Summary of Hurricane Ike on September 13 of 2008 over Brays Bayou

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October 16, 2008

Tropical Storm Ike was generated on September 3 and made its way westward to the U.S. Gulf Coast. In a single day, Ike transformed from a tropical storm into a powerful Category 4 hurricane on September 4. Ike emerged over the Gulf of Mexico on the afternoon of September 9 as a Category 1 hurricane after striking Cuba. The National Hurricane Center (NHC) issued the public advisory estimating that Ike would be an extremely dangerous Category 2 hurricane with sustained winds near 100 miles per hour on September 9. It was expected to re-intensified, possibly into a major hurricane, over warm Gulf waters as it moved toward Texas. The vast size is Ike's most notable feature to the public: the southern fringes of the storm touch Mexico's Yucatan peninsula, while the northern fringes hang over Louisiana.

On September 12, Hurricane Ike as a strong Category 2 storm with winds of 105 miles per hour, started pounding the Texas and Louisiana coast with high winds and battering waves even though the eyes of the storm remained well off shore. The NHC warned that despite the strong winds, the real danger associated with Ike was coastal flooding and large, damaging waves. It was also estimated that Ike could push water 20 to 25 feet above normal high tide levels, burying coastal regions by more than nine feet of water as much as a mile island. The surge was expected to extend over a wider distance than usual because of Ike's tremendous size. Stretching about 600 miles in width, Hurricane Ike made landfall at the island city of Galveston at about 2: 10 am on September 13, flooding thousands of homes in coastal areas.

On September 13, Hurricane Ike as a powerful storm made landfall from the Gulf of Mexico producing an extremely moist atmosphere; more than 8 inches of rain fell in some portions of the Greater Houston area in the next 24 hours. Nearly all parts of Harris County received at least six inches of rain, as did many surrounding counties. The records for September 13 from Harris County Office of Emergency Management (HCOEM) shows that the northwest of Houston along Whiteoak Bayou (7.29 inches), northeast of Harris County (12.99 inches), San Jacinto River area (10.59 inches) and Clear Creek area (9.69 inches) received highest rainfall during this event (Figure 1).

The Rice University/Texas Medical Center (TMC) Flood Alert System (FAS) was developed in 1997 and updated with FEMA funds in 2004. FAS has successfully provided important data for predicting flood levels along Brays Bayou for more than 40 major events since it was developed. The current version, called FAS2 uniquely utilizes higher-resolution radar (NEXRAD) data coupled with a real-time hydrologic model (RTHEC-1) and newly developed hydraulic prediction tool – FloodPlain Map Library (FPML). It has been tested during 2006 season with excellent performance and is being used as e a prototype for other flood-prone areas along the Gulf coast.

The FAS2 team began to watch Hurricane Ike moving towards the Gulf Coast on September 11. The north fringe of Ike reached Houston and started to rain over Brays Bayou at 9:45 p.m. on September 12. Table 1 reports details of FAS2 performance and bayou observation from USGS during the whole event. By 2:10 a.m. of September 13, when Hurricane Ike made landfall at Galveston, Brays Bayou only had a flow rate of 935 cubic feet per second (cfs). Because both Rice University and TMC experienced power failures during the early morning of September 13, and FAS2 could not be viewed on the available hardware. After being contacted by TMC, Dr. Bedient contacted Vieux & Associates, Inc. in Norman of Oklahoma for backup and provided TMC with data and information updates on the flooding status of Brays Bayou. After making landfall, Ike began to drop rainfall more steadily and intensively over Brays while moving north. NEXRAD radar estimated that this rainfall cluster dropped about 5.5 inches of water over the entire Brays Bayou watershed. At 9:30 a.m. of September 13, Brays Bayou reached its climax at 25,500 cfs versus the predicted value of 26,811 cfs. Rainfall clouds from the massive system diminished gradually over the Brays Bayou watershed right after the peak flow occurred in the bayou. By 1:40 p.m. of September 13, it was recorded that the whole rainfall event lasted for 15 hours, and the bayou water noticeably started to recede. The peak measured stage of Brays Bayou during this event was 41.02 ft while the maximum measured flow value was 25,500 cfs (See Table 1). We found out that the bayou water surface responded to this rainfall event very quickly by the fact that the water surface elevation at Main St. rose up from 30.67 ft to 41.02 ft within five hours.

At 3:20 a.m. of September 14, a cold front from the northwest began to come in over the Brays Bayou watershed with 6in/hr rainfall intensity in several cells. At 5:00 a.m., water surface started to rise up again. FAS2 predicted 12,729 cfs of peak flow occurred at 10:15 a.m. versus the USGS measured peak value of 13,100 cfs occurred at 9:15 a.m. The maximum measured stage value in this event was 32.94 ft (See Table 1). Since this event occurred twelve hours after the previous event, the bayou water did not reach as high as the previous peak stage. The total duration of this event is seven hours.

Table 2 with the Brays Bayou watershed illustration indicates the average radar rainfall totals from FAS2 from September 13 - 14, 2008, and clearly shows the middle reach of Brays (between Main St. and Gessner St.) received the highest rainfall total. Comparing with other watersheds in Harris County, the Brays Bayou watershed had relative less rainfall than others. This event can be categorized as a less than 5-year storm based on the 24 hour total NEXRAD estimated rainfall in the Brays Bayou watershed.

Figure 2 shows four images captured from FAS2 website about simulated and measured hydrographs for Brays Bayou at Main St. during this event. We found that both shapes of the hydrographs are very similar, and the simulated rising limb is off about one hour from the measured. Figure 3 shows a comparison between FAS2 prediction and USGS observed flow for this event. In summary, the double-peaked hydrograph produced from the tropical storm and the cold front is very unique and not easy to be predicted in advance. FAS2 comparisons were some of the best ever computed by the system over the past 10 years.

Table 1: Detailed Report of Rainfall Progression Over Brays Bayou

September 12/12pm –September 14/12pm, 2008

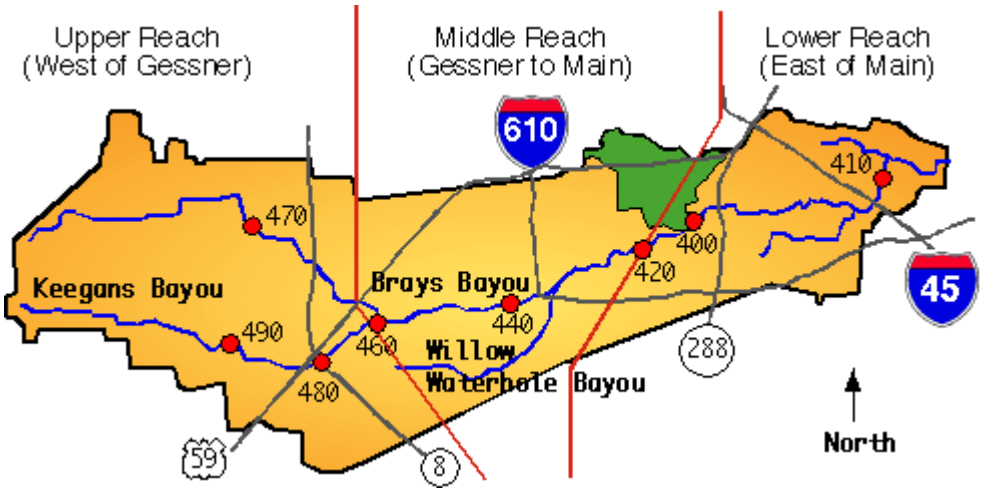
Time	Cumulative Rainfall (in)	FAS2 Predicted Flow (cfs)	USGS Measured Flow (cfs)	USGS Measured Stage (ft)
9/13/2008 2:10 am	0.35	1,150	935	19.06
9/13/2008 4:00 am	1.39	4,594	4,740	25.00
9/13/2008 5:00 am	2.05	10,000	10,300	30.67
9/13/2008 6:30 am	3.46	16,902	16,800	35.65
9/13/2008 7:30 am	4.63	22,707	21,800	38.43
9/13/2008 9:30 am	5.51	26,811	25,500	41.02
Maximum in first peak		**26,811**	**25,500**	**41.02**
9/14/2008 3:20 am	5.98	1,538	1,850	20.93
9/14/2008 5:00 am	6.28	3,940	2,240	21.60
9/14/2008 8:00 am	7.52	10,523	9,570	30.02
9/14/2008 10:15 am	7.69	12,729	13,100	32.94
Maximum in second peak		**12,729**	**13,100**	**32.94**

Table 2: Peak NEXRAD Rainfall over Brays Bayou

September 12/12pm – September 14/12pm, 2008

Duration	All of Brays	Lower Brays (East of Main)	Middle Brays (Main to Gessner)	Upper Brays (West of Gessner)	Upstream of Main (West of Main)
Max 1 hr (in)	0.98	1.08	1.08	1.15	1.02
Max 3 hr (in)	2.87	2.99	2.78	3.14	2.99
Max 6 hr (in)	4.81	5.29	4.90	4.47	4.65
Max 12 hr (in)	5.72	6.38	5.77	5.32	5.50
Max 24 hr (in)	5.98	6.68	6.03	5.51	5.73
9/12 total (in)	0.12	0.17	0.14	0.06	0.09
9/13 total (in)	5.86	6.51	5.88	5.46	5.63
9/14 total (in)	1.71	0.96	2.36	1.69	1.97
Total (48hrs)	**7.69**	**7.64**	**8.38**	**7.21**	**7.69**

Each number represents the maximum cumulative rainfall for the duration listed on the left and the region listed above.


Upper Reach
(West of Gessner)
Middle Reach
(Gessner to Main)
Lower Reach
(East of Main)
610
45
288
59
8
470
490
480
460
440
420
400
410
Keegans Bayou
Brays Bayou
Willow
Waterhole Bayou
North

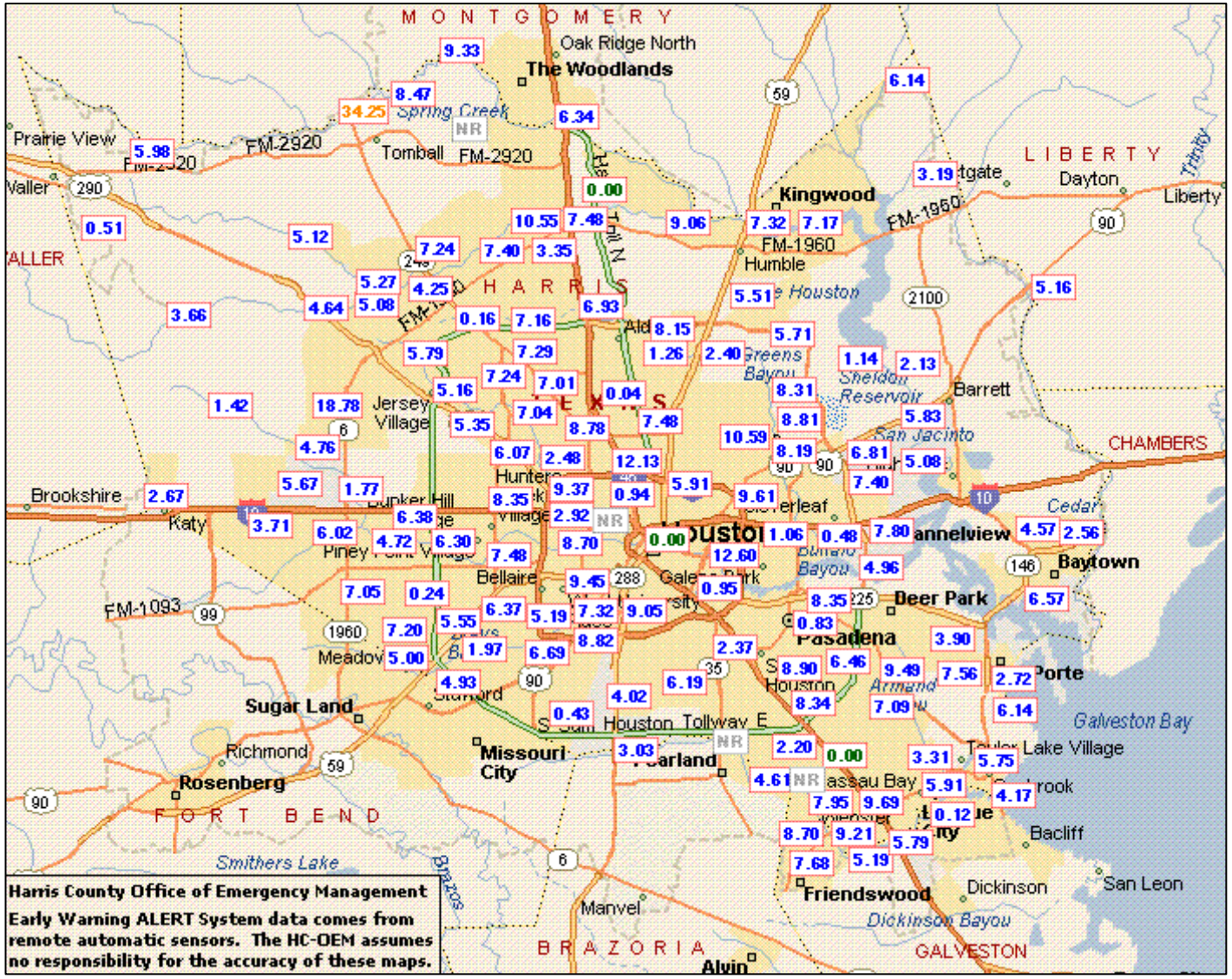
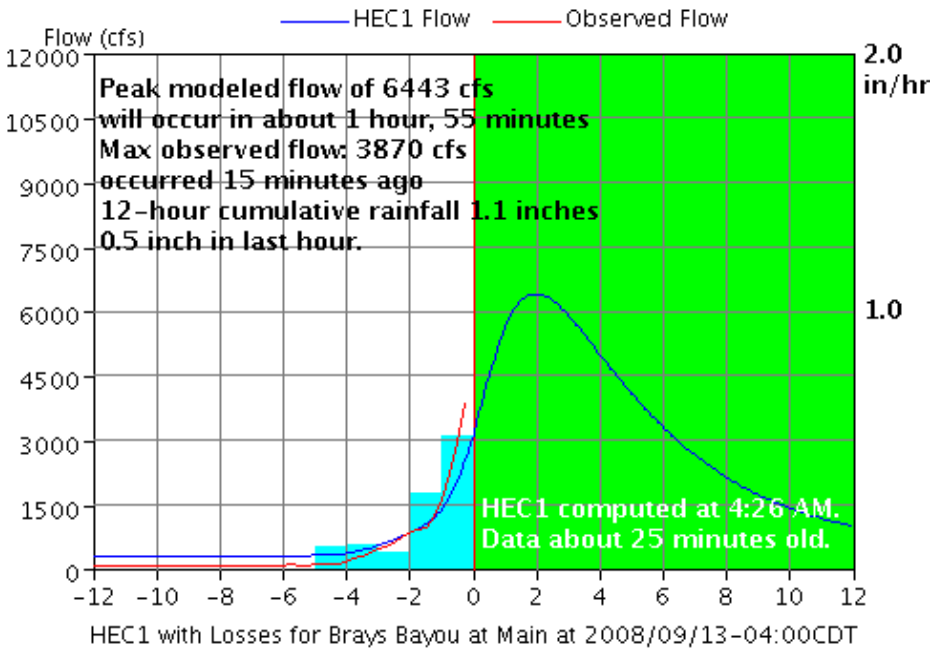
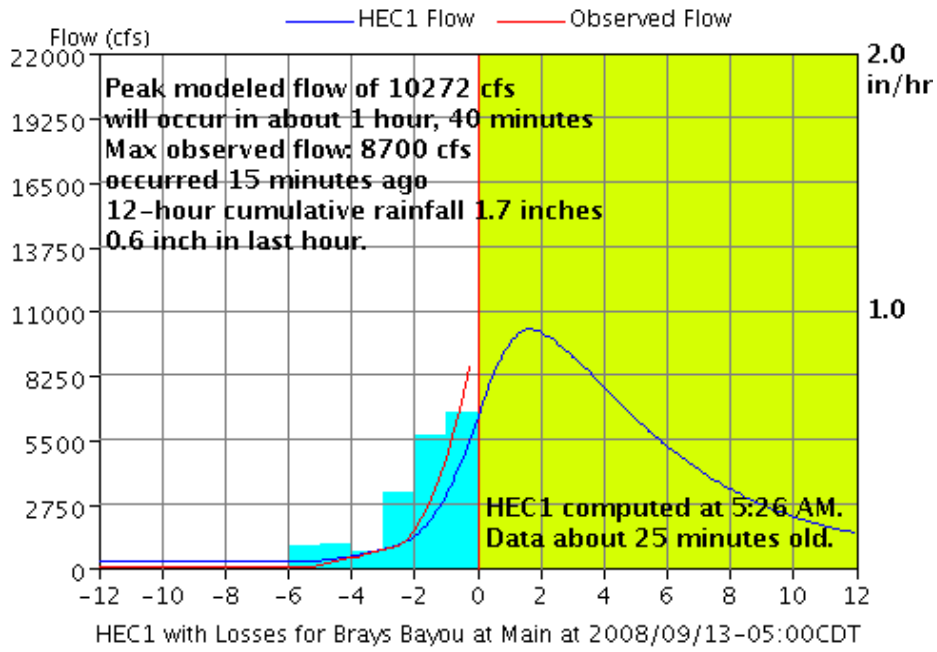
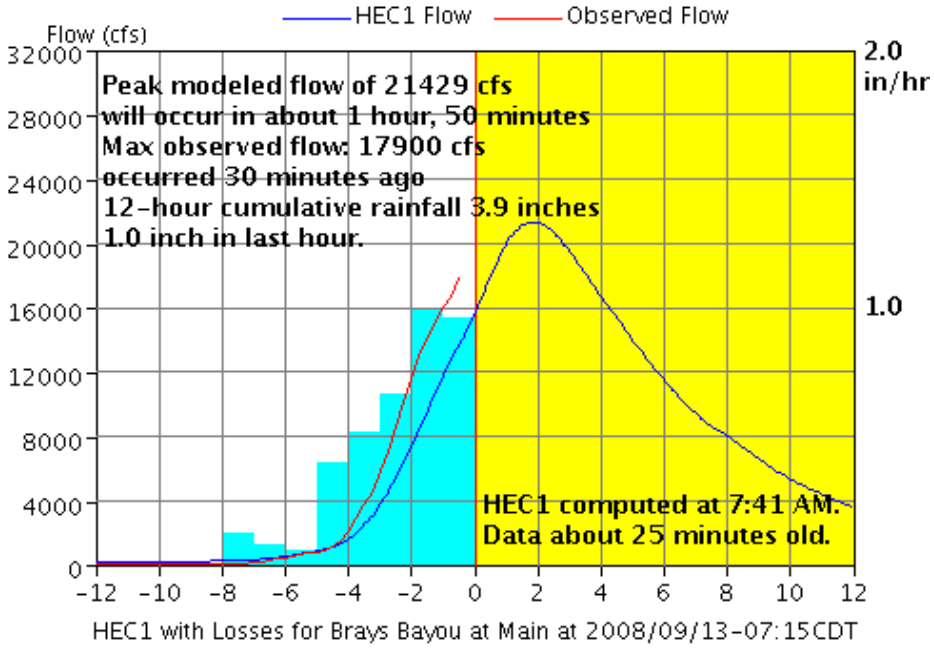


Figure 1 HCOEM Observed Total Rainfall during Hurricane Ike on September 13 of 2008







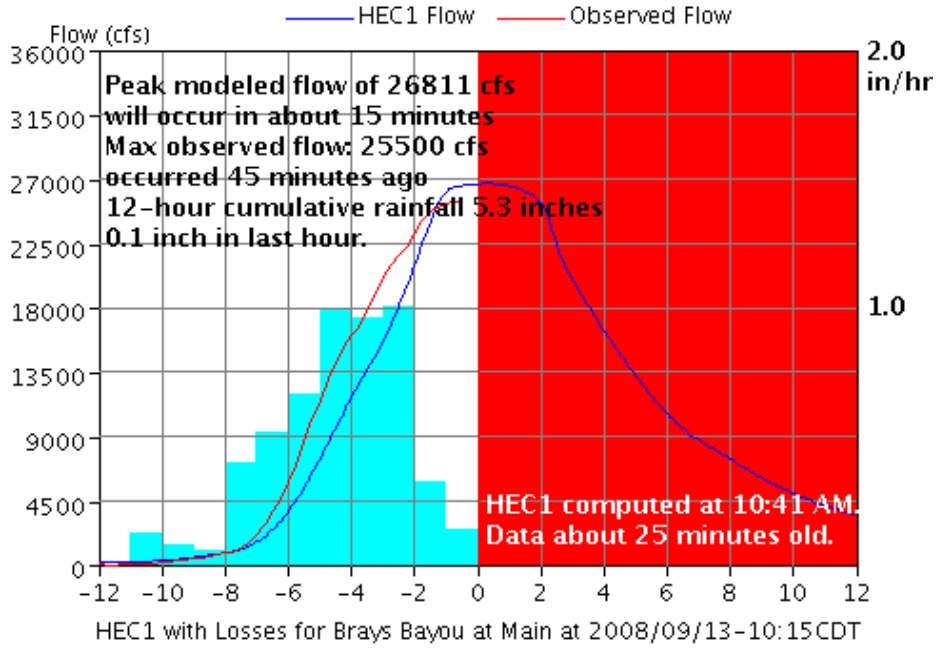


Figure 2 Images Captured from FAS2 Web about Simulated and Observed Hydrographs during Oct 15-16, 2006

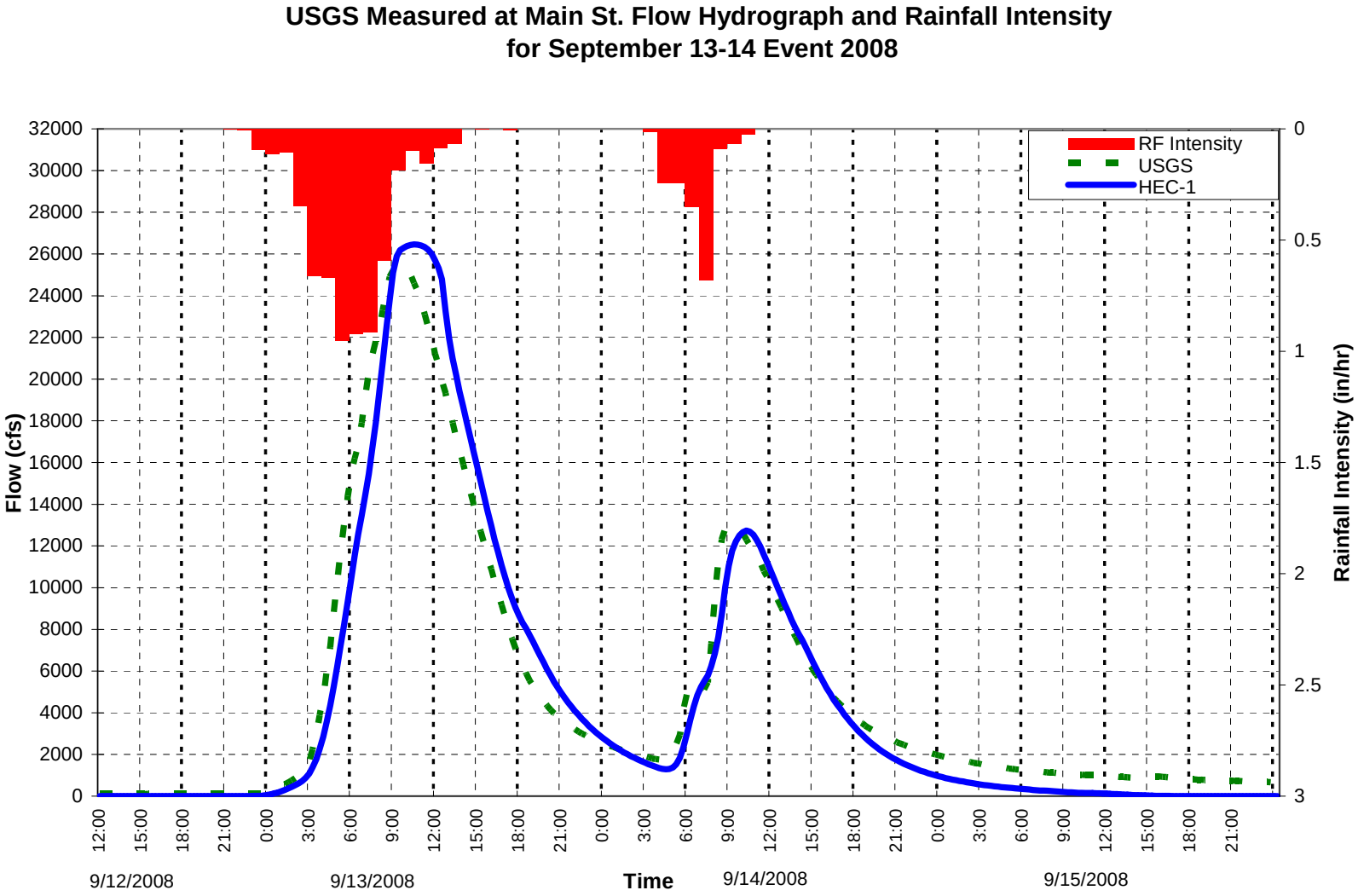


Figure 3 Comparison of Prediction and Observation during September 13 -14, 2008