Flood Alert Systems

What is FAS4?

FAS4 is the latest version of the Rice/TMC Flood Alert System designed by Dr. Philip Bedient, Dr. Nick Fang, and Dr. Baxter Vieux. FAS4 uses real-time radar rainfall data to predict flood levels at critical locations. Over the last twenty years, TMC has used the FAS system to determine when to implement emergency protocols regarding the placement and/or closing of gates and doors in order to prevent flood damage to the Texas Medical Center. These systems are designed for specific TMC end-users, but the real-time predictions and flood warnings are also available to the public online. See FAS4's performance during Harvey on page three.

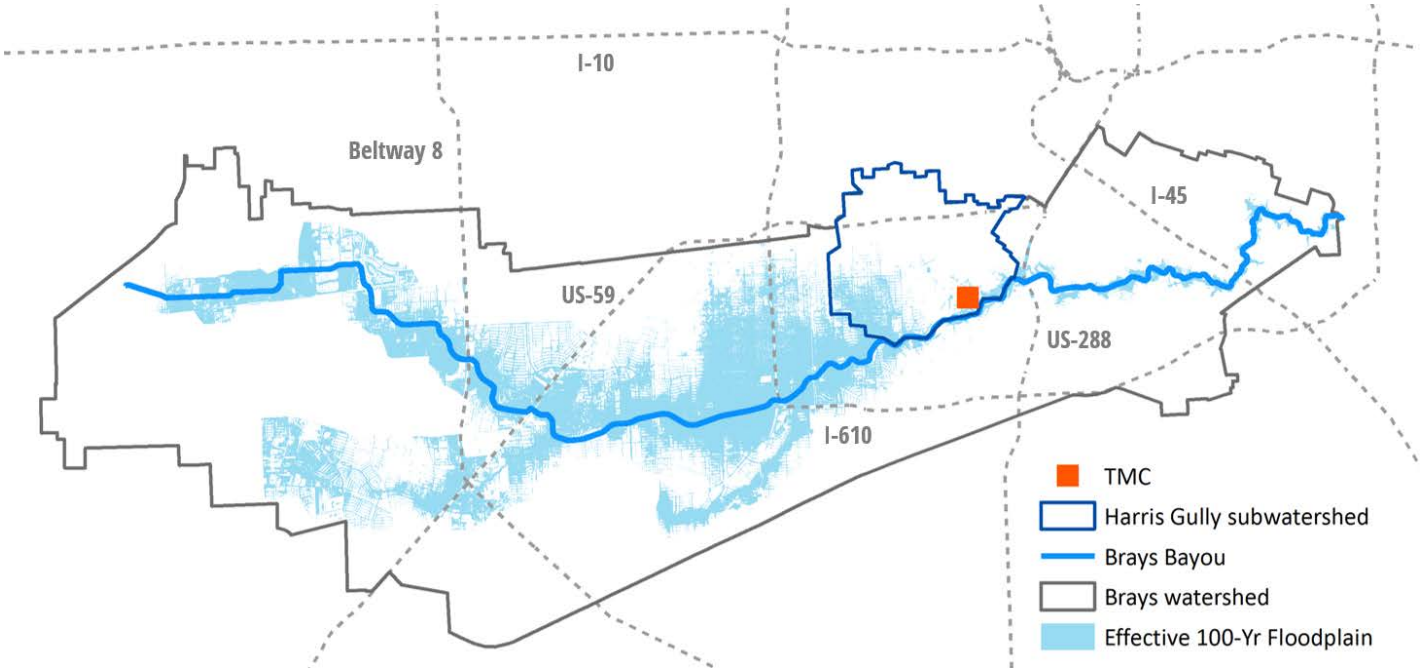

Figure 1 Overview of Brays Bayou Watershed and the effective 100-Yr Floodplain, including TMC's critical watch point, Harris Gully.

FAS4 Features

- Reliable and robust flood prediction with excellent performance for the past 20 years
- Increased lead time for flood warning
- Accurate real-time radar rainfall estimates since '98
- Implements Google Earth/Maps technologies
- Visualized Radar Rainfall over the watershed and individual sub-basins
- Communication for emergency response and operations
- Frequent information updates via

  FAS4.flood-alert.org or mobile.fas4.flood-alert.org

Current Users

- Texas Medical Center
- City of Sugar Land

FAS4 Website

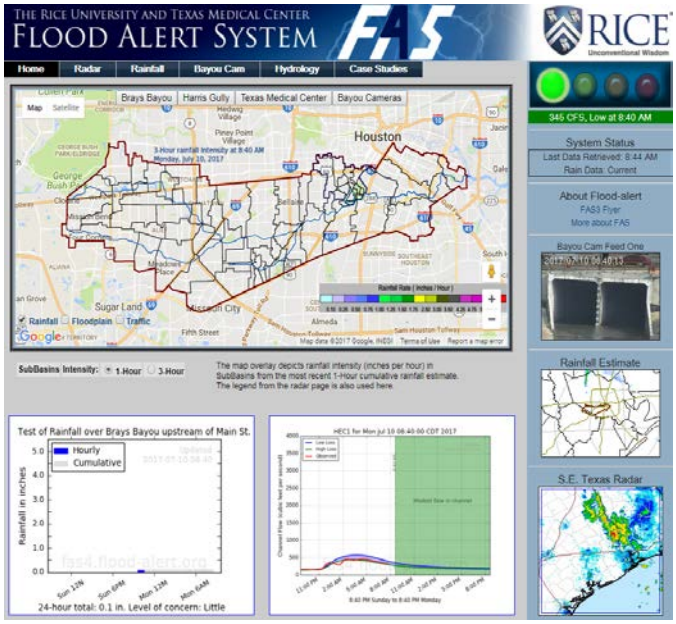

Figure 2 Homepage of the Rice/TMC FAS4 website showing in low alert or "green status".

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How does FAS4 work?

The SSPEED Center at Rice University has built localized Flood Alert Systems for the Texas Medical Center and others. For over 20 years, TMC has used the FAS system. The latest version, FAS4, was released in 2017. It uses real-time radar rainfall data to predict flood levels at critical locations. The below flowchart gives an overview of the FAS4 system.

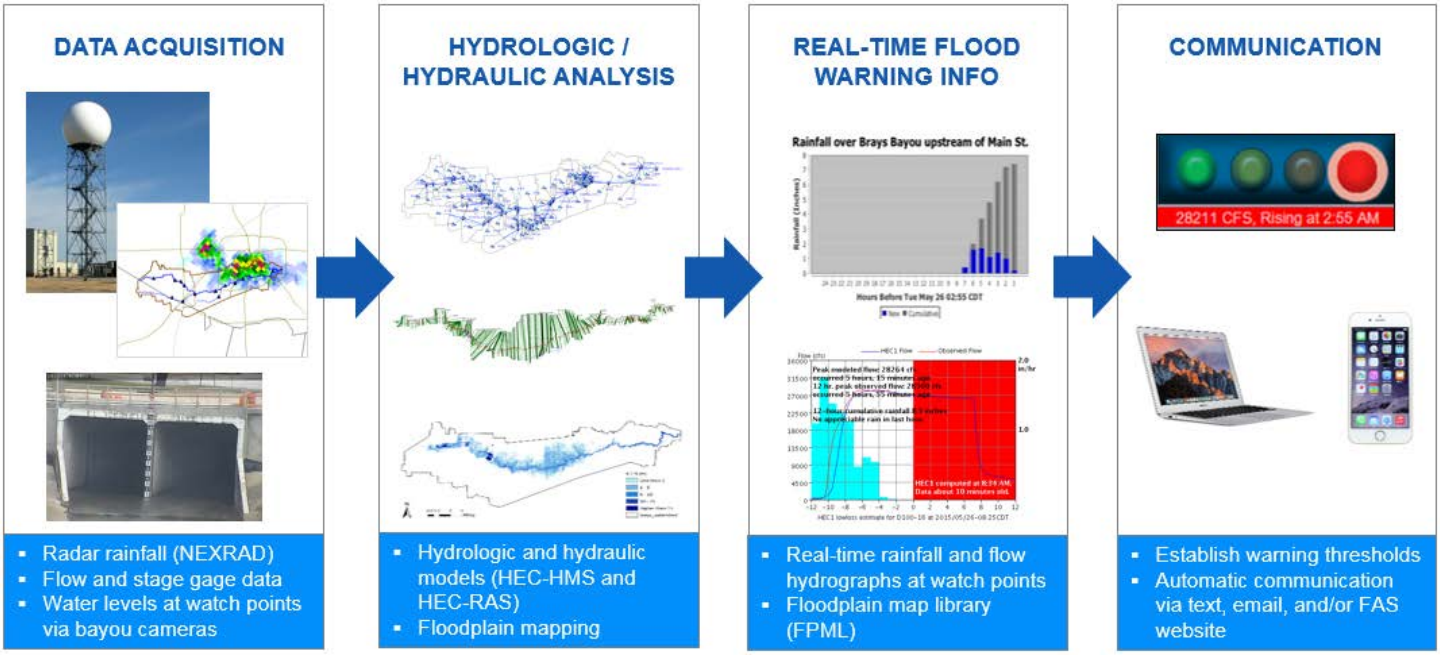

Figure 3 Flowchart showing data & modeling programs used to create & communicate real-time flood warning information.

FAS4 in Detail

NEXRAD Radar Rainfall

Radar data reflects off raindrops and is processed and calibrated by Vieux and Assoc., Inc. (VAI) in Oklahoma every 5 min. During a rainfall event, VAI radar rainfall data is delivered to Rice for 43 sub-basins over Brays in 5 min intervals. This process is repeated every 5-10 min during a storm as the overall hydrograph is developed and plotted within FAS4.

Flow & Stage Gauge Data

A USGS stream flow gauge at TMC records the elevation and flow of water in Brays Bayou. FAS output is compared with this gauge data in real time to validate the model performance.

Bayou Cameras

Bayou cameras provide vital water levels and visual confirmation during a flood event. The Harris Gully Gage was selected as the critical point to view gage activity for the Rice/TMC system. Gully levels are automatically communicated to TMC.

Hydrologic Models

During a rainfall event, VAI radar rainfall data is used in the hydrologic model, HEC-1, to create flow hydrographs. For TMC, HEC-1 predicts the peak flow in Brays Bayou, which triggers a status change on the FAS4 website and sends a notification to TMC.

Floodplain Maps

SSPEED created a library of floodplain scenarios that are representative of flooding conditions under different rainfall amounts using HEC-RAS. Radar Rainfall data are used to pull the corresponding floodplain during a storm event to give a user the extent of flooding that might be observed.

Communication

Real-time flood information is communicated automatically via text, email, and/or the FAS website. On the website, warnings are indicated through the status tree. For TMC, a status change triggers a sequence of safety protocols, which could include closing flood gates or doors (example on page 4).

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FAS4 & Hurricane Harvey

Hurricane Harvey made landfall on August 25, 2017 near Corpus Christi, Texas. Over the next five days the storm devastated the Texas coast, dropping over 36 inches of rain over 2500 sq mi area and causing unprecedented levels of damage. Harvey is likely the costliest storm in U.S. history, exceeding Hurricane Katrina. Life-threatening flooding in the City of Houston and surrounding areas caught the world's attention.

Figure 4 Flood waters receding near the Medical Center

"The Texas Medical Center remained fully operational throughout [Harvey]. This is due in large part to the investment of more than $50 million in our infrastructure, including elevating our electrical systems and implementing an advanced floodgate system designed to protect all of the buildings from water. … We also utilize a sophisticated radar-based system designed by Rice University researchers that tracks and measures rainfall in the surrounding area. [FAS4] initiate[s] our emergency flood protocol that coordinates the activation of our floodgates around all of our hospitals, clinics and research buildings. As Harvey's rainfall continued, …, our storm gates held strong and protected our buildings from being inundated with water. All of our hospitals remained open and employees continued to care for our patients throughout the storm."

Courtesy of TMC CEO, William F. McKeon - TMC News, President's Perspective: How the TMC survived Harvey

FAS4 in Action

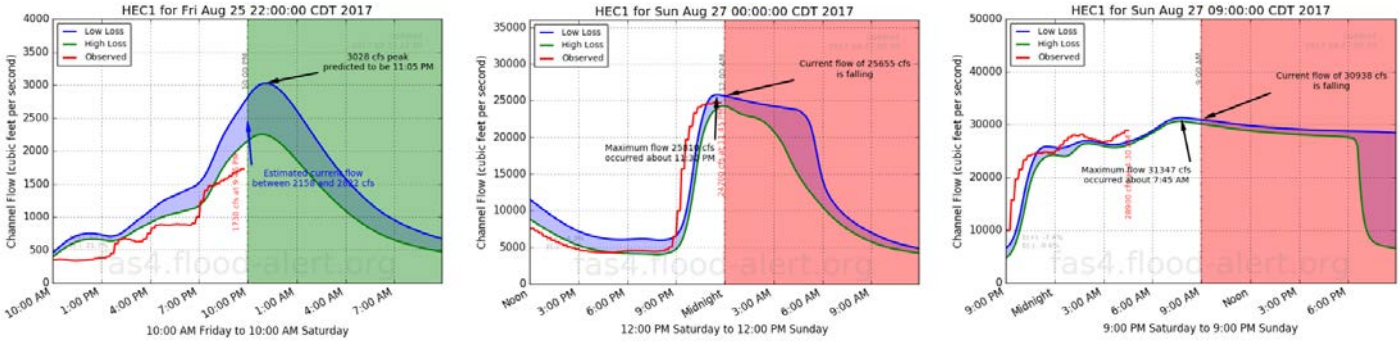

Figure 5 Hydrographs of FAS4 performance during Hurricane Harvey (August 2017)

(a) (b) (c)

Figure 6 Harris Gully Bayou Camera on 08/26/17 at (a) 21:00:05 and (b) 22:00:14 and on 08/27/17 at 06:00:16

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FAS4 History & Authors

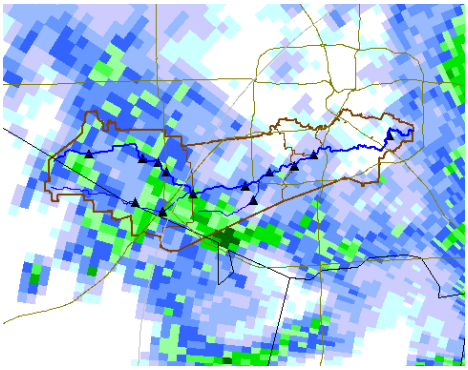
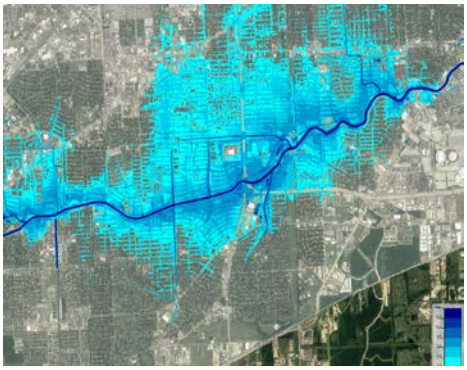

Figure 7 TMC floodgate | VAI's Radar rainfall image of Hurricane Harvey over Brays Watershed | Floodplain Map of Harvey (S Gessner Rd to Main St)

Development of FAS4 (1997-2018)

1997 Developed for Brays Bayou (tested on >40 events since 1997)
2001 System tested on TS Allison
2003 System upgraded to FAS2
2005-2013 Core hydrologic model calibrated & improved
2009 Floodplain Map Library (FPML) implemented within Google Maps
2010 FAS2 upgraded to FAS3
2017 FAS3 upgraded to FAS4 & mobile site launched

Authors

Philip Bedient

Dr. Bedient is the Herman Brown Professor of Engineering at Rice University in Civil and Environmental Engineering. He teaches and performs research in surface water hydrology and flood prediction systems. He has directed 60 research projects over the past 35 years, and has written over 180 articles in journals and conference proceedings. Dr. Bedient directs the SSPEED Center at Rice for severe storm prediction, consisting of several universities in the Gulf Coast area, which has funding to address the impacts of Hurricane Ike in the Houston area. Dr. Bedient has directed the development of FAS4 since 1997 with funding from The Texas Medical Center and FEMA.

Nick Fang

Dr. Nick Z. Fang is an assistant professor in the Civil Engineering Department at the University of Texas – Arlington. He obtained his Ph.D. in Civil and Environmental Engineering at Rice University. He has been working on surface water and groundwater problems for over ten years including floodplain studies, hydrologic/hydraulic modeling, water treatment, hydrodynamic simulation, storm water management modeling, and water quality assessment for a number of watersheds in Texas, Florida, and Louisiana. Dr. Fang's Ph.D. research focused on developing the mapped libraries for flood inundation for FAS4.

Baxter Vieux

Dr. Vieux's professional focus is radar rainfall and distributed hydrologic modeling. He is distinguished in the application of high-resolution rainfall monitoring to hydraulic modeling of collection systems. Dr. Vieux has directed the development of design storms for collection system planning, operations He has over 100 publications appearing as textbooks, journal articles, and conference proceedings. Dr. Vieux was a full Professor at the University of Oklahoma. His company, Vieux & Associates (VAI), delivers the calibrated radar for use in FAS4, and delivers similar products to clients all over the world.

For more information regarding FAS4, please visit our website, FAS4.flood-alert.org.