will provide guidance to users of CFD software on an as needed or periodic basis determined by the State DOTs.
- Computing Support: The TRACC team will use the TRACC clusters for work done on projects; The TRACC system administrator will maintain the clusters and work closely with the Argonne system administrator's community; The TRACC system administrator will also install the latest versions of the STAR-CCM+ CFD software and other software that may be required for accomplishing projects.

Progress this Quarter (includes meetings, work plan status, contract status, significant progress, etc.):

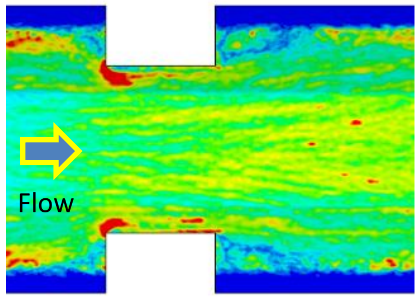
- Hydraulic Performance of Shallow Foundations for Support of Bridge Abutments
  - The database from flume experiments focused on the performance of riprap layouts based on field installations and FHWA HEC-23 design guidelines against clear-water abutment scour combined with Computational Fluid Dynamics (CFD) is used to investigate how flow fields at single span bridge openings, dominated by flow contraction, adjust in response to variations of bed roughness and cross-section geometry due to riprap installations. These adjustments increase bed shear stress magnitudes on the unprotected erodible channel bed leading to underestimated contraction scour depths therefore creating instability, and ultimately causing edge failure of the riprap. The CFD modeling is used to investigate the hydraulic performance of bridge openings with different opening widths and slope lengths. The objective is to explore the criteria for determining when bridge openings might be prone to edge failure of the scour protecting riprap.



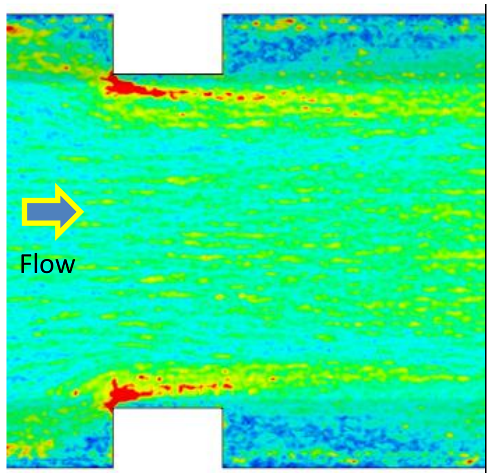
Bed shear stress for the model with flow depth to opening ratio = 8, slope length = 1.43ft



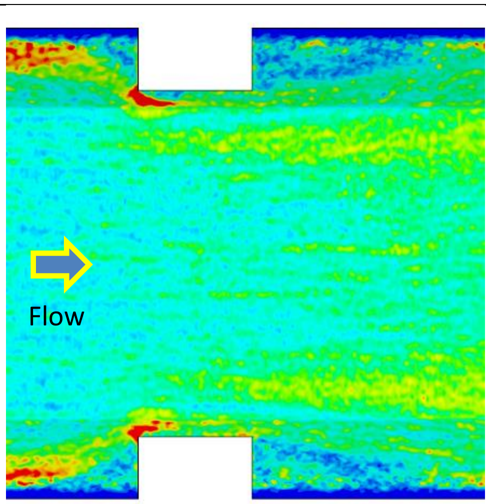
Bed shear stress for the model with flow depth to opening ratio = 8, slope length = 2.53ft



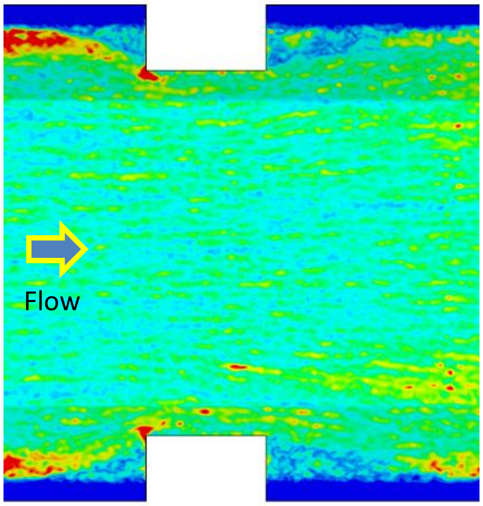
Bed shear stress for the model with flow depth to opening ratio = 8, slope length = 3.97ft



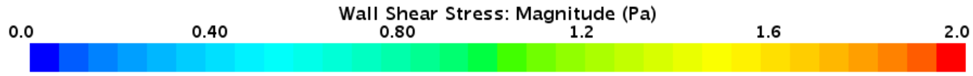
Bed shear stress for the model with flow depth to opening ratio = 16, slope length = 1.43ft



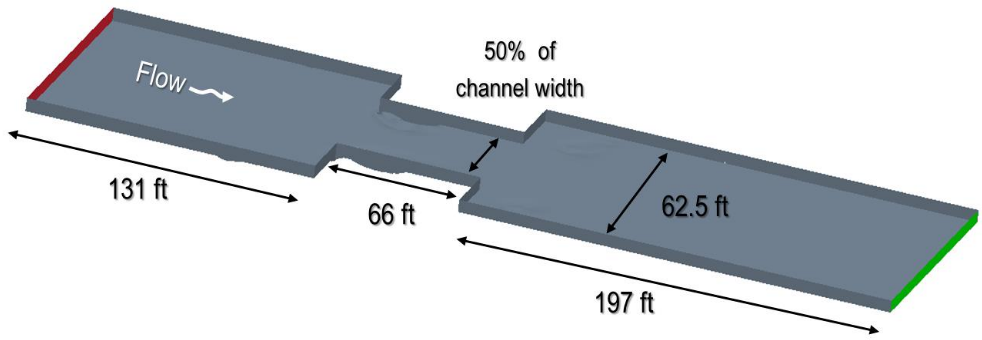
Bed shear stress for the model with flow depth to opening ratio = 16, slope length = 2.53ft



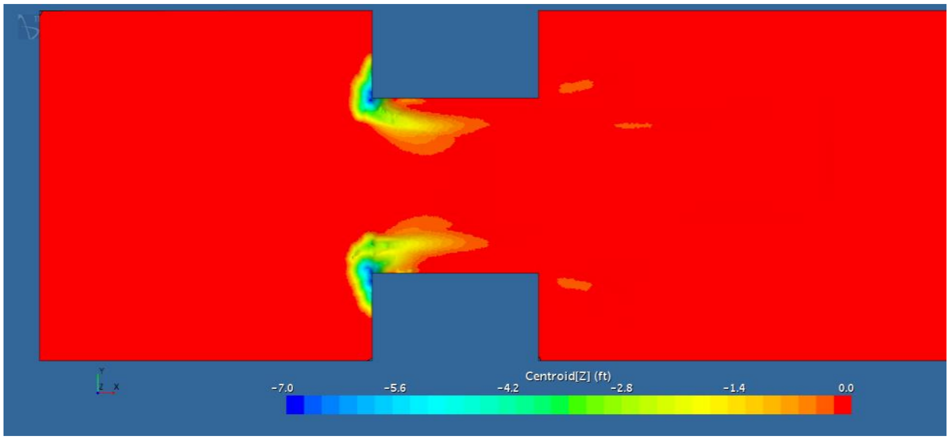
Bed shear stress for the model with flow depth to opening ratio = 16, slope length = 3.97ft



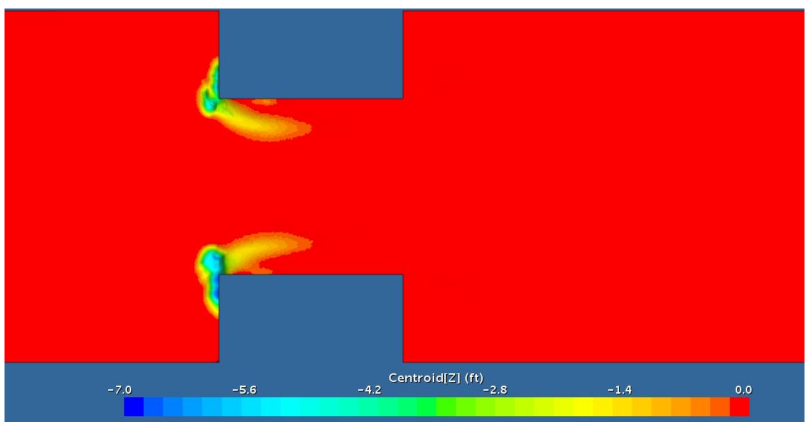
- Erosion Force Decay Function for Abutment Scour
  - The new scour vision proposed to use the concepts of hydraulic loading and soil erosion resistance to compute the scour depth. Many previous research results have verified that hydraulic loading decreases with the increase of scour depth regardless the type of scour, which is defined as the erosion force decay function. One of the essential steps in the new scour vision is to develop a scour decay function. Therefore, a few cases of contracted channel with different soil resistance were simulated by CFD models to provide a basis for development of abutment decay function.



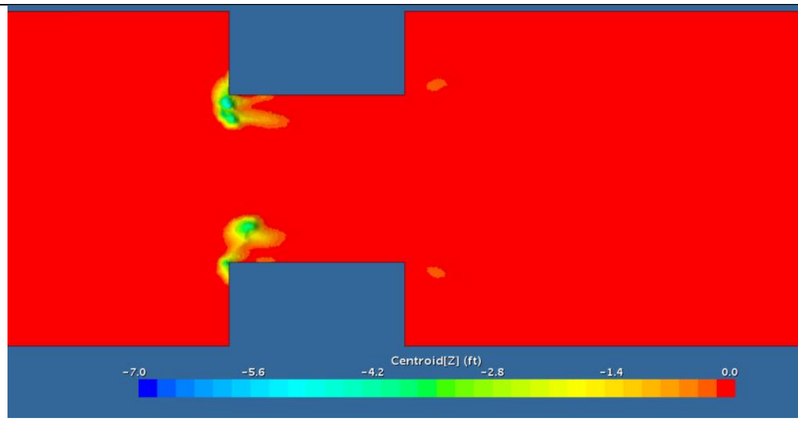
Geometry of the contracted channel



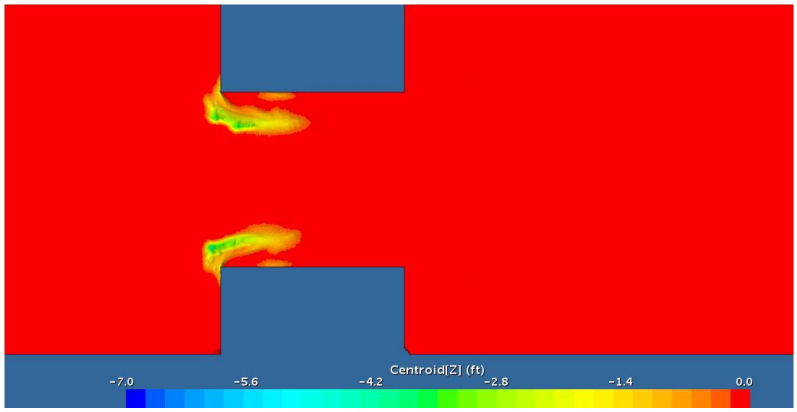
Case 1, maximum scour depth = 7.0 ft



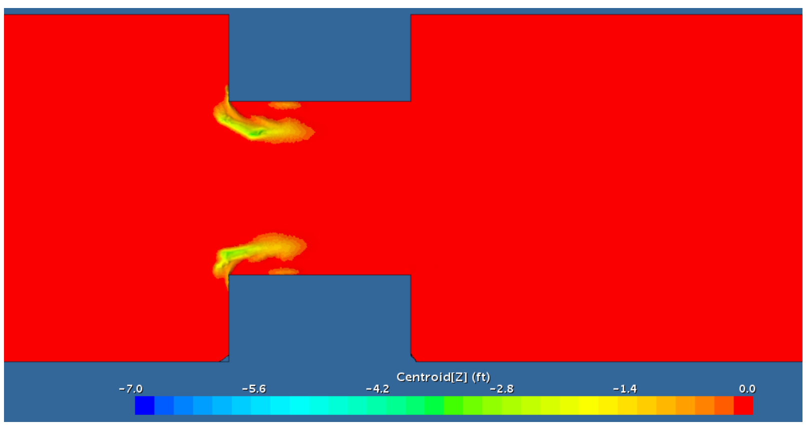
Case 2, maximum scour depth = 6.6 ft



Case 3, maximum scour depth = 5.1 ft



Case 4, maximum scour depth = 4.1 ft



Case 5, maximum scour depth = 3.4 ft

Anticipated work next quarter:

- More cases with different contraction ratios will be studied to develop the abutment scour decay function by using CFD simulations.

Significant Results:

- The criteria for determining when bridge openings might be prone to riprap edge failure were studied.
- Five cases of contracted channels were simulated by CFD models to develop the erosion force decay function

for abutment scour.

Circumstance affecting project or budget. (Please describe any challenges encountered or anticipated that might affect the completion of the project within the time, scope and fiscal constraints set forth in the agreement, along with recommended solutions to those problems).

None to report.

Potential Implementation: