IMPLEMENTATION OF A RIVER-LEVEL FORECAST SITE IN THE SUWANNEE RIVER BASIN, FLORIDA

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Abstract. River level forecasting has been undertaken by the National Weather Service (NWS) in the Suwannee River basin since the late 1970's. Among others, forecast sites were established in the lower reach of the Santa Fe River, a major tributary to the Suwannee River. Since that time, extensive riverbank and floodplain development has occurred upstream of those forecast sites in the Santa Fe River. During the 1980's and 1990's, some riverine stretches experienced significant flooding events, which at times were not preceded by adequate warning from the existing flood warning network.

In response to a request from affected residents, the NWS and the Suwannee River Water Management District (SRWMD) cooperated in establishing the first new forecast site in the basin in over 20 years. Data review and analysis, field surveys, and public meetings were conducted to identify the optimal gage location and establish the appropriate action, cautionary, and flood stages. Data analysis showed the existence of two distinct types of flood events in the basin, one inherent to rainfall over the basin and the second due to backwater effects. The Southeast River Forecast Center (SERFC) has incorporated the new forecast site in the National Weather Service River Forecast System (NWSRFS) and it is in the process of redefining the existing setting for the Santa Fe River. The enhancements in the new setting will include the use of dynamic routing to account for the backwater effects in the Santa Fe River due to flooding in the Suwannee River basin.

INTRODUCTION

Among the responsibilities of the NWS is the issuance and dissemination of river-level forecasts at various sites. Most forecast sites have been selected mainly based on the need of the population to be warned about rises in river levels that might adversely affect their property and potentially cause injuries or fatalities. Although there are roughly 15 flood forecast sites in the Suwannee River basin, the rationale and procedures of forecast site establishment needs to be described.

Santa Fe River floodplain residents from the area known as Hollingsworth Bluff, located near the State Road 47 bridge about 16 miles upstream of the confluence with the Suwannee River, felt they were not being served by existing flood forecast sites on the lower Santa Fe River. This paper describes procedures considered to establish a new flood forecast site on the Santa Fe River. In the Suwannee River basin in Florida, the SRWMD cooperates closely with the NWS in collecting river level and precipitation data used in developing the forecasts, as well as by interfacing with the affected public. NWS personnel worked closely with the SRWMD in this effort.

BACKGROUND

River level forecasting has been undertaken by the NWS in the Suwannee River basin since the late 1970's. Two forecast sites were established in the lower reaches of the Santa Fe River, the focus area of this paper, primarily to protect low-lying areas subject to inundation due to backwater from Suwannee River flooding. Since that time, extensive riverbank development has occurred upstream of those forecast sites in the rural, unincorporated areas of Alachua, Gilchrist, and Columbia counties (Figure 1). During the 1980's and 1990's, these upstream areas experienced rapid and significant flooding, which often was not included in the existing flood warning network.

The SRWMD employs a non-structural floodplain management strategy. The strategy has three primary components: floodplain regulation, floodplain acquisition, and forecasting and education.

SRWMD floodplain regulations have been in place since the mid-1980's. They require the elevation of structures and limit the placement of fill and obstructions in floodplain. They also established the use of riverbank setbacks and erosion control measures.

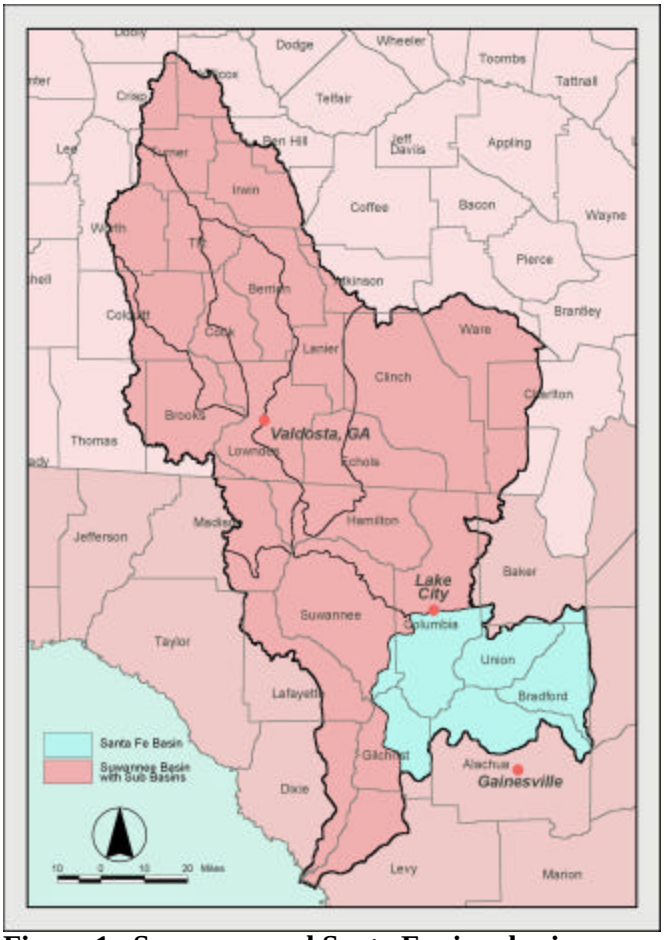

Figure 1. Suwannee and Santa Fe river basins.

The floodplain acquisition component is undertaken with the purpose of providing natural storage for flood waters and reducing the potential loss of life and property due to floods, in addition to environmental protections it affords.

SRWMD's forecasting and education efforts are accomplished through its close cooperation with the NWS, the SERFC and Florida's emergency management officials through outreach activities including brochures, newsletters, workshops, and other public information endeavors.

DESCRIPTION OF THE AREA

The Suwannee River basin originates in the Okefenokee Swamp in southeastern Georgia and flows toward the Gulf of Mexico. Two major tributaries, the Alapaha and Withlacoochee Rivers, also originate in Georgia. The Santa Fe River flows west from its headwaters to join the Suwannee near Branford. The drainage area for the Santa Fe comprises 1,384 square miles (Hunn and Slack, 1983).

Extensive karstification in the subsurface limestone has caused all streams in the SRWMD except the Suwannee to disappear underground as they exit the peninsular highlands for the coastal plain. The Santa Fe River goes underground at OLeno State Park in Columbia County and resurfaces three miles downstream at Santa Fe Rise (Kincaid, 1997).

The main rainfall-producing weather events in this area are frontal systems during the winter and tropical events during the summer. The annual precipitation is about 55 inches, with roughly 50 percent of this amount occurring during the months of June through September. Summer rainfall is associated with localized thunderstorm activity, while the winter frontal rains are usually more widely spread and of longer duration.

The United States Geological Survey, in a cooperative agreement with the SRWMD, monitors water level and discharge at three long-term gages on the Santa Fe River. These gages are located at Worthington Springs (WORF1), near Fort White (FWHF1), and near Hildreth (FTWF1). The Hildreth gage is also a forecast site for the NWS. In addition, the SRWMD operates two other gages in the Santa Fe River, Three Rivers Estates (TREF1), a NWS forecast site, and a long-term gage at High Springs (HSPF1). These gages are shown on Figure 2. FWHF1 has been in operation since 1928, and it is the closest long-term gage to the area of concern. Therefore, this site would be examined for establishing the new forecast site.

PROCEDURES TO ESTABLISH FLOOD STAGE

River forecasts are based on the flood stage, or the level at which threats of significant property damage or

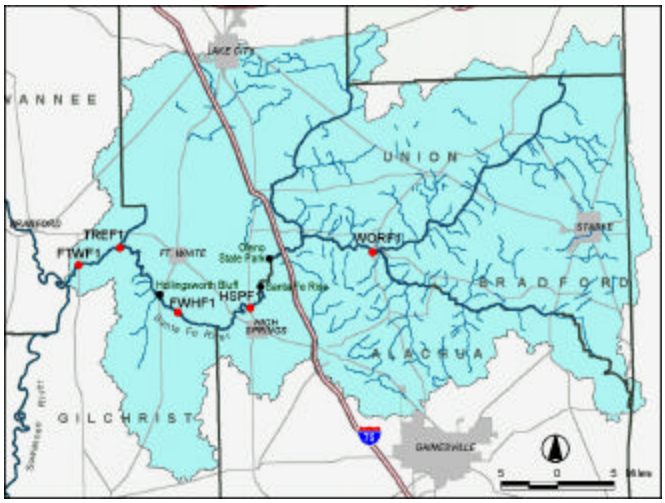

Figure 2. Location of Santa Fe Gaging Stations.

to personal safety occur. This stage is also part of the static input to the NWSRFS hydrologic model. It also assists the NWS forecaster in visualizing a potential rise which might trigger a flood forecast. Additionally, there are times when emergency management or public works agencies must act in response to a hydrologic situation and initiate relief functions as soon as the river reaches a certain stage. This is typically a lower stage than flood stage and is generally known as the 'action stage'.

The SERFC uses the NWSRFS to simulate the river levels at forecast sites. The forecasts produced at the SERFC are disseminated to the public and emergency response agencies. In order to determine the impacts produced by high river levels, the flood stage is used as reference. Therefore, proper establishment of this stage is fundamental for the issuance and interpretation of the flood statements.

NWS and SRWMD staff conducted field surveys of the reaches of the Santa Fe River to be covered by the proposed forecast location, reviewing past flood impacts with affected residents and local officials (Figure 3). This information is used to create a stage-damage graph. Besides the field survey, a review of the historical floods was conducted to help establish the flood stage.

An analysis of the historical data indicated that prior to the initiation of flood forecasting by the NWS, three major floods took place in the Suwannee basin (1948, 1964, and 1973). The 1948 and 1973 events appear, in hindsight, to have been induced by El Niño conditions; both occurring during the months of March and April. In 1964, Hurricane Dora produced the flood of record for the Santa Fe River.

Starting in the 1980's the highest levels in the Santa

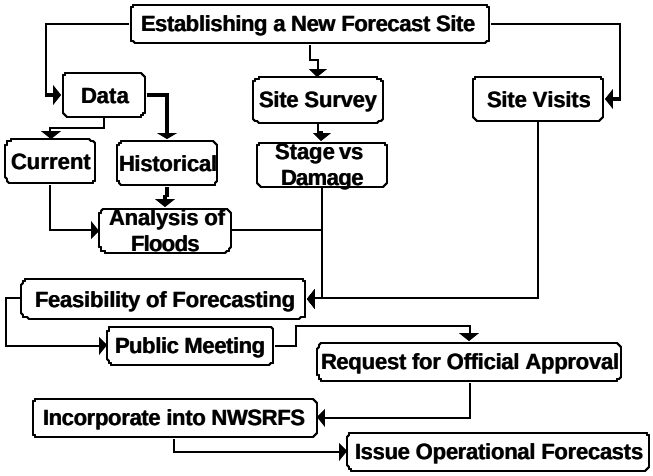

Figure 3. Forecast Point Establishment Process.

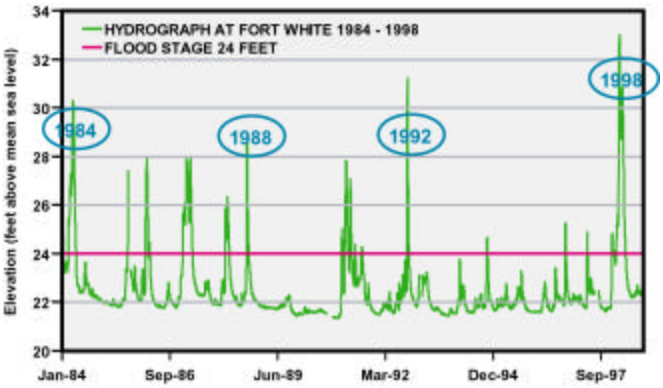

Figure 4. Santa Fe River Flood Events, 1984-1998.

Fe basin occurred in years 1984, 1988, 1992, and 1998 (Figure 4). In 1984, flooding was caused by strong El Niño conditions, while 1988 and 1992 were set off by tropical events. During the normally dry season in October 1992, 11 to 13 inches of rain fell in one weekend in the upper Santa Fe River basin. For the most recent flood event in February-March 1998, the highest water levels in 25 years on the Santa Fe occurred due to the prolonged rainfall caused by that year's El Nino event. Since 1998, the region has been affected by severe drought and flooding has not occurred.

Problems with flood forecasts in the middle Santa Fe basin first became apparent during the 1992 event. Extensive flooding occurred in the Hollingsworth Bluff reach of the river upstream of the NWS forecast site of TREF1, but forecasts for TREF1 were not issued until after the flood crest had passed the affected areas. Because the flood stage at TREF1 would not be reached until about 5 days after the crest at Hollingsworth Bluff, these forecasts were of no use for the upstream affected areas. Due to this and other instances, affected residents requested that the NWS establish a new river forecast site for the reach of the river near State Road 47 bridge. This forecast location would involve the use of the gaging site at FWHF1.

FLOOD PROCESSES IN THE SANTA FE BASIN

Analysis of the long-term stage data from the FWHF1 portrays the impact of two distinct types of flood events in the basin, one inherent to rainfall primarily in the Santa Fe basin and the second due to backwater effects from the Suwannee River. Figure 5 presents a stage-stage relationship for selected Santa Fe River floods between FWHF1 and the nearest downstream forecast site, TREF1. This illustration shows that most floods in the basin were backwater, or

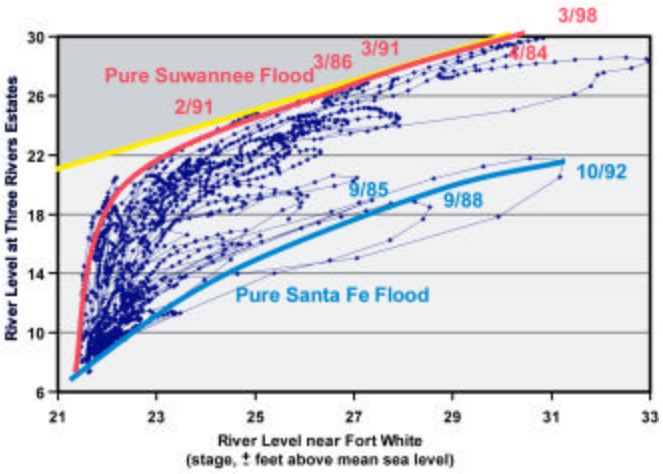

Figure 5. Flood types for Santa Fe River.

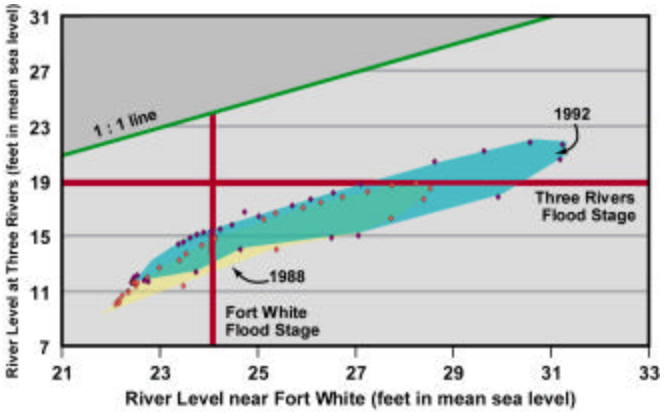

Figure 6. Comparison of Impacts for Two Flood Events.

Suwannee-induced events. However, it is also evident that the Santa Fe itself could produce significant flooding, typically during hurricane season. Further examination of FWHF1 data from 1984 to 1998 showed five tropical flood events that affected the Hollingsworth Bluff area that were not covered by existing forecasts.

For residents of Hollingsworth Bluff, the distinction between tropical and backwater flood events is significant, as can be seen in the stage-stage comparison of these gaging stations for two floods, September 1988 and October 1992 (Figure 6). The flood stage for TREF1 and a trial flood stage for FWHF1 are superimposed on the figure, as is the 1:1 line, which would imply that the slope of the river was 0 (flat) between the two gaging stations. Both events caused little impact on the lower Santa Fe River and flood stage was not even reached at TREF1 for one of the events. However, the magnitude and the rapid rise in upstream reaches resulted in significant damage and restriction of access to large riverine stretches during these events. Therefore, flood forecasting on this upper reach of the Santa Fe River became necessary.

RECOMMENDATIONS

Based on the data review and the field survey, two public meetings were held with area residents and emergency management officials in Columbia and Gilchrist counties to obtain input for final action stage and flood stage levels. As a result of feedback provided during these meetings, a final flood stage of 24 feet above mean sea level at FWHF1 gage (Santa Fe River near Fort White) was identified and recommended to NWS Southern Region Headquarters in Dallas, TX.

The next step is to make the forecast site part of the NWSRFS; an experimental simulation has been initiated until the model calibration can be completed. The high water levels which would allow testing of the performance of the current settings have been lacking in the basin since 1998. Because the Santa Fe River can be easily affected by backwater from the Suwannee River, the use of a hydraulic model has been recommended; it is expected that dynamic routing will be utilized by the SERFC for forecast modeling.

The stage-damage graphs developed for a forecast site could be transformed into a stage-cost graph, which would help to determine the cost of damage caused by different flooding. These figures could be reviewed and revised as necessary, particularly if further development has occurred in the area.

CONCLUSIONS

When evaluating the request for establishing a new forecast site, several aspects must be considered. The hydrologic analysis in a river basin, the type of storms affecting it, and the variation of the flow regime are fundamental to establish adequate forecast sites that will properly address the needs of the riverine population.

Site visits as well as the implementation of public meetings are essential tools to reinforce the analytical results about flooding impacts, by bringing individual and site-specific impacts into consideration. The knowledge of people who have experienced different floods in the proposed forecast area are invaluable; thus the discussion and information collected during these activities support the selection of the flood stage. Further, by encouraging the

participation of local Emergency Managers, additional 'action' stages that may facilitate flood preparation, such as Caution Stages, might be identified. This paper deals with some of these aspects, addressing the hydrological analysis in more detail.

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