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

Predicting impacts of super storms to the transportation infrastructure and evaluating flood protection strategies to alleviate impacts in urban areas

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Flooding from super storm events are likely to grow worldwide due to climate change. A super storm is defined as extreme rain events with return periods higher than 100 years. Enhancing the understanding of how the transportation infrastructure is affected by large scale flooding is of vital importance. This project applies hydrologic modeling to assess how the transportation infrastructure in San Antonio, TX would be effected during super storms and how climate change might intensify them. Firstly, the future intensity-duration-frequency curve (IDF) will be estimated for the 4.5 and 8.5 representative concentration pathways (RCP). Then, flooding maps will be generated in two watersheds in San Antonio: Leon Creek and Upper San Antonio. The hydrologic models tested include the HEC-River Analysis System (RAS), combined with the Hydrologic Modeling System (HEC-HMS) and Gridded Surface Subsurface Hydrologic Analysis (GSSHA). The evolution of flood scenarios will be assessed and alternatives to mitigate flooding will be studied.

Background

Data from governmental agencies shows a clear exponential growth in fatalities, damages, and recovery costs due to extreme weather events in the U.S. (see Figure 1).

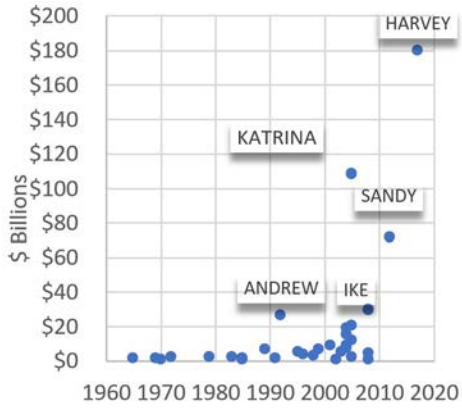

Figure 1. Cost of hurricanes in the U.S.

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. Because super storms are likely to become more frequent and severe due to climate change, 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 (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. 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.

Project Summary

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 can alleviate the impacts in highly populated urban areas. Four objectives are proposed: (1) to assess the impacts of super storms flooding in the transportation infrastructure, (2) to explore alternative flood protection structures that can minimize damages and maximize the resilience of transportation systems in large metropolitan areas, (3) 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, and (4) to enhance the public awareness of about the impacts of super storms in the built environment, with an emphasis in the main transportation infrastructure.

The case study is the Upper San Antonio and Leon Creek watersheds in the City of San Antonio, TX, which lays within a flood prone region in Texas referred as the Flash Flood Alley (Figure 2). This region is particularly vulnerable to super storms;

the flash Flood Alley constitute one of the most flood prone areas of the North American continent.

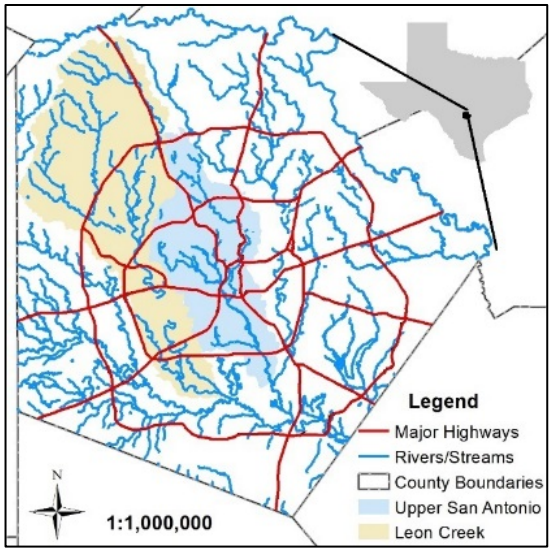

Figure 2. Location of Leon and Upper San Antonio watersheds.

Status Update

A total of 52 climate change projections of future rainfall generated by General Climate Models for two future scenarios were analyzed to represent a broad range of future rainfall patterns. After applying bias corrections methods, three future periods were investigated (near future from 2025-2049, medium future from 2050-2074, and far future from 2075-2099). Intensity Duration Frequency curves (IDFs) were generated and compared to existing IDFs used by TxDOT. The minimum, maximum, medium, first and third quartiles of IDF curves were generated.

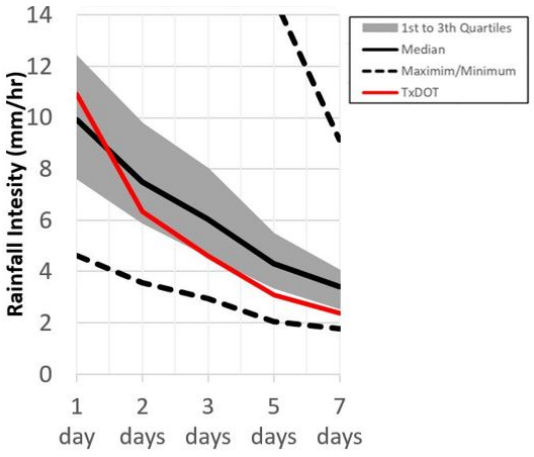

Figure 3. 100 years return period IDF for RCP 4.5 for medium future (2050-2074).

Figure 3 shows the rainfall intensity for durations ranging from one to seven days and it shows that climate projections are likely to increase rainfall intensities, in particular for multi-day storm events.

Long duration storms, such as Hurricanes and Tropical storms, are the one of high potential producing severe flooding and inundation. Similar behavior was found for the near and far future, for both RCP scenarios and return periods. Hydrologic and hydraulic models of the Leon Creek and Upper San Antonio are currently under development.

Impacts

The deliverables of this project include: 1) the development of state-of-the-art simulation models; 2) a website to disseminate the findings of the project, and to raise awareness among the public about intense storm events and floods; 3) one training workshop to engage different agencies impacted by floods, such as TxDOT and city officials and floodplain/watershed managers. The present proposal will have a positive impact on the communities of Region 6, in particular the City of San Antonio. The proposed analysis will investigate how recent hydrologic and hydraulic modeling developments affects the delineation of floodplain mapping. In particular, the model outputs will be used to identify how super storms impact transportation infrastructure. Furthermore, the project will have a strong educational component that will include workforce development and dissemination of results using the web.

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

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For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Mr. Christopher Melson (Tran-SET Program Manager) directly at transet@lsu.edu.

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