

# MOORE KNOWLEDGE

## **PRACTICAL FLOOD PROTECTION**

### **Be Ready for Stormy Weather**

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### At a Glance

1. A reliable flood alert system (FAS) is a benefit to urban areas like Houston, Texas, where tropical storms regularly occur. But real-time flood systems are complex and costly.
2. A simple and practical alternative is a rainfall gage-based FAS system that uses real-time information.
3. Walter P Moore developed an FAS for the Houston Theater District that uses readily available data, provides ample warning time to city personnel and results in an annual \$30,000 savings.

A flood alert system (FAS) is a floodplain management tool that gives emergency management personnel adequate time to implement active flood protection. Such an FAS reduces the damage risk of an impending flood and provides community rating credit for the National Flood Insurance Program.

There are robust flood alert systems based on real-time observations of rainfall, runoff and hydrologic and hydraulic models. The systems can be automated and Web-based to provide continuous information that can then be interpreted as a risk to be followed by a warning. Developing a real-time FAS is a complex process that requires multiple entities to collect, analyze, interpret and communicate the appropriate data and, most importantly, to disseminate alerts and react to the pending event.

A reliable FAS is extremely beneficial to urban areas like Houston, Texas, where tropical storms regularly occur. However, the complexity and cost of a real-time FAS can make it hard for communities to develop and maintain. Development and implementation requires a community to prioritize system delivery and operations costs. Even though a real-time system's cost benefit is positive over its lifetime, the initial cost is often determined to be too expensive. In addition, the system has regular maintenance costs to continually provide data, even though it might be years between alerts. When political pressure is exerted to keep costs down, this type of expenditure is often determined to be nonessential.

### A Simple and Practical Alternative

A rainfall gage-based FAS is a useful alternative to a real-time system where an extensive stream gage system exists, such as Harris County, Texas. The rainfall-based FAS is designed based on the predictive pattern of hydraulic response of channel cross sections and the time-based channel response, or more

simply put, using an understanding of how a particular stream will respond to a particular rainfall event. The rainfall gage-based FAS also allows for sufficient warning time to be given from the assessment of flood wave propagation.

### Case Study: A Gage-Based Flood Alert System for the Houston Theater District

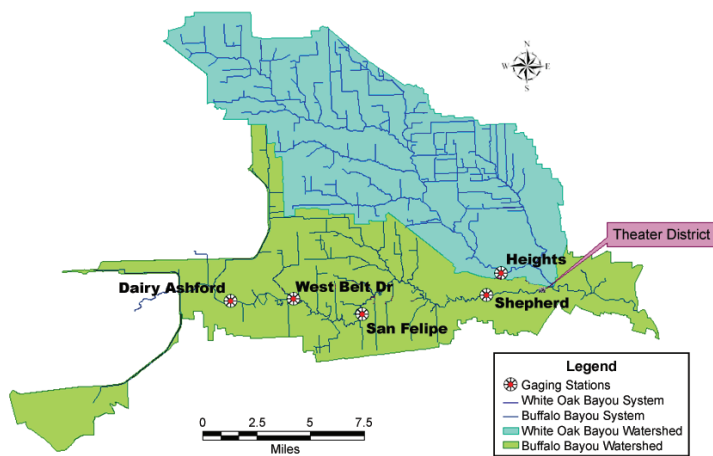
In June 2001, Tropical Storm Allison dropped an excessive amount of rain, exceeding the 1 percent annual exceedance rainfall probability (100-year storm) over much of metropolitan Houston. The city-owned underground parking garages in the Houston Theater District were heavily flooded during this event, causing considerable damage and loss of life.

As a result, the City of Houston developed a flood protection system comprised of flood walls, flood doors, improved drainage systems and flood gates to protect the garages and city buildings in the flood-prone areas. The city needed an additional detection device to provide sufficient warning so that the flood protection measures could be implemented in time to protect city property. The city asked for a solution that would allow it to utilize the Harris County stream gage and rainfall reporting systems to alert Houston emergency operations personnel, who in turn would warn the facilities staff of pending flooding.

Walter P Moore used stream and rainfall gage information to develop an FAS for the Houston Theater District. The rainfall gage-based FAS was developed on the basis of real-time monitoring of data on rainfall and stage heights at various upstream locations of the Buffalo Bayou and White Oak Bayou, two major channels that join together immediately adjacent to the downtown area. (See Figure 1.) The alert system's primary purpose is to warn City of Houston personnel of pending flooding.

Upstream Gaging Station	Warning Stage (ft)	Minimum available warning time (h:min) to peak at Texas Avenue after alert
Dairy Ashford	61.19	6:30
West Belt Drive	56.24	5:01
Gessner	53.37	4:22
Piney Point	49.90	3:56
San Felipe	46.52	3:30
Voss	43.22	3:21
Farther Point	37.75	3:09
Loop 610 Frontage	31.56	3:04
Shepherd	25.07	2:56

**Table 1. The theater district FAS gives City of Houston personnel calculated warning stages and warning times.**



**Figure 1. The Houston Theater District's flood alert system is based on real-time data from upstream monitoring locations.**

The risk is determined based on rainfall and stream gage observations at one or more upstream Buffalo Bayou and White Oak Bayou stations. These data are available from the Harris County Office of Homeland Security and Emergency Management Web site ([www.hcoem.org](http://www.hcoem.org)). Emergency management personnel analyze the warning using automated gage warning information from the Harris County Stream Gage Reporting System and criteria developed for Buffalo and White Oak Bayous based on the modeled response of the streams to a range of rainfall events. (See Table 1.) City emergency management personnel interpret the information and instruct facility personnel on actions to take in implementing active flood protection when a risk threshold is reached.

### Conclusion

This solution allows the City of Houston to use data generated by the Harris County Flood Stream Monitoring system, which is provided in real time to city emergency management personnel, to provide adequate warning to implement the \$2.1 million investment in flood protection of the garage and tunnel system. The warning system has no annual maintenance costs and is carried out by personnel already on duty to provide emergency monitoring. This solution saved the city the implementation cost of the Web-based system of about \$150,000.

The gage-based flood alert system provides cost-effective warning that will allow the City of Houston ample reaction time to implement the Houston Theater District flood protection system.

The authors are members of the Civil Engineering Services Group at Walter P Moore, where civil engineering is about community service, intelligent development and quality of life. Our comprehensive flood mitigation services include risk evaluation, comprehensive design and operations protocol development. Our solutions incorporate all viable building codes, long-term facility goals, long-range improvements, implementation plans and coordination with funding sources and adjacent facilities.

### ABOUT THE AUTHORS

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