Report for 2002TX47B: Enhanced Flood Warnings for the Texas Medical Center: A Second Generation Flood Alert System (FAS2)

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Report Follows:

Title: Enhanced Flood Warnings for the Texas Medical Center: A Second Generation Flood Alert System (FAS2)

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Results and Progress to Date:

Significant progress has been made over the last year with respect to developing an enhanced flood warning system for Brays Bayou and the Texas Medical Center in Houston, Texas. Research has been made possible by a wide range of funding sources in addition to the TWRI, including the Federal Emergency Management Agency (FEMA), the Texas Medical Center (TMC), and Rice University. The research funds provided by TWRI were specifically used to upgrade computer hardware capabilities to permit the wide ranging and intense computational analyses performed as part of this research.

The second generation Rice University / Texas Medical Center Flood Alert System (FAS2) has upgraded the capabilities of the current FAS by incorporating recent advances in NEXRAD technology, weather prediction tools and GIS-based distributed hydrologic models. This section briefly presents results and progress to date in each of these areas.

Next-Generation Radar and Quantitative Precipitation Forecasts

The lead-time afforded by the first generation FAS is being improved by the incorporation of a Quantitative Precipitation (QPF) algorithm in its rainfall analysis process. The QPF algorithm selected for analysis and application to a hydrologic model was based on the Growth and Decay Storm Tracker (GDST) developed at MIT (Wolfson, Forman et al. 1999) . The GDST provides forecasts of 16-level precipitation at grid scales as small as 1 km^2. GDST-based data has been obtained through Vieux and Associates, Inc. (VAI). The data product provided by VAI, called PreVieux, provides up to 60-minute forecasts (or extrapolations based on radar images) for each radar volume scan. Forecasts are provided in 5 minute bins; therefore, each radar scan has 12 associated forecast images or datasets beginning with the t+5 minute scan and continuing with t+10, t+15 and so forth up to t+60 minutes. The algorithm currently uses 16-level, base reflectivity, lowest radar tilt data.

The goal of this portion of the research was to evaluate the performance of the GDST from a hydrologic perspective, first from a rainfall intensity perspective and then later incorporate the data into a hydrologic model. The impetus for this research was based on the previous use and performance of the original FAS. It was observed that while the FAS provided about 2 hours of lead time from a strictly hydrologic perspective, system users were deriving qualitative estimates of rainfall in the future from observed storm motion in the radar image loops. Any method to quantify the future position and intensity of existing storms would greatly reduce the error associated with these qualitative estimates. Figure 1 provides an example of the

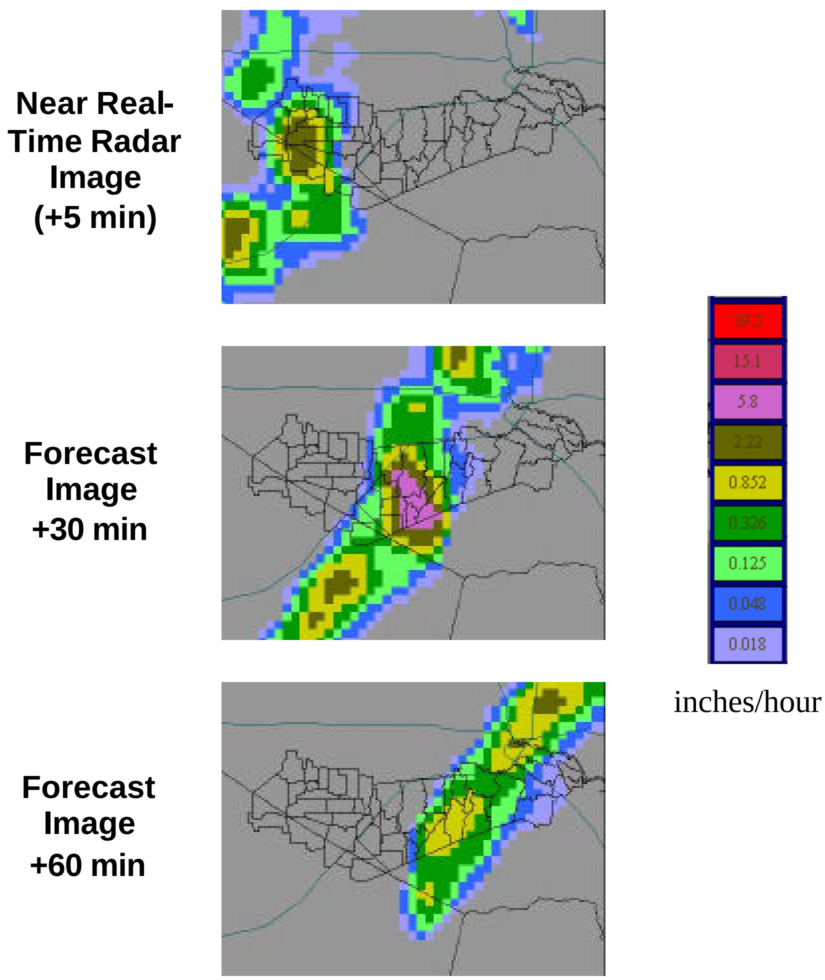

Figure 1 : GDST (PreVieux™) data in gridded format over Brays Bayou

GDST data as provided by VAI. The figure shows the progression of a frontal storm as predicted by the algorithm. The grid values are intensities in inches/hour and are superimposed on the subwatersheds of Brays Bayou.

QPF data based on the GDST algorithm was obtained through VAI for the period May 2002 through December 2002. Twenty-seven separate rainfall events have been identified and collected over that period. Although the data is available in gridded format as seen previously, for the purposes of this study, the data was provided in subbasin averaged rainfall format. Figure 2 shows an example of this basin averaged data for a storm event on April 7th, 2003, during

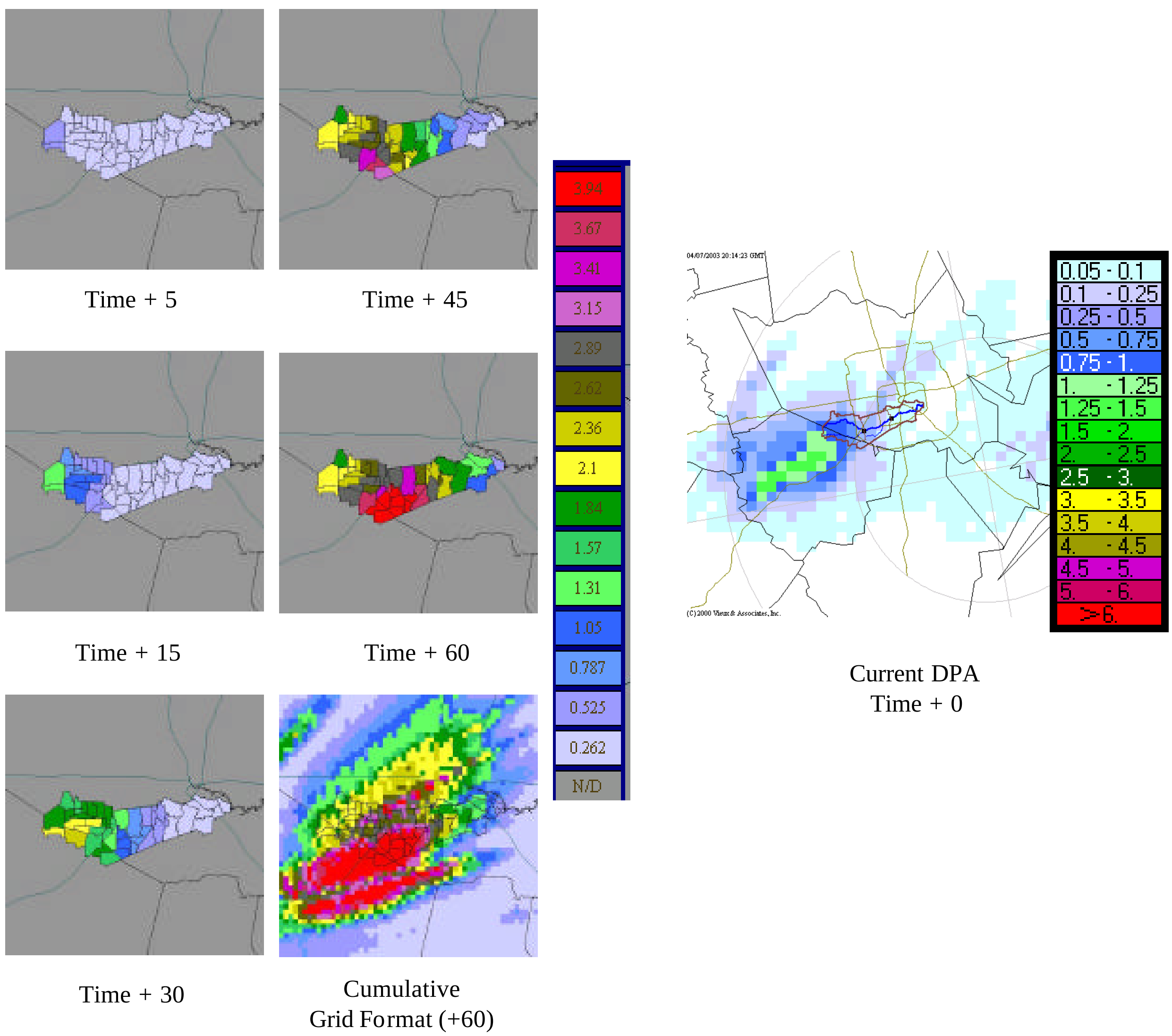

Figure 2 : QPF (PreVieux TM) and DPA data for a storm cell moving west to east across Brays Bayou on April 7th, 2003 (Color schemes for each legend are different)

which an isolated storm cell moved from west to east across Brays Bayou. The images on the left are a PreVieux^{TM} product operating in real-time and show the cumulative predicted rainfall expected over a 60 minute period in inches. Snapshots of the basin averaged values were taken at 15 minute intervals. The image in the lower right corner shows the same data accumulated over 60 minutes but in the 1 km^2 grid format. The image on the right is the radar image displayed on the current FAS website, which shows the Digital Precipitation Array product. The DPA exhibits rainfall (in inches) that has fallen over the previous 60 minutes in a 4 km^2 grid format.

On-going research is focusing on comparing the QPF data at various forecast time intervals (+15, +30, +45, and +60) to the actual radar data and then rain gages to determine the feasibility of incorporating it with a hydrologic model. Preliminary results are indicating that the algorithm performs acceptably well for line storms (well-organized frontal systems) up to the +45 to +60-minute forecast interval. While the algorithm does not perform as well for convective systems, exhibiting the approximately the same skill for frontal storms at only the +30 min forecast interval, additional research must be performed to confirm the results. Additionally, the QPF algorithm's performance remains to be evaluated once coupled with and used as input to a hydrologic model.

Development of Real-Time Hydrologic Models

The second major improvement to the original FAS completed as part of this research is the creation of real-time hydrologic models that make the best use of radar data, QPFs, and the information dissemination capabilities of the internet. Two real-time models have been developed and are scheduled to eventually replace the "nomograph" approach used in the current system. Two models were developed, one a distributed hydrologic model and the other a lumped parameter hydrologic model, to enable the system to draw on the strengths of each modeling approach.

The distributed model being used in this study was created using a proprietary software package called Vflo^{TM}, developed by VAI. The Brays Bayou Vflo^{TM} model was developed by Eric Stewart and has been calibrated and validated against historical storms. A real-time operational structure for this particular model has been developed by VAI and will be incorporated in the new system shortly. Figures 3 and 4 show the Vflo interface and two different scale views of the Brays Bayou model.

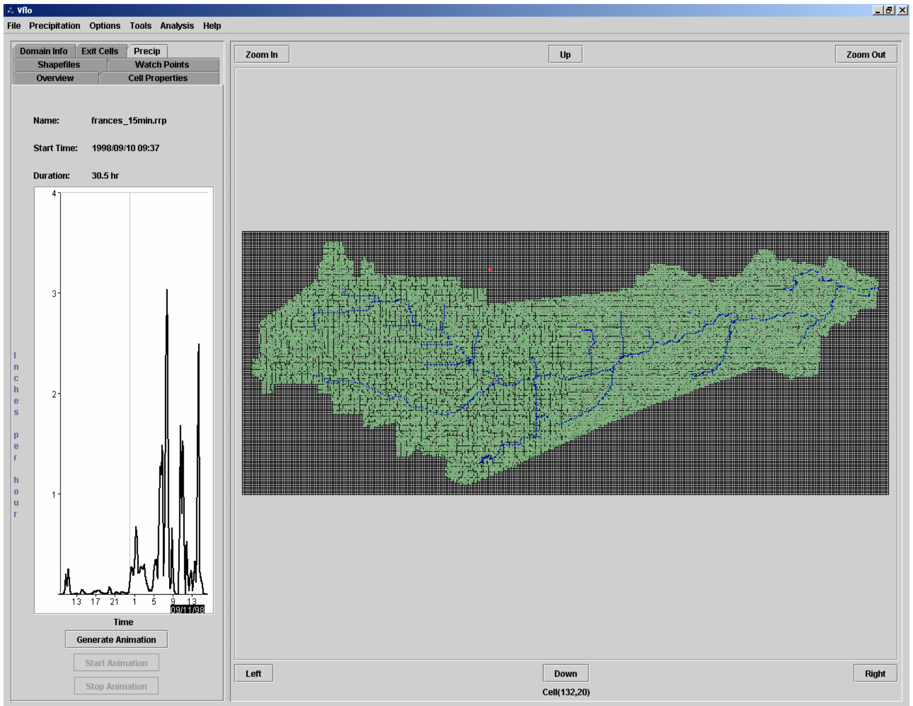

Figure 3 : Screenshot of the newly developed Brays Bayou Vflo^{TM} Distributed Hydrologic Model

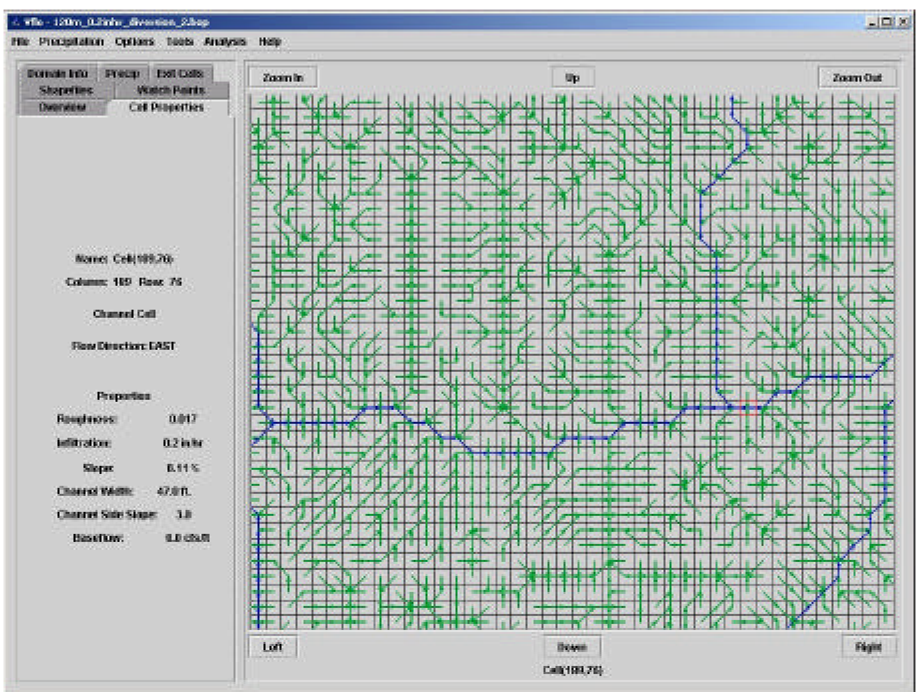

Figure 4 : Close-up screenshot of the Brays Bayou Vflo^{TM} model showing both overland and stream flow connectivity

The lumped parameter model created for use in this study was developed using the standard HEC-1 / HEC-HMS hydrologic modeling programs used in flood studies throughout the United States. However, the Brays Bayou HEC-1 model has been upgraded with a novel real-time interface, permitting both the incorporation of real-time rainfall data and the dissemination of real-time flow hydrographs for Brays Bayou. The interface has been tested for several small storm events in early 2003. The Real-Time HEC-1 Brays Bayou Model (RT HEC-1) remains to be calibrated and validated against both historical and real-time storms. It is hoped that this will be completed by late Summer / early Fall 2003. Figure 5 illustrates the RT HEC-1 real-time output for a small storm event over Brays Bayou on March 3rd, 2003. The graphs show the

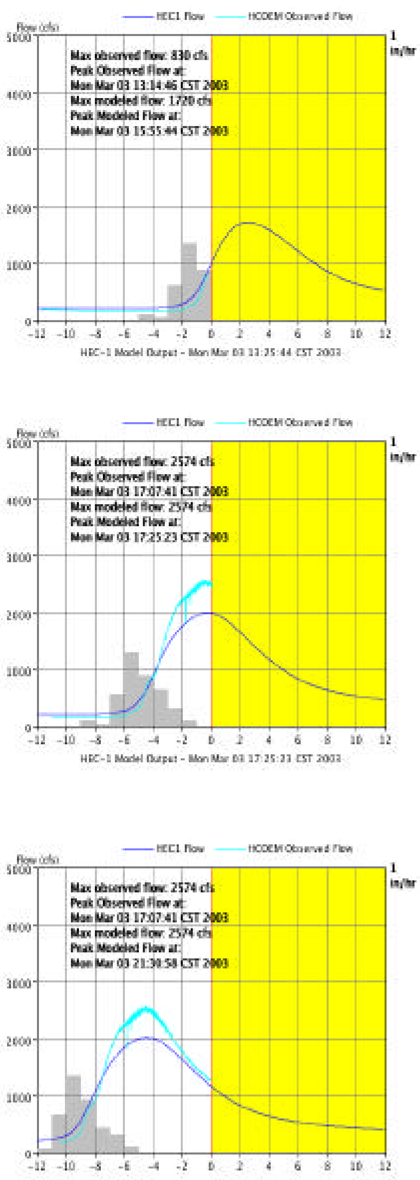

Figure 5 : Real-Time HEC-1 model results for a small storm over Brays Bayou (uncalibrated)

progression of the flood wave past Main St. The vertical red line in the center represents the "now-line" or time of current observation. The light blue line is the observed stream flow data as recorded by the Harris County Office of Emergency Management (HCOEM). The dark blue line represents the modeled hydrograph based on HEC-1 runs using Digital Precipitation Array (DPA) NEXRAD radar as rainfall input. The rainfall intensities are illustrated with gray hyetographs in each figure. The differences between the observed and modeled hydrographs are attributed to the fact that the model is currently uncalibrated and the fact that the storm event was quite small.

System Redundancy and Web-based Improvements

A wide range of operational system improvements have been completed. These include the securing of a second radar rainfall feed from the KGRK NEXRAD installation located in central Texas. This second feed is in addition to the currently used KHGX NEXRAD feed located in Dickinson, Texas. The need for radar feed redundancy was highlighted in the summer of 2002 when the KHGX installation was out of service for approximately 2 weeks after it suffered multiple lightning strikes. The system now has the capability to illustrate radar images and process radar rainfall data from each installation.

Additional system servers are currently being installed for a total of three server locations: Rice Univeristy, the Texas Medical Center, and the University of Oklahoma. The multiple server locations will allow the alert system to continue to process information and issue warnings and flood updates even in the event of a local loss of electrical power. Additional methods of communicating these alerts are being implemented to include automated email, pager, and cell phone alerts.

A number of improvements have been made to the current website including improving the efficiency of the web page by developing custom JAVA scripts, enabling the system to withstand a larger number of "hits" during critical times of operation.

Improved Alert Level Information for Harris Gully and the Texas Medical Center (TMC)

A detailed study has been completed of historical rainfall and stream flow levels at the Harris Gully / Brays Bayou confluence in order to determine a new set of alert level data for the Texas Medical Center. The updated alert levels are still in the process of being evaluated and verified, although initial results are indicating that the action levels might become less stringent –

effectively reducing the number of false alarms and thus, reducing inefficiencies and costs to the overall operation of the TMC. These new alert levels are being developed in close cooperation with TMC emergency response personnel and other consultant agencies currently working on the flood proofing/flood protection measures in the "tunnel system" of the TMC.