Transportation Pooled Fund Program TPF-5(446) Quarterly Progress Report

Quarter 4, October - December 2022

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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 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 # *(i.e., SPR-2(XXX), SPR-3(XXX) or TPF-5(XXX)* *TPF-5(446)*	**Transportation Pooled Fund Program - Report Period:** ☐Quarter 1 (January 1 – March 31) ☐Quarter 2 (April 1 – June 30) ☐Quarter 3 (July 1 – September 30) ☒Quarter 4 (October 1 – December 31)

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+ and OpenFOAM 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.)

1: Computational Mechanics Research on a Variety of Projects

1.1: Computational Study of Hydraulic Performance of South Carolina DOT Inlets CB-1, CB-16, and CB-17
The hydraulic efficiency analysis of the three types of catch basin, Type 1, 16, and 17, with the use of Computational Fluid Dynamics. CFD analysis yields data to produce the following results: efficiency curves as function of the spread or volume flow rate, the longitudinal slope, and the shoulder width, as well as the variation of flow spread along the roadway in the vicinity the catch basin inlet. The results of the computational analysis are combined in a Microsoft Excel spreadsheet with programmed calculations that will aid the engineers in calculating spacing between drainage on South Carolina roads.

The file consists of the following worksheets: the 'Directions' tab contains these instructions, the 'RI' tab contains data on rainfall intensity (in/hr) for 2, 5, 10, 25, 50, and 100-year event with a duration of 5, 10, 15, 30, and 60 minutes for each South Carolina county. Tabs 'CB1, SX=0.005', 'CB1, SX=0.02', 'CB16, SX=0.005', 'CB16, SX=0.02', 'CB17, SX=0.005', and 'CB17, SX=0.02', refer to the catch basin type and travel lane cross slope considered in the study, where CB stands for 'catch basin', SX stands for 'cross-slope'. These tabs contain the following data: longitudinal slope (ft/ft), cross slope (ft/ft), flow rate (cfs), intercepted flow (cfs), bypass flow (cfs), efficiency (%), spread (ft), max depth (in), mean velocity (ft/s). The sheets at tabs numbered '1', '2', '3', etc. contain formulas that are used to perform calculations to determine drainage spacing. The green shaded cells are for entry of data by the user as detailed below. Data and information will appear in other cells as data needed to complete calculations for those cells is entered.

SCDOT Type 1, 16, 17 Inlet Spacing

Assumptions:		Project information:			
Gutter cross-slope	0.059	Road:	I - XX	Sheet No:	1/1
Gutter width (ft)	1.42	Roadside (RT/LT):	Left	Project ID:	36765
Rainfall event frequency (years):	10	Storm Sewer System:	100	Project:	I - XX Widening
Max design spread (ft):	3	Receiving Stream/Outfall:	OFD 1	Engineer:	
		Drainage start station [ft]:	1000.00	Date:	9/1/2021
		County:	Williamsburg		

Note: User fills in GREEN cells only

				Discharge											Cross section and spread				Output for inlet			
CB no.	Station (ft)	Type of catch basin	Road cross-slope	Spacing between inlets, L (ft)	Width of the drainage area, W (ft)	Drainage area, A_roadway (acre)	Offsite drainage area, A_offsite (acre)	Roadway runoff coeff., Cw_road	Offsite runoff coeff., Cw_off	Conc. time, tc (min)	Rainfall intensity, I (in/hr)	Flow rate, Q (ft3/s)	Previous bypass flow (ft3/s)	Total flow (ft3/s)	Roadway width (ft)	Longitudinal slope (ft/ft)	Water depth at curb, d (in)	Efficiency, E (%)	Spread, T (ft)	Gutter velocity, V (ft/s)	Total flow interception (ft3/s)	Bypass flow (ft3/s)
1	1376.00	CB-17	0.020	376.00	18.42	0.16	0.10	0.90	0.87	5.00	8.54	1.97	0.00	1.97	17.00	0.020	2.22	0.81	6.50	3.76	1.58	0.39
2	1450.00	CB-17	0.020	74.00	9.42	0.02		0.90		11.00	6.60	0.10	0.88	0.97	8.00	0.010	1.96	1.00	5.46	2.54	0.97	0.00
3	2000.00	CB-1	0.020	550.00	13.42	0.17		0.90		7.00	7.75	1.18	0.00	1.18	12.00	0.050	1.36	0.93	3.94	5.81	0.11	1.07
4	2200.00	CB-17	0.005	200.00	13.42	0.06		0.90		10.00	6.85	0.38	1.07	1.45	12.00	0.100	1.48	0.69	9.66	5.55	1.79	0.50
5																						
6																						

Figure.1. Screenshot of the spreadsheet with inlet spacing calculations

Instructions on how to use the spreadsheets with calculations:

1. Fill in the general information about the project in the header.
2. It was assumed that the inlet spacing calculations are conducted for a road with a curb-and-gutter and that the design spread is 11.5 feet. The values for these items cannot be changed.
3. Fill in with information about the project as appropriate: 'Road', 'Roadside', 'Storm sewer system', 'Receiving Stream/Outfall', as well as 'Sheet No', 'Project ID', 'Project', 'Engineer', and 'Date'.
4. Enter the 'Drainage start station' in cell M7. The value should be the location of the station in feet that is the starting point for the next section of inlets. This value will be used to calculate the first spacing between inlets in Row 12.
5. Select the county from a dropdown list of counties in the cell M8.
6. For each row beginning with row 12, enter information in the green cells to determine the design position for the next inlet until the design is complete for all inlets as follows:
7. Enter the catch basin number as an integer in the CB no. column A.
8. Enter an estimate of the next inlet location in feet in the Station column B.
9. Select the type of catch basin from a drop-down menu in Type of Catch Basin column C. You can choose between CB-1, CB-16, and CB-17.
10. Select the roadway cross slope from a drop-down menu in Road cross slope column D. You can choose between 0.005 ft/ft and 0.02 ft/ft.
11. Enter the offsite drainage area in acres in column H.
12. Enter the runoff coefficient in column I and the offsite runoff coefficient in column J.
13. Enter the estimated concentration time in minutes, 5 min ≤ t_c ≤ 60 min in Conc. time column K.
14. Enter the roadway width in feet in the Roadway width column P.
15. Enter the roadway longitudinal slope (ft/ft) in the Longitudinal slope column Q.

If needed, the spreadsheet with calculations can be copied multiple times to perform separate inlet spacing analysis for each run of highway drains.

Anticipated work next quarter:

1: Computational Mechanics Research on a Variety of Projects

- hydraulic analysis of catch basins on grade and in sump
- analysis of water film thickness on pavements (hydroplaning water film thickness and speed)

2: Computational Mechanics Research Support

This work will continue.

Task 3: Computing Support

This work will continue.

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

None.