

ORDINANCE 2019-05-30-0445

**APPROVING A RESEARCH AGREEMENT WITH THE UNIVERSITY OF TEXAS AT SAN ANTONIO (UTSA) IN THE AMOUNT OF \$49,000.00 FOR A STUDY EVALUATING FLOOD PROTECTION STRATEGIES TO ALLEVIATE SUPER STORM IMPACTS ON THE CITY'S TRANSPORTATION INFRASTRUCTURE AND ENVIRONMENT WITH FUNDS INCLUDED AND AVAILABLE IN THE FY 2019 ADOPTED STORM WATER OPERATING FUND BUDGET.**

\* \* \* \* \*

**WHEREAS**, the National Center for Environmental Information (NCEI) and the National Oceanic and Atmospheric Administration (NOAA) evaluates the impacts of severe weather events have on the nation; and

**WHEREAS**, NCEI and NOAA's data reveals between 1980 and 2017, damages from severe storms and flooding cost the United States \$320.9 billion; and

**WHEREAS**, the City of San Antonio lies within a region prone to flooding in Texas referred to as Flash Flood Alley, which constitutes one of the most flood prone areas of the North American continent, and this region is experiencing one of the fastest growing population rates in the U.S. and is especially vulnerable to super storms because it is partially located in an area characterized by rugged natural drainage and intense rainfall events referred to as the Balcones Escarpment; and

**WHEREAS**, the agreement with UTSA for a super storm study will provide the City with the necessary research information to develop a framework capable of predicting super storm impacts to transportation infrastructure and the environment; and

**WHEREAS**, the Upper San Antonio and Leon Creek watersheds were selected as part of the study because the Upper San Antonio watershed has one of the most developed, urban area flood control systems in the U.S., while the Leon Creek watershed is unprotected against large storm events; **NOW THEREFORE**,

**BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF SAN ANTONIO:**

**SECTION 1.** The City Manager, or designee, is authorized to execute a research agreement with the UTSA for a study evaluating flood protection strategies to alleviate super storm impacts. A copy of the proposed Agreement is attached hereto and incorporated herein for all purposes as **Attachment I**.

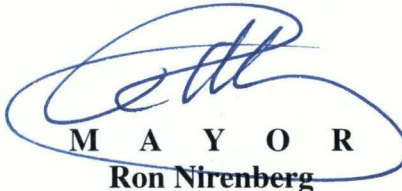
**SECTION 2.** Funding in the amount of \$49,000.00 for this ordinance is available in Fund 29070000, Cost Center 2304030001 and General Ledger 5201040 as part of the Fiscal Year 2019 budget.

**SECTION 3.** Payment not to exceed the budgeted amount is authorized to University of Texas at San Antonio (UTSA) for a study evaluating flood protection strategies to alleviate super storm impacts on the City's transportation infrastructure and environment.

**SECTION 4.** The financial allocations in this Ordinance are subject to approval by the Director of Finance, City of San Antonio. The Director of Finance, may, subject to concurrence by the City Manager or the City Manager's designee, correct allocations to specific SAP Fund Numbers, SAP Project Definitions, SAP WBS Elements, SAP Internal Orders, SAP Fund Centers, SAP Cost Centers, SAP Functional Areas, SAP Funds Reservation Document Numbers, and SAP GL Accounts as necessary to carry out the purpose of this Ordinance.

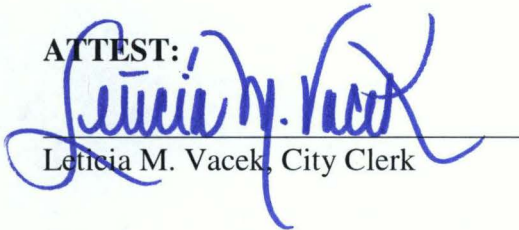
**SECTION 5.** This ordinance shall become effective immediately upon passage by eight or more affirmative votes; otherwise, it shall be effective on the tenth day after passage.

**PASSED AND APPROVED** this 30<sup>th</sup> day of May 2019.



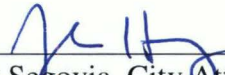
**M A Y O R**  
Ron Nirenberg

**ATTEST:**



Leticia M. Vacek, City Clerk

**APPROVED AS TO FORM:**



for Andrew Segovia, City Attorney

| <b>Agenda Item:</b> | 26 ( in consent vote: 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27A, 27B, 27C )  |                    |            |            |                |               |               |
|---------------------|---|--------------------|------------|------------|----------------|---------------|---------------|
| <b>Date:</b>        | 05/30/2019  |                    |            |            |                |               |               |
| <b>Time:</b>        | 09:35:28 AM   |                    |            |            |                |               |               |
| <b>Vote Type:</b>   | Motion to Approve   |                    |            |            |                |               |               |
| <b>Description:</b> | Ordinance approving a research agreement with the University of Texas at San Antonio (UTSA) in the amount of \$49,000.00 for a study evaluating flood protection strategies to alleviate super storm impacts on the City's transportation infrastructure and environment with funds included and available in the FY 2019 Adopted Storm Water Operating Fund Budget. [Roderick Sanchez, Assistant City Manager; Razi Hosseini, Interim Director, Transportation & Capital Improvements] |                    |            |            |                |               |               |
| <b>Result:</b>      | Passed  |                    |            |            |                |               |               |
| <b>Voter</b>        | <b>Group</b>  | <b>Not Present</b> | <b>Yea</b> | <b>Nay</b> | <b>Abstain</b> | <b>Motion</b> | <b>Second</b> |
| Ron Nirenberg       | Mayor   |                    | x          |            |                |               |               |
| Roberto C. Treviño  | District 1  |                    | x          |            |                |               |               |
| Art A. Hall         | District 2  |                    | x          |            |                |               | x             |
| Rebecca Viagran     | District 3  |                    | x          |            |                | x             |               |
| Rey Saldaña         | District 4  |                    | x          |            |                |               |               |
| Shirley Gonzales    | District 5  | x                  |            |            |                |               |               |
| Greg Brockhouse     | District 6  |                    | x          |            |                |               |               |
| Ana E. Sandoval     | District 7  |                    | x          |            |                |               |               |
| Manny Pelaez        | District 8  |                    | x          |            |                |               |               |
| John Courage        | District 9  |                    | x          |            |                |               |               |
| Clayton H. Perry    | District 10   |                    | x          |            |                |               |               |



# **Attachment I**

STATE OF TEXAS

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COUNTY OF BEXAR

**CITY RESEARCH AGREEMENT  
THE UNIVERSITY OF TEXAS AT SAN  
ANTONIO**

This **CITY RESEARCH AGREEMENT** (Hereafter to as the "Agreement") is made between The University of Texas at San Antonio, ("University"), an academic component of The University of Texas System ("System"), having an address at One UTSA Circle, San Antonio, Texas 78249, and The City of San Antonio, a local agency with a principal place of business at 114 W. Commerce Street, 6<sup>th</sup> floor, San Antonio, TX 78205 ("City"), under the authority of Chapter 791 of the Texas Government Code.

**Recitals**

**WHEREAS**, University and City are each pursuing research in the area of super forms flooding in the transportation area; and

**WHEREAS**, City desires to collaborate with University and is willing to help contribute funding to the University's research; and

**WHEREAS**, City desires to obtain certain rights to patents and technology resulting from the research; and

**WHEREAS**, University is willing to collaborate and to grant certain rights to patents and technology that result from the research collaboration to City; and

In consideration of the mutual covenants and promises herein contained, the University and City agree as follows:

**1. PERIOD OF PERFORMANCE**

This Agreement shall be effective as of July 1, 2019 (the "Effective Date") through and including May 30, 2020 (the "Term"). The parties may extend this Agreement for a mutually agreeable period.

**2. RESEARCH PROGRAM**

- a. University will use its own facilities and its reasonable efforts to conduct the research program described in Exhibit A ("Research Program") under the direction of its employee, Marcio Giacomoni, or a successor as mutually agreed to by the parties (the "Principal Investigator").
- b. City understands that University's primary mission is education and advancement of knowledge and the Research Program will be designed to carry out that mission. The manner of performance of the Research Program shall be determined solely by the Principal Investigator. University does not guarantee specific results.
- c. City understands that University may be involved in similar research through other researchers on behalf of itself and others. University shall be free to continue such research provided that it is

conducted separately and by different investigators from the Research Program, and City shall not gain any rights via this Agreement to other research.

- d. University does not guarantee that any intellectual property will result from the Research Program, that any resulting intellectual property will be free of dominance by other's rights, including rights based on inventions made by other inventors in the System independently of the Research Program.

### **3. COMPENSATION**

- a. As consideration for University's performance, City will pay the University the fixed amount of \$49,000. A single payment of \$49,000 shall be made upon execution of this Agreement, and in accordance with Exhibit B ("Compensation Schedule & Deliverables").
- b. City will make payments to "The University of Texas at San Antonio", referencing the Principal Investigator and Research Program title, to the following address:  
  
The University of Texas at San Antonio  
Grants and Contracts Financial Services (GCFS)  
One UTSA Circle  
San Antonio, TX 78249
- c. The Principal Investigator may transfer funds within the budget as needed without City's approval so long as the scope of work under the Research Program remains unchanged.
- d. University shall retain title to all equipment purchased and/or fabricated by it with funds provided by City under this Agreement.

### **4. COMMUNICATION AND REPORTS**

- a. City's designated representative for communications with the Principal Investigator shall be Marcio Giacomoni, or any other person City may designate in writing to University and the Principal Investigator ("Designated Representative").
- b. The Principal Investigator shall submit a comprehensive final report within ninety (90) days after termination of the Agreement.

### **5. PUBLICITY**

Neither party will reference the other in a press release or any other oral or written statement intended for use in the public media in connection with the Research Program and its results, except as required by the Texas Public Information Act or other law or regulation. University, however, may acknowledge City's support of the Research Program in scientific or academic publications or communications without City's prior approval. In any permitted statements, the parties shall describe the scope and nature of their participation accurately and appropriately.

### **6. PUBLICATION AND ACADEMIC RIGHTS**

The Principal Investigator has the right to publish or otherwise publicly disclose information gained in the course of the Research Program. In order to avoid loss of patent rights as a result of premature public disclosure of patentable information, University will submit any prepublication materials to City for review and comment at least sixty (60) days prior to planned submission for publication. City shall notify University within thirty (30) days of receipt of such materials whether they describe any inventions or discoveries subject to the parties' rights under Section 8. University shall have the final authority to determine the scope and content of any publications, subject to the requirements of Section 7 of this Agreement.



## **7. CONFIDENTIAL INFORMATION**

- a. The parties may wish to disclose confidential information to each other in connection with work contemplated by this Agreement ("Confidential Information"). Each party will use reasonable efforts to prevent the disclosure of the other party's Confidential Information to third parties during the Term, and for a period of three (3) years from the end date of this Agreement, provided that the recipient party's obligation shall not apply to information that:
  - i. is not disclosed in writing or reduced to writing and marked with an appropriate confidentiality legend within thirty (30) days after disclosure;
  - ii. is already in the recipient party's possession at the time of disclosure;
  - iii. is or later becomes part of the public domain through no fault of the recipient party;
  - iv. is received from a third party having no obligations of confidentiality to the disclosing party;
  - v. is independently developed by the recipient party; or
  - vi. is required by law, court order, or regulation to be disclosed.
- b. In the event that information is required by law, court order, or regulation to be disclosed, the party required to make disclosure shall notify the other to allow that party to assert whatever exclusions or exemptions may be available to it under such law, court order, or regulation.

## **8. PATENTS, COPYRIGHTS, AND TECHNOLOGY RIGHTS:**

- a. Title to all inventions and discoveries made solely by University inventors resulting from the Research Program shall reside in University; title to all inventions and discoveries made solely by City inventors resulting from the Research Program shall reside in City; title to all inventions and discoveries made jointly by University and City inventors resulting from the Research Program shall reside jointly in University and City. Inventorship shall be determined in accordance with U.S. Patent law.
- b. University will disclose to City any inventions or discoveries resulting from the Research Program as soon as possible after creation and reduction to practice. City shall notify University within thirty (30) days of receipt of disclosure whether:
  - i. City desires University to file patent applications on any invention, in which case City shall reimburse all University patent application filing costs, including those for patentability opinions; or
  - ii. City desires to use its own patent counsel to file patent applications, in which case City shall be directly responsible for patent application filing but shall obtain University's prior approval of counsel and of patent applications; or
  - iii. City does not desire that a patent application be filed in which case the rights to such invention shall be disposed of in accordance with University policies with no further obligation in City.
- c. With respect to inventions for which City has agreed to file patent application or to reimburse University's costs for filing patent applications, University grants City an option to negotiate an exclusive or non-exclusive, worldwide, royalty-bearing license to make, use or sell under any invention or discovery owned wholly or partly by University and made or conceived and reduced to practice during the Term of this Agreement or within six (6) months thereafter and directly resulting from the Research Program. If City elects an exclusive license, it will include a right to sublicense with accounting to University. City shall have three (3) months from disclosure of any invention or discovery to notify University of its desire to enter into such a license agreement, and the parties shall negotiate in good faith for a period not to exceed six (6) months after that notification, or such period of time as to which the parties shall mutually agree.
- d. If City and University fail to enter into an agreement during such period of time, the rights to such invention or discovery shall be dealt with in accordance with University policies with no further obligation to City.

- e. Under University policy, University investigators own copyright in their scholarly works. Scholarly works resulting from the Research Program are not subject to the terms of this Section 8.

## **9. LIABILITY/INSURANCE**

- a. University and City acknowledge that they are political subdivisions of the State of Texas and are subject to, and comply with the applicable provisions of the Texas Tort Claims Act, as set out in Civil Practices and Remedies Code, Section 101.001 et seq. and the remedies authorized therein regarding claims or causes of action that may be asserted by third parties for accident, injury or death. This Agreement will be interpreted according to the Constitution and laws of the State of Texas.
- b. Each party shall be responsible for its own actions and those of its employees and/or persons acting by or on its behalf while carrying out the purpose of this Agreement. Each Party agrees to have sufficient insurance in place to cover all obligations assumed in this Agreement and any liabilities arising while carrying out those obligations.

## **10. INDEPENDENT CONTRACTOR**

For the purposes of this Agreement and all services to be provided hereunder, the parties shall be, and shall be deemed to be, independent contractors and not agents or employees of the other party. Neither party shall have authority to make any statements, representations, or commitments of any kind, or to take any action which shall be binding on the other party, except as may be expressly provided for herein or authorized in writing.

## **11. TERMINATION**

- a. This Agreement may be terminated prior to the above stated expiration date by means of a signed written agreement of both parties.
- b. In the event that either party shall be in default of its material obligations under this Agreement and shall fail to remedy such default within sixty (60) days after receipt of written notice thereof, this Agreement shall terminate upon expiration of the sixty (60) day period.
- c. Termination of this Agreement shall not affect the rights and obligations of the parties accrued prior to termination. UTSA shall be entitled to payment for all reasonable expenses incurred or committed as of the effective termination date, with total payment not to exceed the compensation amount described in Section 3 above.
- d. Any provisions of this Agreement which by their nature extend beyond termination shall survive such termination.

## **12. EXPORT CONTROL**

- a. It is understood that both parties are subject to U.S. laws and regulations controlling the export of certain items, commodities, defense articles, Confidential Information, proprietary technical data or source code, collectively hereafter referred to as "Items." Each party is obligated to comply with applicable U.S. export laws and regulations (including the Arms Export Control Act, as amended, and the Export Administration Act of 1979). Prior to providing any Items which are subject to U.S. export laws and regulations, and prior to furnishing any Items where oral instruction or inspection may disclose technical data subject to such export controls, the disclosing party shall notify receiving party's export control officer in writing of the Items and applicable export controls. Receiving party shall have the right to decline or limit the receipt of such Items, and any task requiring receipt of such Items. The transfer of Items may require a license from the cognizant agency of the U.S. government. The parties agree to cooperate in securing any license which the cognizant agency deems necessary in connection with this Agreement.



- b. For cases whereby University is the Receiving Party, recipients of Confidential Information disclosed to University for the purposes hereunder may include, but are not limited to, the individual person(s) identified in the attached Exhibit C ["Acknowledgement Of Contact Person for The University Of Texas at San Antonio (UTSA)"].

### 13. EXHIBITS

- a. Exhibits A, B and C are incorporated herein and made a part of this Agreement for all purposes.
- b. In the event of any direct conflict between the terms and conditions of this Agreement and any document referenced herein or any Exhibit, the terms of this Agreement shall control.

### 14. GENERAL

- a. This Agreement may not be assigned by either party without the prior written consent of the other party; provided, however, that subject to the approval of University, which may not be unreasonably withheld, City may assign this Agreement to any purchaser or transferee of all or substantially all of City's assets or stock upon prior written notice to University, and University may assign its right to receive payments hereunder.
- b. This Agreement constitutes the entire and only agreement between the parties relating to the Research Program, and all prior negotiations, representations, agreements, and understandings are superseded hereby. No agreements altering or supplementing the terms hereof may be made except by means of a written document signed by duly authorized representatives of the parties, subject to and contingent upon appropriation of funds by City Council for any increase in expenditures by the City.
- c. Any official notice required by this Agreement shall be given by prepaid, first class, certified mail, return receipt requested, or by a recognized overnight courier, addressed as follows:

in the case of University to:

The University of Texas at San Antonio  
Office of Contracts and Industrial  
Agreements  
Attn: Jessica Fernandez  
One UTSA Circle  
San Antonio, Texas 78249

or in the case of City to:

City of San Antonio  
114 W. Commerce Street, 6<sup>th</sup> Floor  
San Antonio, TX 78205  
ATTN: Nefi Garza, PE  
210-207-8054

or at such other addresses as may be given from time to time in accordance with the terms of this notice provision.

Other communications regarding the day-to-day administration and operation of this Agreement shall be mailed (or otherwise delivered), and addressed as follows:

in the case of University to:

The University of Texas at San Antonio  
Research Service Center for Sciences  
and Engineering  
Attn: RSC Director Amy Ossola-Phillips  
One UTSA Circle  
San Antonio, Texas 78249  
PHONE: (210) 458-6472

or in the case of City to:

CITY of SAN ANTONIO  
114 W. Commerce St.  
PO Box 839966  
San Antonio, TX 78283  
ATTN: Kelcey Young  
PHONE: 210-207-5879

d. This Agreement shall be governed by, construed, and enforced in accordance with the internal laws of the State of Texas.

IN WITNESS WHEREOF, the parties have caused this Agreement to be executed by their duly authorized representatives.

**THE UNIVERSITY OF TEXAS AT SAN ANTONIO**

**City Of San Antonio**

By *Michelle Stevenson*

By \_\_\_\_\_

Michelle Stevenson, Ph.D., CCEP  
Associate VP, Office of Sponsored Programs  
Administration

Peter Zanoni  
Deputy City Manager

Date: April 01, 2019

Date: \_\_\_\_\_

Principal Investigator:

I have read this Agreement and understand my obligations hereunder:

By *Marcio Giacomoni*

Name Marcio Giacomoni, Ph.D.

Title Principal Investigator



## EXHIBIT A

### Scope of Work

#### Assessing the Impacts of Super Storms Flooding in the Transportation Infrastructure – Case Study: San Antonio, Texas

### INTRODUCTION

The National Center for Environmental Information (NCEI) is the agency within the National Oceanic and Atmospheric Administration (NOAA) responsible for scorekeeping the impacts, including number of death and costs, of the Nation's severe weather and climate events. NCEI's data shows that since 1980 until August 2017, severe storms and flooding overall damages cost the U.S. \$ 320.9 Billion CPI<sup>1</sup> adjusted (NOAA 2017). These figures only accounts for extreme events that produced costs higher than \$1 Billion and does not yet include the costs for Hurricane Harvey, Irma and Maria. The tropical storm Harvey broke all the rainfall records for the U.S. (more than 50 inches) and produced unprecedented flooding in Eastern Texas, with a total damage estimation of \$160 billion and at least 60 deaths. In another recent event, the City of Baton Rouge, LA, received approximately 25.5 inches of rainfall from August 12-14, 2016, which caused unprecedented flooding, damaged around 60,000 houses, and killed at least 13 people. Another recent catastrophic event, super storm Sandy occurred on October 24, 2012, in New Jersey. Sandy impacted more than 570,000 houses, caused more than \$75 billion in damages and resulted in at least 233 fatalities. The data shows a clear exponential growth in damages and costs due to extreme weather events (*Figure 1*).

Most critical infrastructure built in urban areas, including that for transportation and flood protection are designed to handle a design storm with a 1% probability of occurrence in one year or 100 years of return period. Super storms are defined here as rainfall storm events with return periods higher than 100 years and have occurred lately in the U.S. Preliminary calculations indicate that Harvey is a 1,000-year storm event (Geert Jan van et al. 2017), the Baton Rouge flooding was caused by a storm event with return period of 500 years (van der Wiel et al. 2017), and the Sandy's storm surge return period ranged from 150 to 1,000 years (Karamouz et al. 2017). Moreover, the impacts of storm events and the design of flood protection structures are typically assessed using hydrologic and hydraulic simulation models. Many of these models are one-dimensional simplifications of complex drainage and riverine networks that simulate flow in these systems under steady flow conditions.

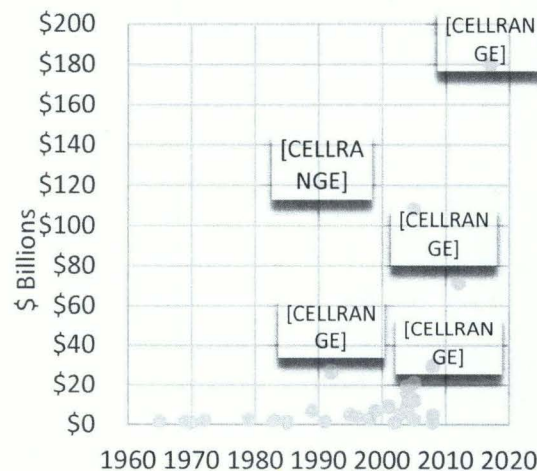


Figure 1 - Cost of Hurricanes in the U.S.

<sup>1</sup> CPI stands for Consumer Price Index and it measures the average change in prices paid for a market basket foods and services.



Because super storms are likely to become more frequent and severe due to climate change (Milly et al. 2008) there is a pressing research need to (1) develop and test new modeling frameworks that can assess the impacts of flooding on the built environment, and to (2) identify mitigation and adaptation strategies that protect critical infrastructure in urban areas against flooding. In recent years, due to the increase of computing capacity, the use of 2 dimensional models (2D) has become more accessible (for instance, the U.S. Army Corps of Engineers released a new version of the software HEC-RAS which now incorporated 2D modeling capabilities and the Hydraulics Laboratory of the US Army Engineering Research and Development Center released the model Gridded Surface Subsurface Hydrologic Analysis (GSSHA)). The use of these models for floodplain mapping has not been sufficiently tested for storm events larger than the 100-year design storms and the suitability of the existing modeling capabilities to accurately represent super storms requires further investigation.

City and Watershed managers have been relying on old modeling software to plan and make design decisions on how to address flooding. Therefore, there is, a critical education need to train the current and next generation of engineers on the proper use of new and more advanced hydrologic and hydraulic simulation tools. In the absence of new hydrologic and hydraulic modeling frameworks as well as educational opportunities for the current and future generation of engineers, the impacts of super storms will only increase, negatively affecting critical infrastructure, the economy, the environment and communities.

## **PROJECT GOAL AND OBJECTIVES**

The main goal of this project is to develop and apply a computational framework capable of predicting the impacts of super storms in the transportation infrastructure and evaluating flood protection strategies that alleviate some of the impacts in highly populated urban areas. Four objectives are proposed:

Objective 1) The first objective is to assess the impacts of super storms flooding in the transportation infrastructure. A suite of hydrologic and hydraulic simulation models will be tested and used to evaluate flood impacts with a focus to the main transportation infrastructure, such as highways and bridges.

Objective 2) The second objective is to explore alternative flood protection structures that can minimize damages and maximize the resilience of transportation systems in large metropolitan areas: The models will be updated and flood control structures, such as levees, dams and alternative land cover will be tested.

Objective 3) The third objective is to train city and transportation officials and watershed managers to better delineate floodplain mapping of super storms and incorporate potential climate change impacts in future city planning.

Objective 4) The last objective of this project is to enhance the public awareness of about the impacts of super storms in the built environment, with an emphasis in the main transportation infrastructure.

All tasks in Objectives 1 and 2 will follow technical guidance provided by the Federal Highway Administration's Hydraulic Engineering Circular N° 17, titled "*Highways in the River Environment - Floodplains, Extreme Events, Risk, and Resilience*" (Kilgore et al. 2016). In this manual, methods for assessing the vulnerability of transportation facilities to extreme events and



climate change in riverine environments are proposed. Vulnerability is defined as a function of three components: exposure, sensitivity and adaptive capacity. All the methodological steps will be described in details and published so it can be replicated in other regions of the U.S.. In particular, the application of the proposed methodology in watersheds of different scales will be discussed in the delivered final report.

## CASE STUDY

The case study is the City of San Antonio, TX, which lays within a flood prone region in Texas referred as the Flash Flood Alley. This region is particularly vulnerable to super storms because: 1) it is experiencing one the fastest population growth rates in the U.S. (the population in 2016 was 1.6 million inhabitants and projected to reach 2.5 million residents in 2050 (TWDB 2012)); and 2) it is partially located in the *Balcones Escarpment*, which is characterized by a geomorphology with rugged natural drainage and intense rainfall events. The flash Flood Alley constitute one of the most flood prone areas of the North American continent. Previous research conducted at UTSA shows that Bexar County leads the country in flood related deaths (Sharif et al. 2014).

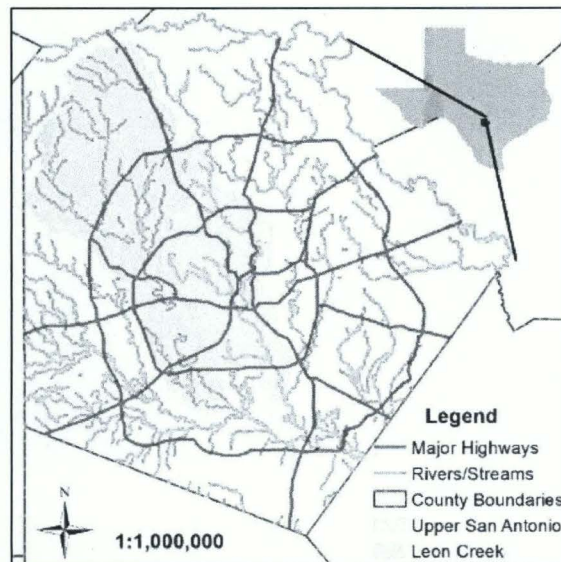


Figure 2 - Location of Leon and Upper San Antonio watersheds.

Two watersheds within the City of San Antonio are selected: the Upper San Antonio and Leon Creek watersheds, located in the central and west portions of the City (Figure 2). The drainage area of Leon Creek and Upper San Antonio watersheds are 336.9 and 133.02 mi<sup>2</sup>, respectively. These two watersheds were selected because of two significant differences. First, while Leon Creek watershed is fairly unprotected against large storm events, the Upper San Antonio watershed is heavily regulated and contains one of the most developed flood control systems in urban areas in the U.S. The Upper San Antonio flood control system includes the Olmos Dam and reservoir that was designed to regulated two consecutive 100-year 24 hours design storm, and two underground tunnels that divert water from the San Antonio River and San Pedro

Creek bypassing the downtown area of the city.

## RESEARCH PLAN

*Objective 1) Assessing the impacts of super storms flooding*

To achieve the first objective, we proposed the development of three main tasks:

### Task 1.1) IDF Update.

First, the latest climate studies will be reviewed in order to update the existing intensity, duration and frequency curves (IDF) of the region. Updated design storms that reflect non-stationary climate will be created. In the light of observable changes in precipitation patterns in the last



couple of decades and expected future changes, new intensity-duration-frequency (IDF) curves will be proposed. These new IDF curves will be based on expected future monthly precipitation statistics, which will be used to stochastically generate sub-daily precipitation time series. An important assumption to be made in this process is that the current relationship between monthly and sub-daily precipitation statistics will hold in the future. Assessment of the effect of this assumption on the precipitation values will be included. Another important potential source of error in the estimation of these IDF curves will be the inability of the Global Circulation Model (GCM) to capture small-size events (i.e., small compared to the  $\sim 300 \times 300 \text{ km}^2$  GCM cells), which might cause extreme-intensity events.

#### Task 1.2) Model Development

Three main models will be constructed: 1) HEC-HMS + HEC RAS (1D), 2) HEC-HMS + HEC RAS (2D), and 3) GSSHA. The software *Watershed Modeling System* (WMS) version 10.1 will serve as the main platform for pre-processing the data and building the models. WMS was developed by Aquaveo and supports a number of hydraulic and hydrologic models. The software provides several tools to automate various basic and advanced delineations and modeling processes and supports the following models: HEC-1, HEC-RAS, HEC-HMS, TR-20, TR-55, NFF, Rational Method, MODRAT, HSPF, CE-QUAL-W2, GSSHA, SMPBK and others. The main methodological steps in this task are depicted in Figure 4 and Table 2 shows the main data inputs, its type, resolution and sources. This task is divided into three main components: Pre-Processing, Model Development and Post-Processing. In Pre-Processing, all the data, that includes digital elevation models, streams, LIDAR, soil maps, land cover, rainfall, RADAR and streamflow, will be collected and processed in the appropriate scale and resolution. The second component includes watershed, stream and X-section delineation, initial parameter estimation, inputs definition (rainfall and temperature), and the creation of an initial model. Each of model will be then calibrated and validated using existing streamflow records and high water marks. Once the model is validated, the post-processing phase encompasses inputting the design storms, running the scenarios and generating floodplains maps. This task will be led by the PI Dr. Giacomoni.

The calibration and validation of the models will be accomplished by comparing simulated and observed stream flow data at locations of watershed where data is available. A combination of manual and automatic calibration will be used. Assessing goodness-of-fit between simulation and observations will be as performed by graphical techniques and four statistical metrics:  $r^2$ , NSE, PBIAS, and RSR. Coefficient of Determination ( $r^2$ ) represents proportion of the variance in observed data explained by the model. The  $r^2$  ranges from 0 to 1 with higher values indicating better model performance and typically values greater than 0.5 are considered acceptable (Santhi et al. 2001). Nash-Sutcliffe efficiency (NSE) (Nash and Sutcliffe 1970) is a commonly used statistics for evaluation of model performance and indicates overall fit of the simulated hydrograph to measured ones (Servat and Dezetter 1991). NSE ranges from  $-\infty$  to 1 with values between 0 and 1 could be regarded as acceptable level of performance (Moriassi et al. 2007a). Percent bias (PBIAS) determines average tendency of simulated data to be greater or smaller than historical series (Gupta et al. 1999). As PBIAS is closer to 0.0, model results are more accurate. Positive values of PBIAS indicate underestimation bias by model and negative values indicates overestimation bias. RMSE-observations standard deviation ratio (RSR) (Singh et al. 2005) is calculated by dividing RMSE to standard deviation of measured data. The optimal value of RSR is 0.0 and can range up to large positive values. As recommended by Moriassi et al.



(2007a) and ASCE (1993) and due to inherit disadvantages of some statistics, implementation of these four statistics provides extensive information that helps to better identify model performance and avoid error in interpretation of model results.

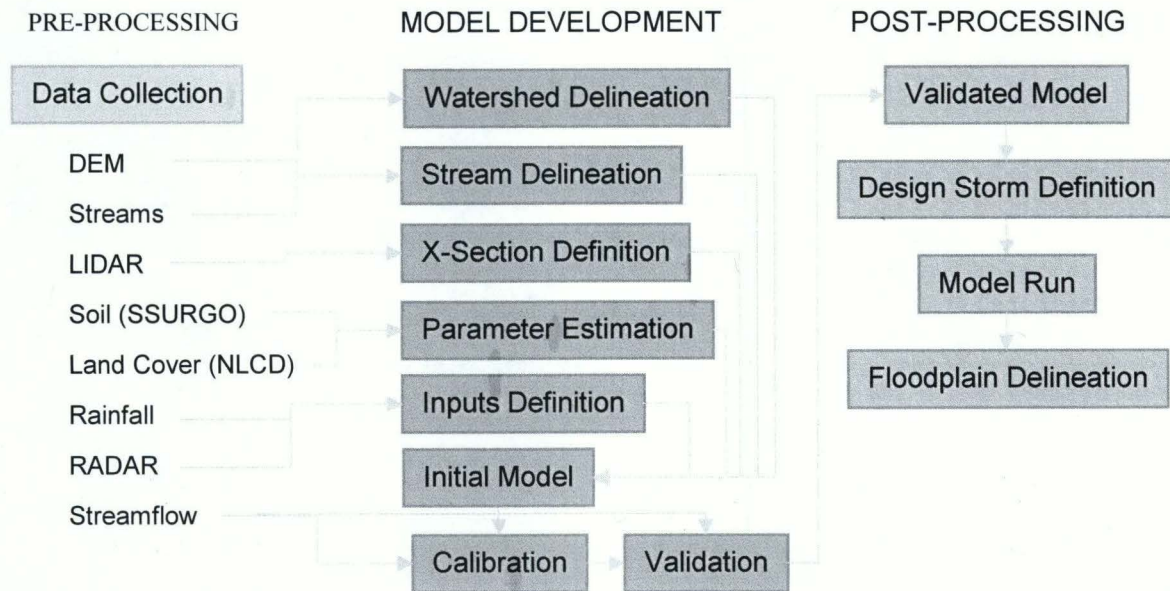


Figure 3. Flow chart of modeling framework.

Table 1. Main data inputs, type, resolution and sources.

| Data Input  | Type        | Resolution/<br>Units          | Source   |
|---|-------------|-------------------------------|--|
| Digital Elevation Map (DEM)                         | Raster      | 10 meters                     | National Elevation Dataset (NED)   |
| LIDAR   | LAS         | -                             | City of San Antonio  |
| Soil Map  | Raster      | 250 meters                    | Soil Survey Geographic Database (SSURGO)   |
| Land Use (1992 <sup>1</sup> , 2001, 2006, and 2011) | Raster      | 30 meters                     | National Land Cover Dataset (Fry et al. 2011; Homer et al. 2007; Homer et al. 2015; Vogelmann et al. 2001) |
| Streams   | Polyline    | -                             | National Hydrography Dataset   |
| Precipitation – Gauges                              | Time Series | 15 minutes                    | National Climatic Data Center (NCDC 2016)  |
| Precipitation – RADAR                               | Raster      | 5 minutes                     | National Climatic Data Center (NCDC 2016)  |
| Temperature (maximum and minimum)                   | Time Series | Sub-daily (°C)                | National Climatic Data Center (NCDC 2016)  |
| Stream Flow   | Time Series | Sub-daily (m <sup>3</sup> /s) | U.S. Geological Survey (USGS 2016)   |

### Task 1.3) Floodplain Comparison

After the models are calibrated and validated, floodplains maps will be generated using synthetic storm hyetographs that are based on the existing IDF's and projected IDF that reflect climate change (Task 1.1). Floodplain maps for future expected development and climate conditions will be compared to existing FEMA maps. The goal is to assess how the floodplains might be increasing due to the effects of climate change or urbanization. The metric Kappa Coefficient (Cohen 1986) will be used to quantify how much the floodplains are changing. The Kappa Coefficient is originally a statistic for discrete multivariate analysis and expresses the expected agreement between two dataset. Kappa ranges from -1 (no agreement) to 1 (perfect agreement) and 0 represents an agreement that can be expected by chance.

#### *Objective 2) Explore alternative flood protection strategies*

The goal of Objective 2 is to use the hydrologic and hydraulics models to explore alternatives that can mitigate the impacts of flooding during storms events.

### Task 2.1) Flood control scenarios

Several scenarios for flood control will be generated and tested using the developed models (Task 1.2). At minimum, three scenarios will be evaluated: (1) Structure Flood Control (that include levees and reservoirs); (2) Floodplain Widening; and (3) Alternative Land Cover (includes reducing impervious cover and widespread use of green infrastructure such as Low Impact Development (LID)). LID counteracts negative impacts of urbanization by implementing decentralized Stormwater Control Measures (SCMs). The SCMs are intended to return the hydrologic flow regime close to its predevelopment state by promoting infiltration, retention, and evapotranspiration of stormwater on the site (Cahill 2012; US EPA 2000). Examples of LID-SCMs are green roofs, permeable pavements, bioretentions, infiltration trenches, rainwater harvesting, and other types of stormwater green infrastructure (GI).

#### *Objective 3) Training*

This task aims to enhance the knowledge of officials, engineers and managers that interface with the problems generated by flooding in urban areas. This component is crucial in transforming the knowledge generated by the research activities into actions that will improve the resilience of the transportation infrastructure and the City of San Antonio against flooding. On the other hand, the activities implemented in this objective will generate feedback information from transportation and floodplain managers to the research team that will be incorporated into the simulation methods.

### Task 3.1) Workshop

The goals of this workshop are to: (1) disseminate the obtained results during the Technical Phase; (2) provide training opportunities for participants in the use of GSSHA and HEC-RAS 2D. Members of the Texas Department of Transportation (TxDOT), City of San Antonio (COSA) and San Antonio River Authority (SARA) will be invited to attend the workshop to be held at UTSA main campus. UTSA students will also be invited to the workshop. The workshop will be one-day long and lunch will be provided for participants (a total of 15 participants are expected). At the end of the workshop, participants will be asked to answer a satisfaction survey.



#### *Objective 4) Education and Result Dissemination*

This project will provide education opportunities for one graduate student at UTSA that will work under direct supervision from the PI Dr. Giacomoni. The materials generated in this study will be incorporated into graduate and undergraduate curriculum at UTSA.

##### Task 4.1) Website Development

A website will be developed to help achieve two goals. First, it will contain information about the impact of severe flooding and storm events. Data from past events that produced catastrophic damages in urban areas around the world will be compiled. Second, the web site will contain the data, the models, and the main findings of the project. The reports will also be available for download at the completion of the project.

##### Task 4.2) Publications.

This project will generate articles to be published in top peer-reviewed journals in the field of water resources such as Journal of Hydrology, Journal of Hydrologic Engineering, and Water Resources Research. Research and educational findings will be presented at the annual national meeting of the American Geophysical Union and the American Society of Civil Engineers World Environmental and Water Resources Congress. At minimum, two journal articles and two conference papers will be submitted for publication.

## Project Schedule

| Tasks                       | Year 1 |     |     |     |     |     |     |     |     |     |     |     |
|-----------------------------|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                             | May    | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
| 1.1 IDF Update              |        |     |     |     |     |     |     |     |     |     |     |     |
| 1.2 Model Development       |        |     |     |     |     |     |     |     |     |     |     |     |
| 1.3 Flood Plain Analysis    |        |     |     |     |     |     |     |     |     |     |     |     |
| 2.1 Flood control scenarios |        |     |     |     |     |     |     |     |     |     |     |     |
| 3.1 Workshop                |        |     |     |     |     |     |     |     |     |     |     |     |
| 4.1 Website                 |        |     |     |     |     |     |     |     |     |     |     |     |
| 4.2 Publications            |        |     |     |     |     |     |     |     |     |     |     |     |



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## **EXHIBIT B**

### **Compensation Schedule & Deliverables**

#### **COMPENSATION**

This is a fixed price agreement and the City will be invoiced for the full amount at the time of contract execution.

#### **DELIVERABLES**

The deliverables of this project include:

- (1) Simulation models of Leon Creek and Upper San Antonio watersheds;
- (2) A website to raise awareness among the public about intense storm events and floods, and to disseminate the findings of the project;
- (3) One workshops to engage different agencies impacted by floods, such as TxDOT and city officials; and
- (4) A Final Report containing all the training materials, data and final assessment and recommendations.

The Principal Investigator shall submit the comprehensive final report within ninety (90) days after termination of the Agreement.

## EXHIBIT C

### Acknowledgement Of Contact Person for The University Of Texas at San Antonio (UTSA):

I have read the Agreement and its Terms and Conditions and understand my obligations, including that if any Confidential Information to be exchanged is export-controlled, I will consult with the UTSA Office of Research Integrity (ORI) before any export-controlled Confidential Information is disclosed. As the UTSA Contact Person, I agree I will not take possession or control of any export-controlled Confidential Information without prior approval from ORI, which is the UTSA office responsible for export controls compliance. I will not ever access, use, file, store, or maintain export-controlled Confidential Information related to this contract on any computer or other electronic medium that I personally own, and I will only use UTSA facilities, including physical desk or file storage and/or computer hard disks and/or other electronic medium owned or maintained by UTSA, to file, store, or maintain export-controlled Confidential Information after obtaining approval from ORI..

Signature: \_\_\_\_\_ Printed Name: \_\_\_\_\_  
Date: \_\_\_\_\_ Title: \_\_\_\_\_

Are you a citizen or permanent resident of the U.S.? ☐ Yes ☐ No

*Additional UTSA Individual Acknowledgement:* To be signed by each additional UTSA individual with access to the Confidential Information of another party.

Complete below or if not applicable, check here: ☐ "Not applicable at this time"

I have read the Agreement and its Terms and Conditions and understand my obligations, including that if Confidential Information to be exchanged is export-controlled, I will consult with the UTSA Office of Research Integrity named above and before the disclosure of any export-controlled Confidential Information. As a UTSA individual with access to the export-controlled Confidential Information, I agree I will not use UTSA facilities, including physical desk or file storage and/or computer hard disks and/or other electronic medium owned or maintained by UTSA, to file, store, or maintain export-controlled Confidential Information without prior approval from ORI, which is responsible for export controls compliance.

Signature: \_\_\_\_\_  
Printed name: \_\_\_\_\_  
Are you a citizen or permanent resident of the U.S.? ☐ Yes ☐ No

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