

## Houston Ground Elevation with Street Flooding During Hurricane Harvey

M. Sai Anudeep Reddy and C. Vipulanandan, Ph.D., P.E.

Texas Hurricane Center for Innovative Technology (THC-IT)

Department of Civil and Environmental Engineering

University of Houston, Houston, Texas 77204-4003

E-mail: srmaddi@uh.edu, cvipulanandan@uh.edu Phone: (713) 743-4278

**Abstract:** In this study, the effect of hurricane Harvey rainfall street flooding was studied along the I10 from Sealy to Baytown for a length of about 73 miles. In this study, the ground elevation pattern was compared with street flooding and rainfall amount. Zip codes from Hurricane Harvey Survey with street flooding are also compared with the elevation. The elevation from Sealy to Baytown varied 54.8 m to 7.58 m above sea level with a total horizontal distance of 73 miles. The amount of rainfall was 30 to 40 inches from Sealy to intersection of I-10 and I-69, and more than 40 inches beyond I-10 and I-69. The street flooding mostly occurred from about 13.4 miles from Sealy to Baytown, at an elevation of about 46 m above sea level. Maximum street flooding occurred in regions with an elevation of less than 8 m and with a rainfall greater than 40 inches.

### 1. Introduction:

The hurricane Harvey caused the second largest loss of over \$125 billion compared to Katrina in 2005. Hurricane Harvey, a category 4 storm that hit Texas on August 25, 2017 caused about \$125 billion in damage affecting about 13 million people from Texas through Louisiana, Mississippi, Tennessee, and Kentucky [1]. Harvey started as a typical weak August tropical storm that affected the Lesser Antilles and dissipated over the central Caribbean Sea. However, after re-forming over the Bay of Campeche, Harvey rapidly intensified into a category 4 hurricane (on the Saffir Simpson Hurricane Wind Scale) before making landfall along the middle Texas coast. The storm then stalled, with its center over or near the Texas coast for four days, dropping historic amounts of rainfall of more than 60 inches over southeastern Texas.

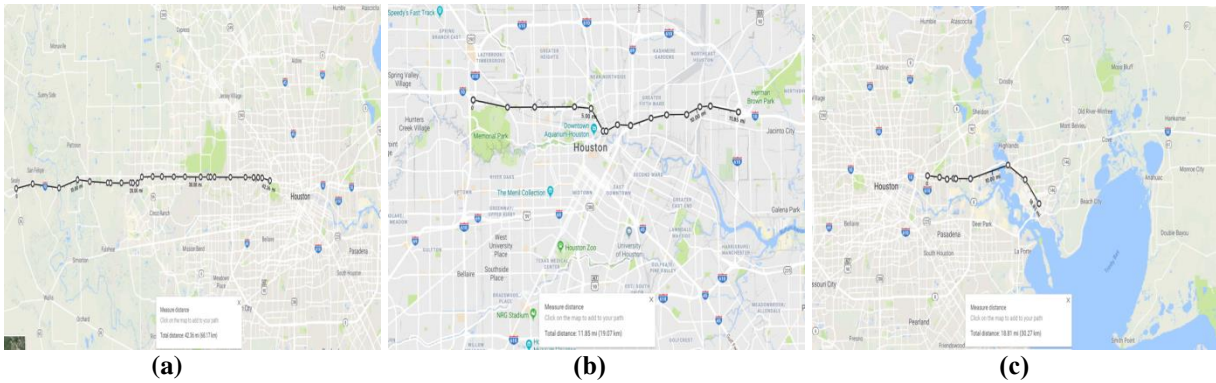
These rains caused catastrophic flooding, and Harvey is the second-most costly hurricane in U.S. history, after accounting for inflation, behind only Katrina (2005). At least 68 people died from the direct effects of the storm in Texas, the largest number of direct deaths from a tropical cyclone in that state since 1919 [2]. More than 20 trillion gallons of rain water caused the damage and losses. This amount of water could cover three biggest states in the country, Alaska, California, Texas by an inch of water. Harvey had the record of total rain fall, record economic loss, recorded to be one of the strongest that hit US [3]. The rainfall amounts across the Houston area rank as roughly a 1,000-year event. This does not mean that it will be 1,000 years before the next flood of this magnitude occurs. With climate change shifting the odds in favour of extreme rainfall events, return period calculations like this are becoming less useful to civil engineers who must design infrastructure to withstand historical floods. The three flooding in Houston 2015 Memorial Day flooding, 2016 – April flooding and 2017 hurricane flooding. In 2015 flooding, Houston had about 12 inches in 10 hrs, 2016 Houston had about 15 inches in 24 hrs while in 2017 about 52 inches in 5 days with 26 inches in 24 hrs at some locations. In fact, the numbers of downpours measuring at least 10 inches have doubled over the last 30 years. There is need to investigate reasons for consequent serial flooding of Houston region through the years.

**2. Objective:** The main objective was to compare the effect of ground elevation on the Houston area street flooding and the amount of rainfall during Hurricane Harvey.

### 3. Method:

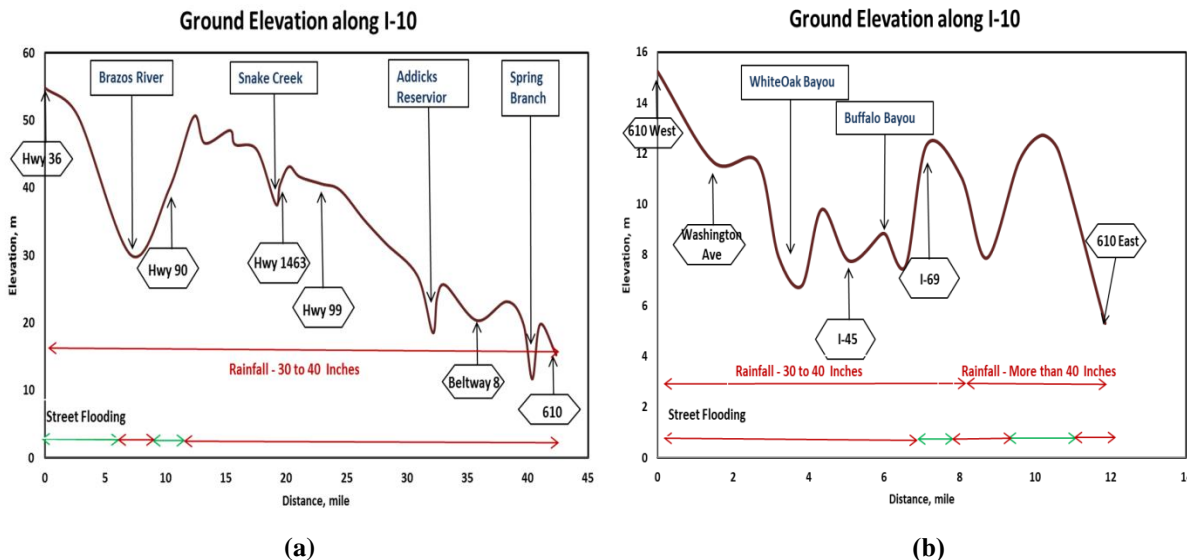
The study was conducted along the interstate highway 10 (I-10) starting from Sealy (Intersection of I-10 and Highway 36 at Sealy) to Baytown for a total distance of 73 miles. The elevation along I-10 is obtained at about 54 points using Elevation service from Google Maps Platform (Fig.1). The rainfall data for Hurricane Harvey is obtained from Harris county flood control district. The data of street flooding is

obtained from Texas Hurricane Center Hurricane Harvey Survey and Hurricane Harvey water Extent Tool from ArcGIS.



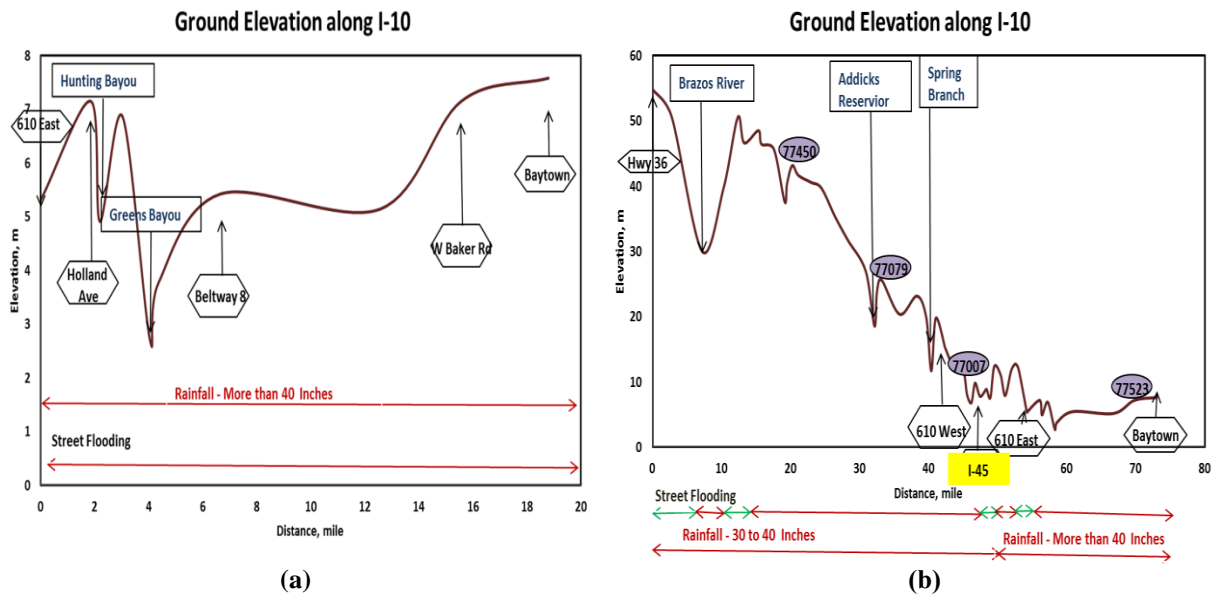
**Figure 1: Data points taken along I-10 (a) From Sealy to 610 west, (b) 610 West to 610 East and (c) 610 East to Baytown**

**4. Results and Discussion:**



**Figure 2: Ground Elevation with rainfall and street flooding along I-10 (a) From Sealy to 610 West, (b) 610 West to 610 East**

The ground elevation at Sealy (Intersection of I-10 and Highway 36 at Sealy) was about 54.8 m while the ground elevation at 610 west dropped to 15.23 m. The region from Sealy to 610 West had a rainfall of 30 to 40 inches with partial street flooding (Fig. 2(a)). The ground elevation reduced from 15.23 m to 5.3 m along I-10 from 610 West to 610 East. The amount of rainfall was 30 to 40 inches from Sealy to I-69 intersection, and more than 40 inches between I-69 and I-610 East. The regions close to 610 West showed complete flooding due to the flooding of Buffalo Bayou. There were regions close to 610 East with rainfall greater than 40 inches and no street flooding. This was partly due to higher elevation between Buffalo Bayou and I-610 East (Fig. 2(b)).



**Figure 3. Ground Elevation with rainfall and street flooding along I-10 (a) From 610 east to Baytown, (b) Sealy to Baytown**

The elevation between 610 East and Baytown was almost constant varying from 5.3 m to 7.58 m. This region had rainfall greater than 40 inches and had street flooding occurring all the way (Fig. 3(a)). The street flooding mostly occurred from about 13.4 miles from Sealy to Baytown, at an elevation of about 46 m above sea level. Maximum street flooding occurred in regions with an elevation of less than 8 m, with a rainfall greater than 40 inches which include zip codes 77450, 77085, 77002 and 77523. (Fig. 3(b)).

**5. Conclusion:**

The elevation from Sealy to Baytown varied 54.8 m to 7.58 m above sea level with a total horizontal distance of 73 miles. The street flooding mostly occurred from about 13.4 miles from East of Sealy to Baytown, starting at an elevation of about 46 m above sea level. Maximum street flooding occurred in regions with an elevation of less than 8 m and with a rainfall greater than 40 inches.

**6. Acknowledgements:**

This study was supported by the Texas Hurricane Center for Innovative Technologies (THC-IT), University of Houston, Houston, Texas.

**7. References:**

1. Kimberly Amadeo, “Hurricane Harvey Facts, Damage and Costs- What made Harvey so Devastating”, US Economy, the Balance, 2018.
2. Eric S. Blake, David A. Zelinsky, “Hurricane Harvey”, National Hurricane Center Tropical Cyclone Report, 2018.
3. Devika Krishna Kumar, “Harvey’s effects on fuel network hit U.S. motorists as gas prices rise”, Environment, Reuters, 2017.
4. “Historic Disaster Response to Hurricane Harvey in Texas”, FEMA, 2017.