Form ProjAgre
(Rev. 5/2009)
(RTI)

RTI
PROJECT AGREEMENT
Between the
TEXAS DEPARTMENT OF TRANSPORTATION
AND

____
(PERFORMING AGENCY/S)

RMC __________
Fiscal Year __________

☐ **Research Project**
☐ **Implementation Project**

Project Number: 0-6654

Document Date: __________

Project Title: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

THIS PROJECT AGREEMENT is made pursuant to the terms and conditions of a Cooperative Research and Implementation Agreement(s) (CRIA) entered into by and between the Texas Department of Transportation (TxDOT) and _____.

This project agreement is under the terms of:
☐ CRIA Article 9A and is considered a part of the Annual Program.
☐ CRIA Article 9B and is considered an independent project.

PART I. Project Description. The Performing Agency(s) will undertake and complete the project named above and as further described in Exhibit B, attached hereto and made a part of this Project Agreement. Exhibit B must comply with the requirements of the most recent Research Manual.

PART II. Project Duration and Performance Period. Continuation of the project beyond August 31 each year is subject to authorization by TxDOT and the availability of funds. TxDOT will notify the Performing Agency(s) of initial project approval and annual continuation approvals by Activation Letters. The Activation Letter will signify final approval and authorization to the Performing Agency(s) to initiate the work for a fiscal year. Each Activation Letter shall include the project activation date and shall be attached hereto and made a part of this agreement as if it had been attached at the time this Project Agreement is signed. The Activation Letters will specify the remaining project duration unless terminated in accordance with Article 29 of the CRIA.

____
Project Termination Date

PART III. Project Budget. The total estimated project cost, which includes all authorized direct and indirect costs which may be incurred by the Performing Agency(s), is shown below along with a breakdown by fiscal year and agency. Attached hereto as Exhibit A and made a part of this agreement is an annual Itemized Budget for each Performing Agency which details approved project costs for each fiscal year of this project.

Budget Breakdown
(Attach an itemized budget for each fiscal year for each Performing Agency.)

FY	Agency	Budget	FY	Agency	Budget

Total Project Budget: __________

PART IV. Project Supervision. The Performing Agency Research Supervisor, whose agency shall be the lead agency, and other primary research staff are named below.

	Name	Title	Agency	Phone No.	Email
Research Supervisor					
Researcher or PI					
Researcher or PI					
Researcher or PI					

PART V. No Waiver. This Project Agreement does not waive the rights, responsibilities, and obligations provided each party under the CRIA and incorporates all the provisions of the CRIA as if set forth herein.

IN WITNESS WHEREOF, this Project Agreement is hereby accepted and executed in duplicate counterparts.

Approved and Accepted by the Performing Agency:

Date: ______________________

____

Name and Title of Signatory
Name of University

Approved and Accepted by TxDOT:

Date: ______________________

____

Rick Collins, P.E., Director
Research and Technology Implementation Office

Texas Department of Transportation maintains the information collected through this form. With few exceptions, you are entitled on request to be informed about the information that we collect about you. Under §§552.021 and 552.023 of the Texas Government Code, you also are entitled to receive and review the information. Under §559.004 of the Government Code, you are also entitled to have us correct information about you that is incorrect. For inquiries call 512/465-7403.

Form ExhA
(Rev. 12/2009)
(RTI)

Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **Texas Tech University**

RMC: **5**
Fiscal Year: **2011**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually — % of time*	
Professional (Combine all Professionals)	$ 5,900	Theodore G. Cleveland (0.5 mo.) — 4%	
Subprofessional & Technical	$ 19,200	Graduate Student	
Clerical			
Total Salaries and Wages			$ 25,100
Fringe Benefits (provide details at the University's option)	$ 6,275		
Total Fringe Benefits			$ 6,275
Expendable Goods & Supplies (provide details at the University's option)	$ 1,200	Supplies (paper, toner, etc.)	
Total Expendable Goods & Supplies			$ 1,200
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ 2,000	Travel to AUS for meeting with PMC	
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ 6,300		
Other			
Total Operating & Other Expenses			$ 8,300
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ 40,875

INDIRECT COSTS			
________ (%) of Modified Total Direct Costs ***		**MTDC** ** = $ 34,575	$ -
less University's Contribution			$ (3,458)
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)			$ 3,458

TOTAL PROJECT COST	$ 44,333

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships,
and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

Note: This electronic form contains formulas that may be corrupted when adding or deleting rows, or by conversion of the spreadsheet. The university is responsible for the accuracy of the budget submitted.

Form ExhA
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **Texas Tech University**

RMC: **5**
Fiscal Year: **2012**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually — % of time*	
Professional (Combine all Professionals)	$ 5,500	Theodore G. Cleveland (0.5 mo.) — 4%	
Subprofessional & Technical	$ 20,400	Graduate Student Researchers	
Clerical			
Total Salaries and Wages			$ 25,900
Fringe Benefits (provide details at the University's option)	$ 6,475		
Total Fringe Benefits			$ 6,475
Expendable Goods & Supplies (provide details at the University's option)	$ 1,200	Supplies (paper, toner, etc.)	
Total Expendable Goods & Supplies			$ 1,200
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ 2,000	Travel to AUS for meeting with PMC	
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ 6,300		
Other			
Total Operating & Other Expenses			$ 8,300
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ 41,875

INDIRECT COSTS	
________ (%) of Modified Total Direct Costs *** — **MTDC ** =** $ 35,575	$ -
less University's Contribution	$ (3,558)
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)	$ 3,558

TOTAL PROJECT COST	$ 45,433

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Form ExhA
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment
RMC: 5
Fiscal Year: 2013
Agency: Texas Tech University
Indirect Rate: 10%

Revision Date: 15 Mar 2010

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually — % of time*	
Professional (Combine all Professionals)	$ 5,000	Theodore G. Cleveland (0.5 mo.) — 4%	
Subprofessional & Technical	$ 21,600	Graduate Student Researcher	
Clerical			
Total Salaries and Wages			$ 26,600
Fringe Benefits (provide details at the University's option)	$ 6,650		
Total Fringe Benefits			$ 6,650
Expendable Goods & Supplies (provide details at the University's option)	$ 1,200	Supplies (paper, toner, etc.)	
Total Expendable Goods & Supplies			$ 1,200
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ 1,000	Travel to Austin for Meetings with PMC	
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ 6,300		
Other			
Total Operating & Other Expenses			$ 7,300
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ 41,750

INDIRECT COSTS		
10.00% (%) of Modified Total Direct Costs ***	**MTDC** ** = $ 35,450	$ 3,545
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ 3,545

TOTAL PROJECT COST	$ 45,295

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Form ExhA
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **University of Texas -- San Antonio**

RMC: **5**
Fiscal Year: **2011**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
________ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **University of Texas -- San Antonio**

RMC: 5
Fiscal Year: 2012
Indirect Rate: 10%

Revision Date: 15 Mar 2010

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
________ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **Univeristy of Texas - San Antonio**

RMC: **5**
Fiscal Year: **2013**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
____________ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **University of Houston**

RMC: **5**
Fiscal Year: **2011**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
______ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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(Rev. 12/2009)
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **University of Houston**

RMC: **5**
Fiscal Year: **2012**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
______ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **University of Houston**

RMC: **5**
Fiscal Year: **2013**
Indirect Rate: **10%**

Revision Date: **15 Mar 2010**

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
______ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

RMC: 5
Fiscal Year: 2011
Indirect Rate:

Agency: U.S. Geologic Survey

Revision Date:

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
________ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Form ExhA
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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: **U.S. Geologic Survey**

RMC: **5**
Fiscal Year: **2012**
Indirect Rate:

Revision Date:

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS		
______ (%) of Modified Total Direct Costs ***	**MTDC ** =**	$ -
less University's Contribution		$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)		$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

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Itemized Budget - Exhibit A

Project No: 0-6654: Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment

Agency: U.S. Geologic Survey

RMC: 5
Fiscal Year: 2013
Indirect Rate: ______

Revision Date: ______

	Estimated Budget	Itemization	Total Costs
DIRECT COSTS			
Salaries & Wages (by category)		list each Professional individually % of time*	
Professional (Combine all Professionals)	$ -		
Subprofessional & Technical			
Clerical			
Total Salaries and Wages			$ -
Fringe Benefits (provide details at the University's option)	$ -		
Total Fringe Benefits			$ -
Expendable Goods & Supplies (provide details at the University's option)	$ -		
Total Expendable Goods & Supplies			$ -
Operating & Other Expenses			
Included in Modified Total Direct Costs			
Travel	$ -		
Other			
Excluded from Modified Total Direct Costs **			
Tuition (in lieu of partial or total salary)	$ -		
Other			
Total Operating & Other Expenses			$ -
Subcontracts ** (list each subcontractor separately, with a brief description of the work)	$ -		
Total Subcontracts			$ -
Equipment (items $5,000 and over) ** (list each item separately)	$ -		
Total Equipment			$ -
TOTAL DIRECT COSTS			$ -

INDIRECT COSTS			
______ (%) of Modified Total Direct Costs ***		**MTDC ** =**	$ -
less University's Contribution			$ -
TOTAL INDIRECT COSTS CHARGED TO PROJECT (limited to Indirect Rate stated at top of page)			$ -

TOTAL PROJECT COST	$ -

* Include **estimated** % of each Professional's time expected to be spent on this project during the period of this budget
** Per OMB Circular A-21, equipment, tuition remission, rental costs, scholarships and fellowships,
and the portion of each subcontract over $25,000 shall be excluded from Modified Total Direct Costs.
*** Calculate this line based on the University's federally approved indirect cost rate, enter % in blank

Note: This electronic form contains formulas that may be corrupted when adding or deleting rows, or by conversion of the spreadsheet. The university is responsible for the accuracy of the budget submitted.

1. Abstract

Water-surface profile modeling assembles models based on generalizations of parameter values from textbooks, professional literature, computer program documentation, and from engineering experience. Stage-discharge relations or measurements of streamflow at or adjacent to the modeling locale are seldom available for use in refining model parameters. In streamflow measurement at least three components are important; depth, width, and velocity. At field scale depth and width are straightforward but the velocity measurement is a significant contributor to overall uncertainty, complicated because a mean section velocity (as reported in a model) requires a spatial integration of the measured velocity field. As a result, modeling efforts by even experienced engineers are assembled and often judged to be valid based entirely on experiences from earlier modeling efforts for hydraulically similar settings.

This situation often leads engineers in good faith to report velocities (needed for assessing forces on bridge piers, and assessing erosion and scour potential) that are unusually large and in some instances absurd. This research will develop an independent way to assess computed velocities based on prior, authoritative, observational experience.

The results will permit an engineer to rapidly evaluate or review modeling efforta and determine if the modeled results are comparatively common or unusual, with the explicit caveat that unusual results could very well be reliable, but that additional explanation should be expended in these unusual situations. The results of this research (graphs and statistical distributions) will additionally provide an assessment of modeling risk that could be used to balance the cost of additional modeling with the cost of accepting an unusual result for design.

2. Project Objectives

The objectives of this project are

1. To determine and present from existing data in Texas, relations between observed streamflow, topographic slope, mean section velocity, and other hydraulic factors, to produce charts such as Figure 1 and to produce empirical distributions of the various flow parameters to provide a methodology to "check if model results are way off!"

   Figure 1, while dimensional, contains information that permits rapid checking of computed velocities for a given discharge any vertical slice of the figure (a specific value of Q) returns an empirical velocity distribution. For example, at $Q = 100$ cfs, observed velocities range between about 0.2 and 5 feet per second (fps). Hence a computed velocity above 5 fps, would be unusual, and if unexplainable in terms of contraction coefficients or other engineered cause, would be suggestive of a modeling error and would warrant further investigation would be warranted.

2. To produce a statistical regional tool to estimate mean velocity or other selected parameters for storm flows or other conditional discharges at ungauged locations (most bridge crossings)

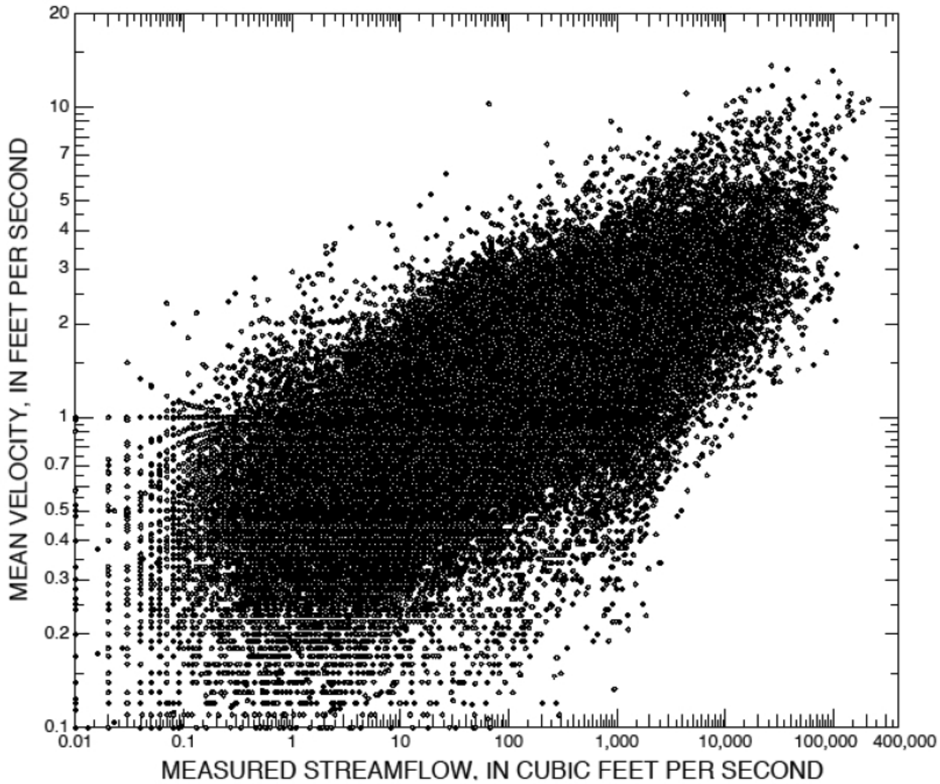

Figure 1: Mean Section Velocity versus Streamflow from U.S. Geological Survey Streamflow Measurement Database in Texas (adapted from Asquith and Herrmann, 2009).

in Texas to provide a secondary way to compare such values to a conventional hydraulic modeling approach.

3. To present ancillary values as statistical significance dictates such as Froude number, stream power, Rosgen channel classification, sinuosity, and other selected characteristics (readily determinable from existing data) to provide additional information to engineers concerned with the hydraulic-soil-foundation component of transportation infrastructure.

3. Work Plan

Task 1: Literature Review.

The researchers will conduct a targeted literature review on the subject of maximum discharge, velocity, slope and ancillary relationships (stream power, Fr, etc.). The focus of this review is to locate in the literature documentation of prior studies that produced findings that relate reasonably straightforward characterizations and classifications of short reaches to maximum velocity and flow geometry. Specific questions to be addressed might include:

1. What is typical natural channel geometry, and how are top-width and discharge related in such channels?
2. What kind of generic classifications of existing river form are appropriate to distinguish different channel types?
3. Can energy slope be inferred from readily available geomorphic and discharge data?
4. Is there a well-documented relationship between topographic slope and energy slope in particular flow systems?

The technical memorandum will summarize the literature reviewed and current answers to these and other questions as they are discovered. Texas Tech will be responsible for the literature review with substantial input from all members of the research team.

Task 2: Gaging Station Characteristics.

Task 1 will identify certain characteristics that will need quantification for the gaging stations in the existing velocity-discharge database and their corresponding contributing watersheds. These gaging stations are part of the existing database that was used to produce Figure 1. These physical characteristics will be computed, inferred, or estimated using geo-spatial tools where appropriate, and manually where necessary. For example a classification based on drainage structure inferred

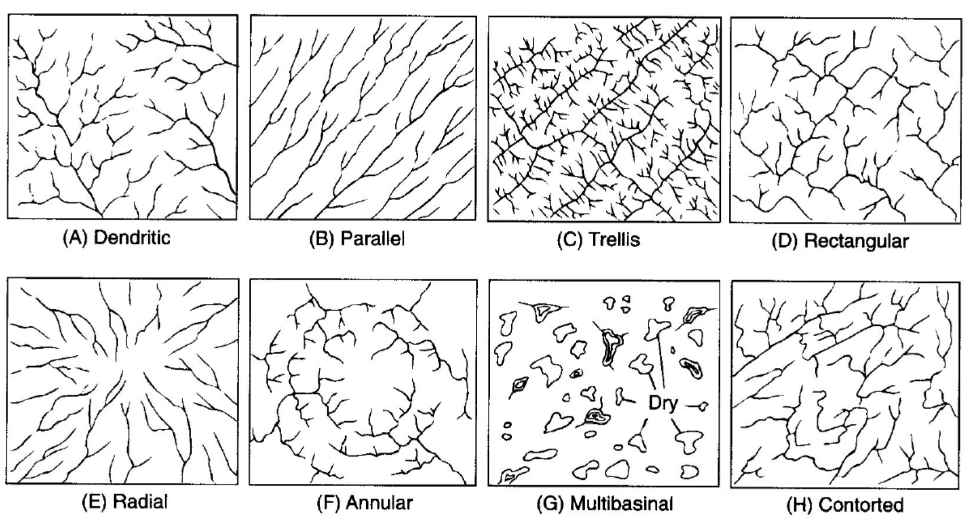

Figure 2: Drainage Pattern Classifications

by automated geo-spatial analysis (Task 4) or manually is appropriate. Figure 2 is an example of 8 possible classifications that are within the realm of repeatable identification, that are anticipated to have an impact on the observed discharge-morphometric structure of a stream and consequently an effect on the engineered drainage system.

Figure 3 illustrates other classifications that are repeatable, and are anticipated to have impacts on the observed discharge-velocity structure. The left panel of the figure displays stream-ordering schema. The scheme itself is unimportant to the research as long as the scheme chosen is consistently applied; higher order streams are anticipated to have a different stage-velocity-discharge structure. The right panel is the sinuosity effect (which is related to the energy slope in a system) admittedly less repeatable between analysts, but of value in that it relates stream gradient to behavior and anticipated discharge-velocity relationships.

In the context of a modeling guidance tool, these classifications for each station are needed to distinguish behavior beyond that which would be conferred by simple topographic and physiographic characteristics such as slope, relative relief, soil type, etc. The researchers further anticipate that these classifications will capture regional differences, that is East Texas and coastal plains will tend to have different, repeatable, broad classifications which will be used in screening before computing the more objective metrics like slope, topwidth, bank-full discharge width, etc.

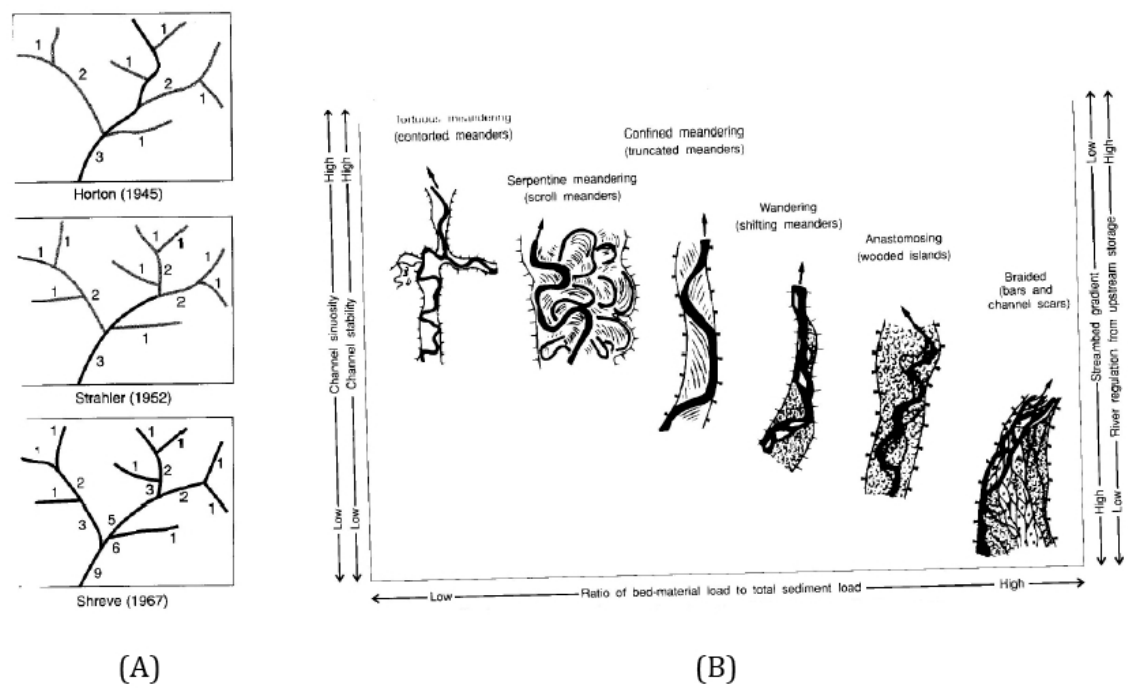

Figure 3: Stream-Order Schema (Panel (A)) and Stream Sinousity/Gradient/Stability Classifications (Panel (B))

As a minimum, the researchers anticipate delineating watershed boundaries, calculating slope, and calculating sinuosity for approximately 437 sites. These calculations will contribute to the velocity and discharge generalization effort of this project. To accomplish this component[1] the following steps are required (presented as a list of what are essentially systematic sub-tasks):

1. Obtain 437 sites as identified for velocity and discharge generalization effort.
2. Assemble the data necessary to carry out the analysis.
    - Obtain National Elevation Dataset 30-meter, 10-meter, 3-meter (where available and appropriate) with hydrological derivatives (flow accumulation and flow direction). These were produced in FY 2010 for a similar effort for the Texas Commission on Environmental Quality (TCEQ), and will be available for this effort.
    - Ancillary data: Digital Raster Graphics (DRGs), 1:24,000 National Hydrography Dataset (NHD)
3. Develop watershed delineations
    - Snap watershed pour points to flow accumulation grid.
    - Watersheds will be delineated for each site using ArcGIS and stored in a single feature class using the Environmental Systems Research Institute, Inc. (ESRI) personal geodatabase format. The ESRI personal geodatabase is backed by Microsoft Access and is very practical for organizing large amounts of spatial data, building interactive queries, and performing various types of spatial analyses. The geodatabase is a framework behind which the geographic data will be used to create relationships among related spatial features.
4. Review and refine watershed delineations
    - Due to the varying topography of the State of Texas, a thorough review of the automated watershed boundaries will be necessary. Special emphasis will be focused on, but not limited to, the following areas due to their unique hydrologic characteristics:
        (a) Rio Grande basin
        (b) Gulf Coast
        (c) Panhandle
    - Ancillary data will be used during refinement to determine if anthropogenic features (e.g. levees, canals, or raised road beds) have altered the drainage patterns of the delineated watershed.
    - Refinement will include regeneration of the watershed through ArcGIS or manual editing. The corrected data will then be incorporated into the personal geodatabase.
5. Develop watershed characterizations

    Watershed characteristics will be computed whenever it is possible to generate them using

[1] Develop watershed delineation characteristics for NWIS surface water gage sites.

automated techniques. Imperfections in base digital elevation models as well as complex topography may prevent certain characteristics from being computed for all watersheds. Specific characteristics will include:

- Main channel sinuosity ratio
- Main channel slope

6. Develop process documentation

   - Create and review federal geographic data committee (FGDC)-compliant metadata;
   - Document methods for (1) assembling data, (2) delineating watersheds, (3) refining watersheds, and (4) watershed characterization. Included in this documentation will be any automated techniques used to compute watershed characteristics when implemented. Documentation submitted will be in Adobe PDF or Microsoft Office format.

7. Develop watershed polygons and characteristics to be delivered upon project completion in an ESRI ArcGIS compatible personal geodatabase containing a single feature class of all delineated watersheds and a related table of characteristics by NWIS station. Documentation (Adobe Acrobat PDF format) and FGDC-compliant metadata which describes the methods used will be delivered upon project completion.

This task will be led by the U.S. Geologic Survey, and will leverage on-going cooperative research for the TCEQ (CITE) activities aimed at similar but not identical characteristics. The U.S. Geologic Survey is selected, as the lead in this particular task because the broader potential use of the characteristics identified in this task demands their oversight. Components of this task may be assigned to Task 4 with PMC guidance, but the classification schemes are likely to be led by the USGS team although the effort distributed among other researchers. For example, the classification of drainage types (Figure 2) might be assigned entirely to TTU, or UH, or UTSA to balance the effort. The RS does not anticipate routine splitting such an effort between two groups, as there is risk of inconsistent development. There will likely be a handful of cross checking by nature of the work.

The technical memorandum generated by this task will include discourse on measures such as Watershed size formatted as a parameterized variable for each of the 437+ active monitoring stations; Watershed delineations and characteristic metadata for each of the 437+ monitoring stations in an agreed upon electronic format; Documented methods for (1) assembling data, (2) delineating watersheds, (3) refining watersheds, and (4) watershed characterization as well as any automated techniques used to compute watershed characteristics when implemented.

Task 3: Database Refinement.

Task 3 will merge the existing flow database, and the characteristics database of Task 2 into the working database. This activity is identified as a separate task to provide a component of the overall project for data addition as new information becomes available during the project. Quality control of data will include elimination of stations that do not have, at least, 10 years of data, and other criteria deemed by the research team to be of importance. In general, the data to be retained should be of sufficient duration to capture some seasonal variation, be over enough years to be useful, and be reasonably tractable. The technical memorandum at the end of this task is anticipated to be a rather extensive data report that will explain the database contents, methods used to construct certain components, and how to access data in the database. This memorandum will not interpret results, but simply describe the database.

Task 4: Development of a GIS Database of Topography and Physiography.

Texas contains seven primary physiographic provinces and several subdivisions. These were based on distinct types of geologic structure, soil, land cover, and climatology. Each province is characterized by a unique geological history of deposition and erosion processes. The stream hydraulic geometries likely differ among these provinces and their subdivisions.

This task will compile a GIS database of physiographic provinces and their subdivisions. Another factor that may define the stream hydraulic geometries is the topography. ArcGIS will be used to compile digital surface topography from UGS1:24,000 topographic data for Texas. Elevations will be assigned according to USGS digital line graph standards. Contour lines will be generated using ArcMap and to create a surface topography coverage. Maps resulting from the combining surface topographic and physiographic analysis will be instrumental in regionalization of discharge-velocity relationships. This task will be led by UTSA in close cooperation with USGS researchers to take advantage of economies of scale and prior expertise in such database construction.

Task 5: Dimensional/Dimensionless Representation of Flow Characteristics.

Tasks 3 and 4 will result in functional databases suitable for analysis and interpretation. The research team will analyze the database to produce dimensional and dimensionless plots that describe the hydraulic geometry of streams.

The relationship between discharge and velocity is one of the primary factors that define the hydraulic geometry of a stream. Typically, a power-law model is used to describe this relationship ($V = aQ^b$). Logarithmic conversion will result in a linear relationship. Based on this relationship one can identify similarities among streams or segments of streams. The process of development of logarithmic relationships will be automated using a spreadsheet or R script such that stations with similar properties can be easily identified. Regionalization of the discharge-velocity relations will be based on this information combined with physical characteristics of the streams (topography, geology, sinuosity, etc).

Dimensionless analysis will provide additional insight into the factors that control the similarities among streams or stream segments. Bankfull discharge is needed for dimensionless analysis. For stations with stage data, the bankfull discharge can be estimated from the discharge stage curve (rollover in the curve), a process that can be automated. The logarithmic relations between discharge and velocity also can enable dimensionless analysis. In absence of a bank-full discharge, the analyst can choose a point from the straight line that describes the relationship near the maximum observed discharge to construct a denominator for the dimensionless analysis.

Dimensional plots will be presented with the understanding that end users may prefer that format. The dimensionless representations will also be presented to illustrate particular patterns that are anticipated to be discovered by the project. In particular, coastal plains, central Texas, West Texas, and South Plains are anticipated to have different dimensionless relationships; such differences may not readily appear on dimensional charts. This task will be led by UTSA with substantial cooperation with UH researchers.

Task 6: Ancillary Properties.

Ancillary properties are properties such as stream power, Froude number, Darcy-Weisbach friction factor[2], bed shear stress, and other properties that are of secondary importance for checking the validity of HEC-RAS model output. While not of primary importance for checking HEC-RAS output, such parameters are important in general fluvial hydraulics, e.g. in support of scour and sediment transport concerns (HEC-18 and similar guidance), and therefore will be calculated and provided as supplementary material.

Exact properties that will be reported will depend on the information available in the dataset produced by Task 3. Properties that can readily be inferred from this dataset will be computed and reported in a meaningful way. The computation and reporting will follow the analysis and presentation format of the main velocity-discharge data. This task will be led by UH with substantial cooperation with UTSA researchers.

Task 7: Empirical Distributions.

Empirical distributions will be constructed from the results of Tasks 3,4, and 5. These distributions (equations relating a value and a cumulative frequency) will constitute the fundamental component of a statistical regional tool to estimate mean velocity or other selected parameters for storm flows or other conditional discharges at un-gauged locations. These distributions are an alternate way to present the information that will be contained in the relationships presented in Tasks 3, 4, and 5. TTU will lead this task in close cooperation with all the research team members.

[2]The D-W friction factors are related to roughness height and Reynolds number. This friction loss model is attractive because it depends on dimensionless values, hence can be scaled to a greater variety of conditions, and because the roughness height in the researcher's opinion is a more measurable quantity. Manning's n is related to the square root of D-W friction factors, the one-sixth power of hydraulic radius, and the square root of gravitational acceleration

Task 8: Reporting and Application Examples.

The reporting task includes the mandatory reporting generated by the first 7 tasks (the technical memoranda), semi-annual reports, and the final report. The maintenance of the research database[3] is also part of this task. The research database will be located on a web-server at TTU maintained by the RS. In addition, the researchers anticipate producing a set of examples of how to use the results, and as such these warrant a task-level consideration. The examples are to be part of the final report, but sufficiently developed to stand-alone in some sense. TTU will lead this task with appropriate input from the other researchers.

4. Identification of Information Technology (IT)

The results of this research will be maps, equations, charts and tables that facilitate checking hydraulic model results and provide insight into ancillary (erosion) issues. As such specific IT products that are proprietary are not anticipated.

Computer spreadsheets (Excel/VBA) and R scripts are the most likely mechanisms for delivery of additional computational support beyond printed equations, maps, charts, etc. The database(s) files are to be delivered in ASCII as far as practical. GIS data files are to be delivered using ESRI standard file types at the conclusion of the project; these files will be organized in a fashion suitable for web-based delivery.

Delivery will be via a web-server maintained by the RS for this project as mentioned in Task 8, **and** by delivery of an entire set of database files on an external USB 2.0 hard drive.

At the time of the writing of this scope of work, Excel and ESRI-ArcGis are known to be in routine use by TxDOT engineers; **R** is an additional tool in limited use by TxDOT engineers. The delivered items are data that function within these environments, as such the researchers do not anticipate added burden to the IT division.

The research team acknowledges that the database files, Excel spreadsheets, **R** scripts, and GIS files "must meet TxDOT architecture requirements at the time of delivery."[4]

5. Assistance by TxDOT Personnel

None beyond the normal guidance of the PMC is anticipated in the first two years of the research. Some involvement in developing the case studies/examples are anticipated in the final year. The RS believes that this involvement can be accomplished by e-mail, phone, webinar, and some face-to-face visits by the RS with the PMC at a location of mutual convenience.

[3]This database includes elements described in the other tasks as well as an electronic literature collection.
[4]From page 4-12 of the University Handbook.

Form DelTblEx
(Rev. 12/2009)
(RTI)

Deliverables Table
Project No. 0-6654

Note: **Deliverables on this Table are not considered received by TxDOT until submitted to RTI.** See chapter 7 of RTI's *University Handbook* for standards for all deliverables.

The Research Supervisor is ultimately responsible to TxDOT for all required deliverables, no matter what agency is assigned as the primary developer of each deliverable.

Products: Minimum Stand-alone Products will be as specified on the **Project Statement** (Research Project) or **IPR** (Implementation Project). Examples of products typically most appropriate as stand-alone items include Guidebooks, Training Materials, Devices, Instruction Manuals, Brochures, and Software.

No.	**Stand-Alone Product Description**	**Due Date** (normally due at or before project termination)	**Primary Agency** (if other than Lead Agency)	**Comments**

Reports: Minimum Reports will be as specified on the **Project Statement** (Research Project) or **IPR** (Implementation Project).

No.	**Report Description** (Succinctly describe intended contents of each report.)	**Due Date** (if blank, defaults to 60 days after project termination)	**Primary Agency** (if other than Lead Agency)	**Comments**
R1	Comprehensive and detailed documentation of all work tasks and results.			Includes: 1. Figures and empirical distribution information on the relations of discharge and mean section velocity, the Froude number, stream power and other ancillary relations. 2. A regionalized estimation tool to estimate expected flow parameter values as an independent check on modeling results. 3. Suggestions on how to use the figures and estimation tool to assess a model result, including examples and possibly case studies. 4. Suggestions on how to report model risk.
PSR	Summary of work performed, findings and conclusions			(approximately 800 words)

Date Updated:

Schedule of Research Activities

Form Schedule
(Rev. 12/2009)
(RTI)

Original Schedule
Work Completed
Revised Schedule

Revision Date:

Note: A Tech Memo will be submitted to the PD & RTI at the end of each non-deliverable task.

FY 2011 | **FY 2012** | **FY 2013**

Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug

	Research Activity	Estimated % of Total Project Budget
Task 1	Literature Review	5%
Task 2	Gaging Station Characteristics	20%
Task 3	Database Refinement	10%
Task 4	Development of a GIS Database of Topography and Physiography	15%
Task 5	Dimensional/Dimensionless Representation of Flow Characteristics	15%
Task 6	Ancillary Properties	15%
Task 7	Empirical Distributions	10%
Task 8	Reporting and Application Examples	10%
	Total (should = 100%)	**100%**

Texas Department of Transportation	**RTI** **Research Project Statement**	(Rev. 4/2009) (RTI)

RMC:	5	**OPR: (for RTI use)**	DES	**Project #: (for RTI use)**	0-6654
Date:		12/8/09		**Research Program Year:**	**2011**
Project Title:		Empirical Flow Parameter Distributions - A Tool for Hydraulic Model Validity Assessment			

Project Description:

What is the problem?
Engineers involved in water-surface profile modeling assemble models based on generalizations of parameter values from textbooks or literature, from computer program documentation, and from experience. Furthermore, measurements of streamflows are rarely available for use in adjusting model parameters. Typically, engineering education and practice provides insufficient physical; i.e., observational experience and exposure, to stream flow metrology (the study of measurement). In streamflow measurement (hydrometry) at least three components are important; depth, width, and velocity. The uncertainty in depth is usually the most significant contribution to overall uncertainty, yet routine gauging is based on a depth measurement and a rating curve. As a result, modeling efforts by even experienced engineers are assembled and often judged to be valid based entirely on experiences from earlier modeling efforts for hydraulically similar settings. This situation often leads engineers in good faith to report velocities (needed for assessing forces on bridge piers) that are unusually large and in some instances absurd. A need exists for an independent way to assess computed velocities based on prior, authoritative, observational experience.

Who is impacted by the problem?
Districts with hydraulic structures that use modeling results in design and evaluation of those structures.

What is the significance / scope of the problem?
In water-surface profile modeling to support hydraulic structure design, outside circumstances in which model parameters can be adjusted using measurements from one or more stream gauging stations, there is seldom any independent information upon which to base a validity assessment in backwater modeling. This assessment is further impaired in ungauged systems, which are by far the majority of systems in Texas. Many assessments of, and discussions about, model validity necessarily begin and end as expressions of individual professional opinion with inadequate quantification to discriminate between valid and invalid models.

Documentation of observed mean velocities could provide a fundamental link to physical reality and potentially provide an authoritative and independent measure of consistency that will allow for enhanced assessment of water-surface profile model reliability. At the very least, velocity generalizations would provide a tool to flag severely inconsistent situations for further scrutiny. In other words, modeled mean velocities, which are inconsistent with the historical database, might suggest that an erroneous model has been made and alternative parameters or other changes should be considered.

The U.S. Geological Survey (USGS), through the streamflow-gauging station network in Texas, has collected and digitally archived about 140,000 streamflow measurements and station inspections for more than 600 stations from December 1897 to February 2009. For 435 selected stations, nearly 60,000 measurements of streamflow with associated cross-section area, mean velocity, and other properties exist.

To date, systematic investigation of these data to generalize the distribution of observed mean velocity has not been made. Such velocity generalization is important for reliable application of backwater computation for modeling flood elevations and mean velocities of design discharges such as 100-year peak streamflows. Mean velocity at a cross-section often is the quantity of interest for subsequent computations of bridge scour or bank protection.

As an example of the anticipated type of results that could be constructed, an exercise was conducted in which all streamflow measurements with values greater than the 1st-percentile daily mean streamflow (a low-flow statistic) were considered if cross-section area and mean velocity data were available and their product within a tolerance matched the recorded discharge. The exercise considered the 620 stations described in USGS Data Series 372, *Summary of Annual Mean and Annual Harmonic Mean Statistics of Daily Mean Streamflow for 620 U.S. Geological Survey Streamflow-Gauging Stations in Texas Through Water Year 2007*, by W.H. Asquith and F.T. Heitmuller. The results of the exercise are shown in Figure 1. From the 620 candidate stations, 435 stations had sufficient data to produce the plot.

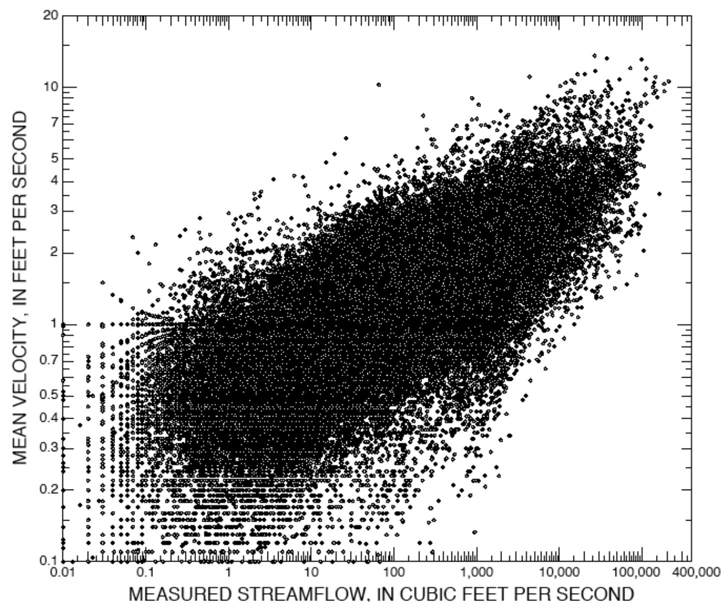

Figure 1. Mean Section Velocity versus Streamflow from U.S. Geological Survey Streamflow Gauging in Texas (adapted from Asquith and Herrmann, 2009).

The figure contains 58,723 points. The figure, as well as potential analyses that could consider factors, such as method of discharge measurement (wading, crane, indirect), regional location (east Texas forest versus central Texas plateau), channel top width, proximal channel slope (as an expression of gravitational forces), and bed material classification (rock, gravel, sand), provides a potential tool for evaluation of limiting mean velocities from step-backwater models.

For example, suppose that a design discharge of 1,000 cubic feet per second has a modeled mean velocity at a cross section in excess of 10 feet per second. Such a coordinate would plot outside of an imaginary hull around the cloud of data points. Should the model be scrutinized for possible errors and improvement? The distribution of the observed mean velocity data suggests "Yes."

Finally, the large streamflow measurement database should facilitate additional as well as emergent lines of investigation. For example, the plot is a velocity plot, but there is sufficient information that the Froude number could be reported, given that there is some evidence that such a dimensionless number relates additional information for drainage engineering. Especially with respect to controlling erosion, scour, and culvert clogging, a similar plot could serve an equivalent purpose to check assumptions used in models and guide modelers to reassess results that fall far outside the range of prior observation.

<table>
<tr><td>RMC:</td><td>5</td><td>OPR: (for RTI use)</td><td>DES</td><td>Project #: (for RTI use)</td><td>0-6654</td></tr>
<tr><td colspan="2"></td><td colspan="4">What are the technical objectives of this project?
The technical objectives of this project are 1) to determine and present from existing data relationships between observed streamflow and mean section velocity, Froude number, stream power, sediment dimension, Rosgen channel classification, sinuosity, and other selected characteristics (determinable from existing data) to produce charts such as Figure 1 and empirical distributions of the various flow parameters, and 2) to develop a statistical regional tool to estimate mean velocity or other selected parameters for storm flows or other conditional discharges at ungauged locations (bridge crossings) in Texas.

What benefits would this project deliver, and how would the results be used within TxDOT?
The result would permit an engineer to rapidly evaluate their modeling effort and determine if the modeled results are common (contained within the 35%-65% range) or unusual (outside this frequency range), with the caveat that unusual results could very well be correct, but that additional explanation should be expended in these situations. The results (graphs and distributions) would additionally provide an assessment of modeling risk that would be used to balance the cost of additional modeling with the cost of accepting an unusual result for design.</td></tr>
<tr><td colspan="2">Minimum Deliverables:</td><td colspan="4">Reports:
- Complete documentation of work performed, methods used, and results achieved. Includes the following:
1. Figures and empirical probability distribution information of the relationships of discharge and mean section velocity, the Froude number, and stream power.
2. A regionalized estimation tool to estimate expected flow parameter values as an independent check on modeling results.
3. Suggestions on how to use the figures and estimation tool to assess a model result, including examples and possibly case studies.
4. Suggestions on how to report model risk.
- Project Summary Report</td></tr>
<tr><td colspan="2">Proposals Requirements:</td><td colspan="4">1. Proposals will be considered non-responsive and will not be accepted for technical evaluation if they are not received by the deadline or do not meet the requirements stated in Chapter 5, Section 3 of TxDOT's Research Manual.
2. Proposals should be submitted in PDF format, 1 PDF file per proposal. File name should include project number and university abbreviation.
3. All proposals should be submitted through the university's Research Liaison to RTI, as instructed in the RFP announcement.</td></tr>
<tr><td colspan="2">Pre-proposal Meeting:</td><td colspan="4">Tuesday, February 9, 2010, 3:00pm – 4:30pm

Camp Hubbard
4000 Jackson Avenue, Building 1
San Jacinto Conference Room, 3rd Floor
Austin, Texas 78731

Attendance through Teleconference or Webinar is available.</td></tr>
<tr><td colspan="2">Notifying RTI of Intent to Propose:</td><td colspan="4">Individuals interested in proposing are encouraged to contact Sandra Kaderka at 512-465-7716 or skaderk@dot.state.tx.us by January 25, 2010 so you can be notified if additional project information is distributed by TxDOT, or make arrangements for teleconferencing a pre-proposal meeting.</td></tr>
<tr><td colspan="2">Proposal Deadline:</td><td colspan="4">Proposals are due to RTI by 4:00 p.m. Central Time, March 25, 2010. Email submissions should be sent to rtimain@dot.state.tx.us.</td></tr>
</table>