Form ProjAgre
(Rev. 1/2018)
(RTI)

RTI
PROJECT AGREEMENT
Between the
TEXAS DEPARTMENT OF TRANSPORTATION (TxDOT) Fiscal Year **2019**
(RECEIVING AGENCY)
AND
Texas A&M Transportation Institute (TTI)
of The Texas A&M University System
(PERFORMING AGENCY/S)

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

Project Number: **0-6992** Document Date: 8/24/18

Project Title: Traffic Safety Improvements at Low Water Crossings

For TxDOT Purposes Only:

Performing Agency/ Subrecipient:		**Federal Awarding Agency: Federal Highway Administration**	
DUNS #	93-848-5539	CFDA #	20.205
Indirect Cost Rate	48.5%	CFDA Name	Highway Planning and Construction
FAIN #	48SPR0511(219)Z560		
Federal Award Date	8/24/2018		
Amount of Federal Funds Obligated to Performing Agency/ Subrecipient	$445,069.00	Amount of Federal Funds Obligated	$445,069.00
Contact Information	TxDOT's Research Technology and Implementation Division	Phone: (512) 416.4730	Email: RTIMain@txdot.gov

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 The Texas A&M University System, Texas A&M Transportation Institute.

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) shall 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. Period of Performance Start and End Date. 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.

May 31, 2020
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 Itemized Budget - 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
19	TTI	$233,932.00			
20	TTI	$211,137.00			

Total Project Budget: $445,069.00

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

	Name	Title	Agency	Phone No.	Email
Project Supervisor	Chiara Silvestri Dobrovolny	Associate Research Scientist	TTI	979-845-8971	c-silvestri@tti.tamu.edu
Researcher or PI	Kevin Balke	Senior Research Engineer	TTI	979-845-9899	k-balke@tti.tamu.edu
Researcher or PI	Subasish Das	Assoc. Transp. Researcher	TTI	979-845-9958	subaishsn@gmail.com
Researcher or PI	Roger Bligh	Senior Research Engineer	TTI	979-845-4377	r-bligh@tti.tamu.edu
Researcher or PI	Adam Pike	Assoc. Research Engineer	TTI	979-862-4591	a-pike@tti.tamu.edu
Researcher or PI	Timothy P. Barrette	Assoc. Transp. Researcher	TTI	979-845-6174	t-barrette@tti.tamu.edu
Researcher or PI	Hasan H. Charara	Software Applic. Dev. III	TTI	979-845-1908	h-charara@tti.tamu.edu
Researcher or PI	David Florence	Assoc. Transp. Researcher	TTI	979-845-9898	d-florence@tti.tamu.edu
Researcher or PI	Geza Pesti	Research Engineer	TTI	979-845-9878	g-pesti@tti.tamu.edu
Researcher or PI	Stefan Hurlebaus	Research Scientist	TTI	979-845-9570	shurlebaus@civil.tamu.edu
Researcher or PI	Richard A. Zimmer	Senior Research Specialist	TTI	979-845-6388	d-zimmer@tti.tamu.edu

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.

Approved and Accepted by the Performing Agency:

DocuSigned by:
William R. Stockton, Ph. D., P.E.
William R. Stockton, Ph.D., P.E.
Executive Associate Director
Texas A&M Transportation Institute
The Texas A&M University System

Date: 8/29/2018

Approved and Accepted by the Receiving Agency:

DocuSigned by:
Kenneth Stewart
Kenneth Stewart
Director of Contract Services

Date: 8/29/2018

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 512/416-4730.

Exhibit A - Itemized Budget

Project No: 0-6992 Created Date: 8/24/18 Form ExhA_DB
Agency: TTI Revision #: (Rev.3/2018)
Primary Agency X Revision Date: (RTI)

Direct Costs

Salaries & Fringe

Role	Fringe Rate	FY19	FY20	Total Costs
Research Supervisor	16.8	18,538.00	7,254.00	25,792.00
Professional	16.8	96,121.00	106,929.00	203,050.00
Sub professional / Technical	16.8	9,646.00	-	9,646.00
Administrative or Clerical ^	16.8	1,322.00	1,163.00	2,485.00
Student (1-PhD grad technical support)	2.4	8,429.00	5,639.00	14,068.00
Total Salaries and Wages		134,056.00	120,985.00	$ 255,041.00

Subcontractors

Sub #	Description of Duties	FY19	FY20	Total
1	Sub to assist in Tasks 7& 8 for I2I and I2V: assist to develop test plan, and coordinate to conduct a controlled environment testing demonstration.	45,500.00	44,500.00	90,000.00
	Total Subcontracts	45,500.00	44,500.00	$ 90,000.00

Equipment (items over $5,000; list each item separately)

Deliverable #	Description of Equipment ^^	FY19	FY20	Total
	Total Equipment	-	-	$ -

Travel

City, State	Purpose	FY19	FY20	Total
Austin, TX	Attend Kickoff project meeting in FY19; attend Close Out project meeting in FY20.	244.00	244.00	488.00
	In-State & Out-of-State Travel Total	244.00	244.00	$ 488.00

Operating, Supplies and Other Expenses

In/Excluded MTDC	Description ^^^	FY19	FY20	Total
Excluded from MTDC	Computer Operations	2,657.00	1,847.00	4,504.00
Excluded from MTDC	Specialized Service Center - Photometric Field Equipment @ $150/day	900.00	-	900.00
Excluded from MTDC	Specialized Service Center - Editing Services @ $54/hour (major deliverables such as: R1& PSR)	-	2,160.00	2,160.00
Excluded from MTDC	Specialized Service Center - Construction Section Services @ $41/hour (preparation of the installation site for testing)	2,000.00	6,724.00	8,724.00
Excluded from MTDC	Specialized Service Center - Evaluation/Reporting & Photographic Research @ $72/hour	-	1,152.00	1,152.00
Excluded from MTDC	Specialized Service Center - Construction Section Services DEMO @ $41/hour (demolition of the installation site and removal of all materials after testing)	-	1,968.00	1,968.00
Included in MTDC	Research Supplies (sensors - $2,390; Brackets - $300; guide wires - $300; signs - $300; base materials - $1,500; asphalt - $750; roller - $1,020; track steer - $840; concrete disposal - $300; misc. items for testing $300)	7,000.00	1,000.00	8,000.00
	Total Expendable Operating and Other Expenses	12,557.00	14,851.00	$ 27,408.00

Total Direct Costs	FY19	FY20	Total
	192,357.00	180,580.00	$ 372,937.00

Indirect Costs

				FY19	FY20	Total
$ MTDC * =	288,529.00	Indirect Cost Rate	48.50%	80,656.00	59,281.00	139,937.00
Less University's Contribution		% MTDC *** =	23.50%	39,081.00	28,724.00	67,805.00
			Indirect Cost Total	41,575.00	30,557.00	$ 72,132.00

Total Project Costs by Fiscal Year .Direct Costs Plus Indirect Costs)	FY19	FY20	Total
Total Project Costs	233,932.00	211,137.00	$ 445,069.00

Comments: The fringe rate excludes medical for staff and eligible students. For budgeting purposes, medical is calculated per the Performing Agency's Fringe Benefit Memorandum and is included in the FY Salaries & Fringe amount(s).

MTDC Notes:

* Calculate Modified Total Direct Costs (MTDC) based on the University's negotiated (federal) F&A agreement. Per 2 CFR 200 Rule, Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards, MTDC should never include, equipment, tuition remission, rental costs, scholarships and fellowships, and the portion of each subcontract over $25,000.

** Enter the University's federally approved indirect cost rate % or 10% de minimis. Form will calculate total, based on MTDC.

*** The Performing Agency will share in the cost of the project by making the above University Contribution.

Notes:

Amounts on Exhibit A are estimates of the project tasks and deliverables.

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 calculations of the budget.

^ Must include documentation to support the charges.

^^ Include equipment specifications and application of equipment within the workplan task(s) for which it is being purchased.

^^^ For Supplies that have an aggregate amount of $5,000 or more, provide line item details.

Components which constitute a larger system, costing over $5,000 in the current project should be listed under Equipment.

0-6992, TRAFFIC SAFETY IMPROVEMENTS AT LOW WATER CROSSINGS

PROJECT ABSTRACT

Texas has been reported to lead the nation in flood-related deaths, with the majority of deaths caused by motorists attempting to drive through moving water. Motorists might attempt to cross a flooded roadway not realizing its depth, or especially at nighttime during heavy storms that make it difficult to see that flooded road. The report established that it only takes 18-24 inches of moving water to sweep away a truck, and 6 inches to carry away a small car (reference to http://www.nws.noaa.gov/om/water/tadd/images/NSC_FinalVersion1-4.pdf). Many accidents, rescues, and deaths occur at low water crossings, and most accidents occur at night. While it may be impractical to raise or remove all low water crossings across the state, there are low-cost means to better alert the driving public to the risks of low water crossings.

The Performing Agency shall investigate low-cost approaches to improve low water crossings, with a focus on easy to install and maintain features, such as:

- Reflective pavement markings and markers,
- Flood-detection sensors,
- Active/passive warning devices, and
- Infrastructure-to-Infrastructure (I2I) and Infrastructure-to-Vehicle (I2V) technologies.

IMPLEMENTATION

Should the Receiving Agency want to implement the research; the Performing Agency shall provide adequate recommendations for improvement at low water crossing locations based on the testing program outcomes conducted to evaluate the accuracy of the detection/warning systems.

WORK PLAN

Task 1: Project Management

The Performing Agency shall determine the Project's Value of Research through a Technical Memorandum (VoR) using a Receiving Agency Project Sponsor's selection of qualitative and economic benefit areas below.

Benefit Area	Qualitative	Economic	Both	TxDOT	State	Both	Definition in context to the Project Statement
Level of Knowledge	X			X			Will aid in better understanding flood events and potentially assist with prioritizing response
Quality of Life	X			X			Will aid in eliminating wasted time for motorists and TxDOT personnel responding to the flooded roadway
Customer Satisfaction	X			X			Will improve the Department's current flooded roadway practices while being cost conscious. Clearer and more accurate public recognition of the hazards at low water crossings could improve customer satisfaction.
System Reliability		X		X			Will aid in providing more consistent and efficient response to flooded roadways
Intelligent Transportation Systems		X				X	Will potentially provide capabilities to measure floodwaters to establish history, assist in forecasting, ITS, and share information with the travelling public
Engineering Design Improvement			X			X	The research may identify some applicable improvements to our current designs.
Safety			X			X	Will improve methods to prevent motorists from driving into flooded roadways thus resulting in fewer lives lost

The Performing Agency shall complete the Value of Research Template, and include it with the basis of the economic calculations, the description of economic variables from within the calculations, and the qualitative values of the benefit areas within the Technical Memorandum.

The Performing Agency shall direct all benefit area data requests to the Receiving Agency's Project Manager. The Receiving Agency shall evaluate the initial submission of the VoR Template and Technical Memo, and provide feedback for the Performing Agency's revisions.

The Performing Agency shall resubmit the VoR Template at the end of the project within the Project Summary Report (PSR) and expand upon it in the Research Report (R1). It shall include any new qualitative and economic VoR data found during the progress of the project.

Project Management deliverables include:

- The VoR Technical Memorandum (VoR);

- Monthly Progress Reports (MPRs) that summarize the progress of tasks;
- The Performing Agency shall arrange and present the findings of the Project in a half hour (30 minutes) recorded webinar within the last two months of the project (P1);
- A research report (R1) documenting all research activities, findings, and results; and a
- A project summary report (PSR) summarizing all activities and findings.

Following the Project Management Committee (PMC) review, the Performing Agency shall revise all documents to incorporate recommendations, and modifications.

Meetings shall include:

- A project kick-off meeting with the PMC to set objectives at the very beginning of the project.
- Status meetings to discuss and evaluate project progress.
- A Close-Out Meeting (CO).

The Performing Agency shall prepare an agenda and log minutes for all meetings.

Deliverables: The Performing Agency shall submit the VOR, MPRs, P1, R1 and PSR, to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 2. Literature Review and Crash Data Analysis

The Performing Agency shall develop a synthesis of relevant information by reviewing the research literature and state policy documents regarding low water crossing related issues. The synthesis shall consist of a literature review to obtain the best available knowledge on the following topics:

- Low water crossing related crash and incident trends, focusing on the effects of the following variables on crash frequency and severity:
  - Roadway geometry (e.g. lane width, pavement marking, and shoulder type).
  - Traffic control devices (e.g. low water crossing signs, and warning devices).
  - Weather (e.g. precipitation, and extreme weather event).
- Effectiveness of different low water crossing countermeasures (e.g., signs, warning devices).
- Receiving Agency practices, including:
  - Low water crossing design and countermeasure implementation warrants.
  - Criteria and methods for diagnosing problems and choosing advanced alternatives.
  - Low water crossing inventory and management approaches.
- Other relevant issues, possibly including design considerations, the needs of connected vehicle technologies, cyber-physical infrastructure, and smartphone app for flood hazard warning.

Upon completion of this Task, the Performing Agency shall:

- Categorize locations/scenarios for consideration of the testing demonstration in Task 8;
- Prioritize characteristics of locations where future device deployment is most needed in Task 3;
- Provide information to assist cost-benefit assessment of flood sensors and warning devices in Task 6.

The Performing Agency shall conduct the literature review using both manual and computerized methods. Computerized searches shall be conducted in the Transportation Research Information Service (TRIS) and Transportation databases. TRIS includes the capability to search several databases including the Highway Research Information Service database for domestic literature, the Highway Research in Progress database for ongoing research studies, and the International Road Research Database for relevant foreign literature. The literature review shall include state policy documents, national guidance documents (e.g., Highway Safety Manual), technical reports/journals, and informational documents published by agencies such as FHWA and AASHTO.

Deliverables: The Performing Agency shall submit Technical Memorandum 2 (TM2) to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 3. Receiving Agency Low Water Crossing Management Approach

The Performing Agency shall investigate each Receiving Agency Area Office's current inventory and management approach for low water crossings. Texas Natural Resources Information System (TNRIS) maintains a location database of low water crossings in Texas. The purpose of this database is to locate all existing low water crossings locations. This database provides locations of 8,339 low water crossings in Texas (https://tnris.org/data-catalog/entry/low-water-crossings/).

The Performing Agency shall use this list to identify low water crossing in association with traffic crashes during flood events. A database on the low water crossing in association with traffic crashes shall be created (P3). The Performing Agency shall review the most recent available five years from the Crash Record Information System (CRIS) database to identify the extent of the low water crossing traffic incidents and useful available information regarding those locations.

The Performing Agency shall access additional datasets to incorporate additional data types (column 1 of Table 1). For each data type, the Performing Agency identifies available Receiving Agency data sources containing pertinent information and data (column 2 of Table 1).

Table 1. Data Types and Existing Receiving Agency Data Sources.

Data Type	Receiving Agency Data Source
Crash	• Crash Record Information System (CRIS)
Roadway	• Road-Highway Inventory Network Offload (RHiNO) • Google earth aerial and street views
Weather	• National Climatic Data Center
Traffic	• RHiNO
Low Crossing related sign and countermeasure location	• Other District data
Construction dates	• Other District data
Project cost	• Other District data

The Performing Agency shall work with the Receiving Agency Districts to identify and categorize types of both passive and active devices utilized by the Districts to improve conspicuity and alert motorists of flooding events at low water crossings.

Deliverables: The Performing Agency shall submit Technical Memorandum 3 (TM3) and the Cross Reference Database (P3) to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 4. Statewide Low Water Crossing Management Approaches

The Performing Agency shall conduct an online survey of other Departments of Transportation (DOTs), American Association of State Highway and Transportation Officials (AASHTO), Federal Highway Administration (FHWA), and other agencies, such as American Traffic Safety Services Association (ATSSA), on low water crossing management techniques. The Performing Agency shall design the survey with the additional intent to identify and categorize types of both passive and active devices utilized by the surveyed Agencies to improve conspicuity and alert motorists of flooding events at low water crossings. The Performing Agency shall conduct follow-up phone interviews for up to five agencies that have the most information to share.

The Performing Agency shall acquire the Receiving Agency's review and approval of the online survey and phone interview questions.

Deliverables: The Performing Agency shall submit Technical Memorandum 4 (TM4) to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 5. Pavement Marking and Marker Evaluations for Low Water Crossings

The Performing Agency shall evaluate the contrast of the markings and markers comparing when the road surface is submerged and not submerged in water during both day and night conditions. The evaluation shall include an assessment of whether the change in visual contrast between submerged and unsubmerged markings provides drivers with enough detection distance to safely stop. The Performing Agency shall receive approval of the testing site, conditions, and other requirements from the Receiving Agency before testing occurs. This research shall be performed in anticipation of potentially developing one or more statewide standards on the use of pavement markings for low water crossings as a potential subsequent implementation project. The Performing Agency describes the methodology to define and acquire treatments for evaluation, to determine the experimental design for evaluation of the treatments visibility, to analyze the collected data, and to develop the task's deliverable in the descriptions below.

- *Definition and Acquisition of Existing or Potential Marking and Marker Treatments for Evaluation*: The Performing Agency shall contact marking and marker treatments manufacturers to identify existing marking or marker products that would be beneficial at low water crossings, serving as either a warning to drivers or to aid in delineating the roadway. The Performing Agency shall consider available potential possibilities such as markings with wet-reflective optics, raised retroreflective pavement markers (RRPMs), internally illuminated markers, different marking colors, and contrast markings. The Performing Agency shall conduct this search with the goal to acquire and test a selection of treatments to determine their capability of providing delineation or warning at low water crossing when submerged and not submerged in water. The Performing Agency shall select marking and marker types for further evaluation through testing.

- *Finalize Experimental Design and Conduct Testing*: The Performing Agency shall prepare an experimental design for appropriate testing of selected markings and markers. The Receiving

Agency shall review and provide feedback on the experimental design. Upon receiving approval of the test design, the Performing Agency shall proceed with testing. The experimental design and subsequent testing shall be set up to yield a dataset suitable for assessing the visibility performance of the selected markings and markers in both dry and wet conditions, during both day and night conditions.

The Performing Agency shall conduct the approved testing in a controlled testing environment due to the unpredictable nature of water flowing across low water crossings. The Performing Agency shall modify the existing facilities typically used for water runoff, soil erosion, and sediment retention for the purposes of conducting this research. The wet conditions shall consist of varying levels of water that shall submerge the treatments. The water used to submerge the treatments shall be of varying clarity (evaluated with a turbidity sensor) to simulate different flooding conditions. The Performing Agency shall use the sediment retention channel to hold water at varying depths while the treatments are placed along the modified bottom, which shall simulate a typical low water crossing road surface. The Performing Agency shall use the facility equipped with a large water holding tank with an agitator to suspend solids in the water to produce varying levels of water clarity and shall evaluate a single treatment at a time. During daytime testing, the sun shall be the only illumination source. The Performing Agency shall use a vehicle headlamp at the appropriate geometry to provide illumination during the nighttime testing and strive to schedule nighttime testing on cloudy or moonless nights. The Performing Agency shall use a calibrated imaging spectroradiometer to capture images of the treatment in the various test conditions. The spectroradiometer captures accurate color and luminance levels for every pixel in the scene. The Performing Agency shall set up the spectroradiometer to represent a typical driver viewing position of the treatments.

- *Analysis of Collected Data:* The Performing Agency shall analyze and quantify the visibility performance of the marking and marker treatments. Performance metrics shall include luminance, color, and their associated contrast with the surrounding simulated road surface. The contrast is a comparison of the treatment value to that of the surrounding surface. The Performing Agency shall collect data using the imaging spectroradiometer and analyze the data with the associated software. The software allows the user to select areas of the image to include in the analysis. The Performing Agency shall include color images in the analysis. These images allow the user to select specific areas to analyze for luminance or color.

For each of the test conditions, the Performing Agency shall develop a database of the results for each treatment. For each metric, the Performing Agency shall first characterize its performance using descriptive statistics and graphical plots to describe its range and variability across different materials and testing conditions. The goal of the analysis is to determine the contrast levels of the markings and markers when submerged and not submerged in water and whether the contrast differences between submerged and unsubmerged markings provides drivers with enough detection distance to safely stop.

Deliverables: The Performing Agency shall submit Technical Memorandum 5A and 5B (TM5A & 5B), 5A shall include the testing site, conditions, and other requirements for the Receiving Agency's approval before testing occurs and 5B which includes material selection, test conduction, findings, and recommendations to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 6. Flood Sensors and Warning Devices Identification

The Performing Agency shall conduct a review of existing sensors and devices that are currently on the market including existing countermeasures, for flood sensors and high-water warning devises devices that are currently being used by the Receiving Agency, utilized by the Receiving Agency and other off-the-shelf flood sensors and warning devices available. The Performing Agency shall assess their cost/benefit, including maintenance and applicability in urban and rural and high-volume and low-volume traffic settings.

The Performing Agency shall develop a metric to evaluate up to five flood sensors and warning device combinations. For the flood sensors, the Performing Agency shall develop a weighting system to judge the priority for incorporating the sensors in Tasks 7 and 8. The Performing Agency shall review the information for the flood sensors and receive approval from the Receiving Agency on a single set of weighting factors for the following attributes:

- Applicability (in urban and rural and high volume and low-volume traffic settings),
- Robustness (e.g. ability to handle freezing),
- Durability (e.g. long term reliability),
- Accuracy (e.g. performance during fluctuating air/water temperature, dirty water, foam penetration, debris),
- Precision,
- Repeatability (linearity and hysteresis, output stability),
- Ease of use (ease of installation, ease of calibration, power requirements), and
- Cost.

The Performing Agency shall conduct laboratory testing to assess the capabilities and robustness of up to three flood sensors and combination of sensors identified in Task 6. The experimental setup consists of a test tank, rugged staff gauge (as reference), flood sensors, water pump, temperature sensor, humidity sensor and the data acquisition system. The Performing Agency shall install the flood sensors, humidity sensor and temperature sensor and connect it to the data acquisition system. The Performing Agency shall use the water pump to change the water level in the test tank. The Performing Agency shall test the air temperature effect, water temperature effect, foam effect, debris effect, wave effects as well as the linearity, hysteresis, drying effects, and output stability on the output of the flood sensor.

Deliverables: The Performing Agency shall submit Technical Memorandum 6A and 6B (TM6A & 6B), in which 6A includes a set of weighting factors for the Receiving Agency's approval and 6B shall include testing setups and results, to RTIMAIN@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 7. Develop Connected Vehicle Implementation

The Performing Agency shall design, build, and test a prototype system for providing alerts and warnings at low-water crossings using connected vehicle (CV) technology. The system shall use appropriate I2I and I2V technologies for providing flood conditions reports at low water crossing in a connected vehicle environment. The Performing Agency shall consider two different architectures: one integrating with the Receiving Agency's Lone Star Traffic Management System software and another as a standalone system for deployment at an isolated low-water crossing. The Performing

Agency shall follow systems engineering principles to design, build and test the system. The Performing Agency's subcontractor shall assist with the following:

- Develop new use cases for providing connected vehicle alerts at low water grade crossings.
- Develop the system architecture and system requirements installing and integrating with flood monitoring equipment with the Receiving Agency's Lone Star Traffic Management System software.
- Develop interfaces for integrating flood-monitoring sensors with Roadside Unit (RSU) devices.
- Develop logic for using basic safety messages for issuing alerts traffic management centers (TMCs) of vehicle entering flooded crossings.
- Develop Traveler Information Message (TIM) sets for providing traveler alerts at low water and flood prone crossings.
- Develop prototype interface for displaying TIM alerts of flooded conditions in connected vehicles.
- Develop interfaces and logic for activating external communication devices [such as Dynamic Message Signs (DMS), flasher assemblies, etc.] to alert travelers to flooded road conditions.

Coordination between other CV projects shall be considered, including but not limited to the Texas Connected Freight Corridor Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) program and the Safety through Disruption (SAFE-D) University Transportation Center (UTC) smart connected corridor.

The Performing Agency shall fund the construction of a prototype system for testing in their close-course environment facility. The purpose of the prototype is to demonstrate the functionality of the system using real systems typically deployed by the Receiving Agency. The Performing Agency shall obtain a traditional real flood detection and warning assembly typically used by the Receiving Agency to achieve this purpose.

The Performing Agency shall use the constructed equipment/instrumentation to conduct the research testing.

Deliverables: The Performing Agency shall submit Technical Memorandum TM7 (TM7), which shall document work performed, findings, and recommendations for designing and testing a prototype system that provides alerts and warnings at low-water crossings using CV technology to RTIMain@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Task 8. Conduct Controlled Environment Testing Demonstration

The Performing Agency shall install and conduct demonstration testing of the prototype system developed in Task 7 during a simulated flood event. The Performing Agency shall complete developmental testing to verify the accuracy of the water level sensors and the functionality of the developed and applied technologies. The Performing Agency shall conduct a final set of tests to validate the accuracy of the overall connected system for those prioritized scenarios identified in Task 3.

To conduct the demonstration, the Performing Agency shall install the system in its test facility where flooding conditions can be simulated on a roadway. The Performing Agency shall use its controlled

environmental test facility for conduction of the developmental testing. This environmental test facility is best suited to meet the needs to conduct the research test plan, only requiring minimal adaptation for testing completion. The concrete ditch is a recessed trench, 12.5 ft. wide, 400 ft. long, and 30 inches deep. A reinforced concrete liner was constructed on the bottom and both sides. Utilization of this existing concrete ditch equates to considerable cost saving for the Receiving Agency.

In conducting the demonstration testing, the Performing Agency shall equip at least two vehicles with connected vehicle technologies, including an in-vehicle system processing and displaying incoming flood conditions alerts and warning, dedicated short-range communication (DSRC) radios for providing two-way communications between the infrastructure and the vehicle, and appropriate software from processing alerts broadcast from the infrastructure. In this test, the Performing Agency shall drive the equipped vehicles, at highway speeds, towards a simulated low-water crossing and demonstrate the different types of messages that can be sent to the vehicle, based on the water levels and flood conditions at the low water crossing and measure the driver's ability to safely stop prior to entering the low water crossing based on the message. The Performing Agency shall test the system under various water clarity and water depth conditions. The Performing Agency shall conduct this testing in close-course test environment.

The Performing Agency's subcontractor shall assist in accomplishing the following:

- Develop a test plan for conducting the demonstration testing that matches the use cases identified in Task 7.
- Install and operate a complete prototype system at a simulated low-water crossing.
- Temporarily equip a least two passenger vehicles, to be provided by the Performing Agency, with connected vehicle test equipment.
- Conduct the demonstration testing according to the test plan.

Deliverables: The Performing Agency shall submit Technical Memorandum TM8, which shall document work performed, findings, and recommendations of installing and conducting demonstration testing of the prototype system during a simulated flood event to RTIMain@txdot.gov, copying the RTI Project Manager, per the attached Project Deliverables Table.

Information Technology (IT) Deliverables to the Receiving Agency

All data used and generated under the terms of this agreement must comply with the attached Exhibit C- Computer Files and Information System Security Requirements attached to, and made part of, this Agreement.

ASSISTANCE OR INVOLVEMENT BY THE RECEIVING AGENCY

Task 3 – Provide assistance in identifying and contacting the Receiving Agency districts for information on inventory and management approach of low water crossings.

Task 4 – Review and provide feedback on survey structure for investigation of Statewide management approaches of low water crossings.

Task 5 – Review and provide feedback on the research experimental design for marking and marker's evaluation. Technical Memorandum 5As approval.

Task 6 – Provide recommendation and feedback to the research approach for ranking identified flood sensors. Technical Memorandum 6As approval.

Task 7 – Provide an off-line, test version of Lone Star system where integration testing can be performed.

Task 8 – Review and approve test plan.

Project Deliverables Table

Project Deliverables (Rev. 2/2018) (RTI)

Project #	0-6992	Project Name:	Traffic Safety Improvements at Low Water Crossings					Original	X	Created Date:	8/24/18
Primary 1:	TTI	FY '19	233,932.00	FY '20	211,137.00	Total	$ 445,069.00	Revised	R	Revision #	
Agency 2:		FY '19	-	FY '20	-	Total	$ -	Completed		Revision Date:	

Task	Agency #	Deliverables*	Task Start Date	Due Date (Budgeted Month End Date)	Monthly Budget Forecast **,*** Primary 1	Comments	FY19 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	FY20 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	FY21 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1	1	Project Management and Research Coordination	9/1/2018	5/31/2020			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X															
2	1	Literature Review and Crash Data Analysis	9/1/2018	2/28/2019			X	X	X	X	X	X																														
3	1	Receiving Agency Low Water Crossing Management Approach	9/1/2018	1/31/2019			X	X	X	X	X																															
4	1	Statewide Low Water Crossing Management Approaches	9/1/2018	2/28/2019			X	X	X	X	X	X																														
5	1	Pavement Marking and Marker Evaluations for Low Water Crossing	9/1/2018	6/30/2019			X	X	X	X	X	X	X	X	X	X																										
6	1	Flood Sensors and Warning Devices Identification	10/1/2018	8/31/2019				X	X	X	X	X	X	X	X	X	X	X																								
7	1	Develop Connected Vehicle Implementation	4/1/2019	11/30/2019										X	X	X	X	X	X	X	X																				
8	1	Conduct Controlled Environment Testing Demonstration	8/1/2019	3/31/2020														X	X	X	X	X	X	X	X																
				Total	-	-																																			
1	1	September 2018 MPR	9/1/2018	9/30/2018	14,036.00		X																																	
1	1	October 2018 MPR	10/1/2018	10/31/2018	14,738.00			X																																
1	1	November 2018 MPR	11/1/2018	11/30/2018	15,089.00				X																															
1	1	December 2018 MPR	12/1/2018	12/31/2018	15,439.00					X																														
1	1	January 2019 MPR	1/1/2019	1/31/2019	15,790.00						X																													
1	1	February 2019 MPR	2/1/2019	2/28/2019	16,141.00							X																												
1	1	March 2019 MPR	3/1/2019	3/31/2019	8,422.00								X																										
1	1	April 2019 MPR	4/1/2019	4/30/2019	8,562.00									X																									
1	1	May 2019 MPR	5/1/2019	5/31/2019	7,158.00										X																								
1	1	June 2019 MPR	6/1/2019	6/30/2019	7,720.00											X																							
1	1	July 2019 MPR	7/1/2019	7/31/2019	8,562.00												X																						
1	1	August 2019 MPR	8/1/2019	8/31/2019	8,702.00													X																					
				Total	140,359.00	-																																		
1	1	September 2019 MPR	9/1/2019	9/30/2019	25,336.00														X																				
1	1	October 2019 MPR	10/1/2019	10/31/2019	22,803.00															X																			
1	1	November 2019 MPR	11/1/2019	11/30/2019	21,536.00																X																	
1	1	December 2019 MPR	12/1/2019	12/31/2019	15,202.00																	X																
1	1	January 2020 MPR	1/1/2020	1/31/2020	14,885.00																		X															
1	1	February 2020 MPR	2/1/2020	2/29/2020	14,252.00																			X														
1	1	March 2020 MPR	3/1/2020	3/31/2020	12,668.00																				X													
				Total	126,682.00	-																																		

Project Deliverables Table

Project Deliverables (Rev. 2/2018) (RTI)

Project #	0-6992	Project Name:	Traffic Safety Improvements at Low Water Crossings			Original	X	Created Date:	8/24/18		
Primary 1:	TTI	FY '19	233,932.00	FY '20	211,137.00	Total	$ 445,069.00	Revised	R	Revision #	
Agency 2:		FY '19	-	FY '20	-	Total	$ -	Completed		Revision Date:	

Task	Agency #	Deliverables*	Task Start Date	Due Date (Budgeted Month End Date)	Monthly Budget Forecast **,*** Primary 1	Comments	FY19 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	FY20 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	FY21 Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
2	1	Value of Research -VoR	10/1/2019	10/31/2019	4,669.00			X																																	
2	1	Technical Memorandum TM2	2/1/2019	2/28/2019	10,738.00							X																														
3	1	Technical Memorandum TM3	1/1/2019	1/31/2019	9,357.00						X																														
3	1	Product P3	12/1/2019	12/31/2019	7,954.00					X																														
4	1	Technical Memorandum TM4	2/1/2019	2/28/2019	19,117.00							X																													
5	1	Technical Memorandum TM5A	11/1/2018	11/30/2018	9,825.00				X																															
5	1	Technical Memorandum TM5B	6/1/2019	6/31/2019	10,106.00											X																								
6	1	Technical Memorandum TM6A	12/1/2018	12/31/2018	10,293.00					X																														
6	1	Technical Memorandum TM6B	8/1/2019	8/31/2019	11,514.00													X																						
				Total	93,573.00	..																																			
7	1	Technical Memorandum TM7	11/1/2019	11/30/2019	16,891.00																X																			
8	1	Technical Memorandum TM8	3/1/2020	3/31/2020	17,736.00																				X															
1	1	Product P1	4/1/2020	4/31/2020	13,513.00																					X														
1	1	R1- Research Report	4/1/2020	4/31/2020	20,691.00																					X														
1	1	PSR - Project Summary Report	5/1/2020	5/31/2020	15,624.00																						X													
				Total	84,455.00	..																																			
				Project Total	$ 445,069.00	Deliverables		VoR		TM5A	TM6A, P3	TM3	TM2	TM4			TM5B		TM6B				TM7				TM8	R1, P1	PSR													

Comments:

Notes:

Deliverables can only be invoiced one (1) time.

* Monthly Progress Reports (MPR/Task Activities) outlining work and staff utilization are to be completed monthly and submitted to RTIMAIN@txdot.gov no later than the 3rd Business day of the following month.

** Amounts on this form are estimates of Exhibit A; see University Handbook, Chapter 3, Section 5.

Per CRIA Article 13, Universities shall submit invoices for Project Deliverables no more frequently than monthly.

See University Handbook for explanation on all items, if necessary

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 form.

EXHIBIT C
Computer Files and Information System Security Requirements

1. DATA REQUIREMENTS

1.1. Data, Data Dictionaries, and Data Flow Diagrams

Performing Agency shall ensure that any Receiving Agency data that is generated, manipulated, transmitted, or stored utilizes the Receiving Agency taxonomy, with documented data dictionaries and data flow diagrams (including security protocols).

1.2. Data Transfer

A. ***At the completion of a deliverable, Performing Agency shall transfer all data generated and stored for that deliverable to Receiving Agency in manner and format acceptable to the Receiving Agency.***

B. ***Any metadata associated with the data transferred must remain attached to that data.***

C. ***Performing Agency shall maintain the appropriate level of data security throughout the transfer of the data to Receiving Agency.***

1.3. Encryption

Performing Agency shall encrypt all data considered confidential in accordance with:

A. Chapter 202 of Title 1 of the Texas Administrative Code, and

B. National Institute of Standards and Technology's ("NIST") SPECIAL PUBLICATION 800-53 REVISION 4.

1.4. Backup and Disaster Recovery

A. ***Performing Agency shall implement business continuity procedures to fulfill all requirements of this agreement that address, as a minimum, fire, theft, natural disaster, technical difficulty, workforce problems, equipment failure, or other disruption of business.***

B. ***Performing Agency shall maintain a disaster recovery plan. Performing Agency is responsible for all project related costs of disaster recovery during the project except for costs associated with disasters beyond Performing Agency's reasonable control, and for those costs included as part of the Receiving Agency infrastructure responsibilities.***

2. INFORMATION TECHNOLOGY SERVICES SECURITY REQUIREMENTS

2.1. IT Services Safeguards

A. ***Performing Agency shall implement appropriate administrative, physical and technical safeguards, in accordance with the agencies' security requirements, that reasonably and appropriately protect the confidentiality, integrity, and availability of information technology ("IT") services provided to the agency***

B. ***Performing Agency shall conform its policies and procedures relating to the implementation of security safeguards to comply with Receiving Agency's information resources security program pursuant to Chapter 202 of Title 1 of the Texas Administrative Code, which provides the Texas Department of Information Resources' Information Security Standards.***

2.2. IT Security Audit Rights

Receiving Agency may on one or more occasions perform an audit or test or an audit and test of the security controls of any information system or systems provided under this agreement.

2.3. IT Security Incident Notification

Performing Agency shall immediately report any security incident to Receiving Agency's Information Management Division (IMD).

2.4. Response time

A. ***Performing Agency must provide proper treatment for any vulnerability that potentially impacts Receiving Agency's business or the security of Receiving Agency's information within 48 hours of learning of such vulnerability unless another response time is agreed to by Performing Agency and Receiving Agency's IMD.***

B. ***Performing Agency's treatment of any vulnerability must be acceptable to Receiving Agency.***

2.5. Applicable Laws, Regulations, and Standards

A. ***Performing Agency shall perform the services in accordance with the following standards, notify Receiving Agency of situations where compliance is not achievable, and assist Receiving Agency with the prevention of security gaps or conflicts that could impair security performance.***

(1) National Institute of Standards and Technology's ("NIST") SPECIAL PUBLICATION 800-53 REVISION 4

(2) Texas Department of Information Resources' ("DIR") SECURITY CONTROLS STANDARDS CATALOG

B. ***Performing Agency shall comply with all applicable federal, state, and local laws and regulations necessary to perform the services, which include the following.***

(1) State Laws and Regulations

a. Title 1 of Texas Administrative Code

i. Chapter 202 – Information Security Standards

ii. Chapter 206 – State Websites

iii. Chapter 213 – Electronic and Information Resources

b. Texas Business and Commerce Code, Chapter 521 – Unauthorized Use of Identifying Information

c. Texas Government Code, Chapter 552 – Public Information

d. Texas Health and Safety Code, Chapter 181 – Medical Records Privacy

e. Texas Penal Code, Chapter 33 – Computer Crimes

2. Federal Laws and Regulations

f. Computer Fraud and Abuse Act ("CFAA") of 1986 (18 U.S.C. § 1030)

g. Computer Security Act of 1987 (Pub. L. 100-235)

h. Privacy Act of 1974 (5 U.S.C. §552a)

i. Section 508 of the Rehabilitation Act of 1973 (29 U.S.C. § 794d)

j. Internal Revenue Service's PUBLICATION 1075 – TAX INFORMATION SECURITY GUIDELINES FOR FEDERAL, STATE AND LOCAL AGENCIES

k. Gramm-Leach-Bliley Act ("GLBA"), also known as the Financial Services Modernization Act of 1999 (Pub. L. 106-102)

l. Children's Internet Protection Act ("CIPA") of 2000 (Pub. L. 106-554)

m. Children's Online Privacy Protection Rule ("COPPA") (16 CFR Part 312)

2.6. Information Technology Solution

A. ***Any proposed information technology solution that will be installed on any Receiving Agency owned equipment or that will access Receiving Agency network must be reviewed and approved by the Receiving Agency IMD Architectural Review Board ("ARB") prior to any development or design.***

B. ***Any proposed information system solution that will be installed on any Receiving Agency owned equipment or that will access Receiving Agency network must be reviewed and approved by the Receiving Agency's IMD Change Advisory Board ("CAB") prior to implementation or delivery.***

2.7. Information Technology ("IT") Procurements
Receiving Agency's IMD must manage all procurements of:

(1) IT hardware (e.g., computers, servers, network gear) and software that will be owned by Receiving Agency or access the Receiving Agency network

(2) IT services (e.g., hosting) funded by Receiving Agency (state appropriated funds), must be reviewed by Receiving Agency's IMD.

3. DEFINITION SECTION

3.1 Information resources - **It means the procedures, equipment, and software that are employed, designed, built, operated, and maintained to collect, record, process, store, retrieve, display, and transmit information, and associated personnel including consultants and contractors.**

3.2 Information resources technologies - **It means data processing and telecommunications hardware, software, services, supplies, personnel, facility resources, maintenance, and training.**