Element 352, WEB1

"Know Your Flood Hazard"

(Detailed Coverage of Priority Topic 1)

Tidal and fluvial flood hazards may occur in the City of Rahway during extreme weather events. Tidal flooding is caused by the passage of severe coastal storms, such as nor'easters and tropical storms. Fluvial flooding, which may occur alone or in combination with tidal flooding, is caused by excess runoff during severe rainfall events.

Flood hazards occur when the carrying capacities of rivers and streams are exceeded -- inundating adjacent, low-lying areas. These include areas adjacent to the main-stem Rahway River, its Robinson's Branch and its South Branch. Also, flooding may occur in small tributaries and lakes, such as Orchard Street Brook, Maurice Avenue Brook, Allen Street Brook, Milton Lake, and around Rahway River Park.

Fluvial flood hazards are exacerbated by the City's downstream location. The upstream Rahway River drains a large and densely developed watershed that contributes high flows during intense rainfall events. Figure 1 illustrates the Rahway River Basin, as delineated and described in a recent study by the U.S. Army Corps of Engineers[1]. This urbanized watershed extends approximately 18 miles and has an area of 83.3-square-mile (53,300-acre).

The headwaters of the Rahway River start at the East and West Branch. The Branches merge into the main stem Rahway River at Springfield and Union Township and flows south, for approximately 2.5 miles, from I-78 to Route 22. From this point it flows directly into Cranford, Winfield, and Clark Township, meeting with the Robinson's Branch in the City of Rahway. Robinson's Branch runs through Clark and Rahway, and is impounded at Middlesex Reservoir and Milton Lake. Approximately half a mile downstream of the confluence of Robinson Branch with the Rahway River is the confluence with South Branch. South Branch has head waters in Edison at Roosevelt Park and runs eastward, through Iselin and Colonia, to meet the main stem in the City of Rahway. Thus, flood waters are contributed from a vast and "flashy" watershed, and a regional approach is needed to address the City's fluvial-flood problems[2].

Approximately 4.5 miles downstream from the confluence of the Rahway River and South Branch is the mouth of the Rahway River (in Carteret and Linden) and the Arthur Kill tidal strait. Within Rahway City limits, nearly all of the main-stem Rahway River, and South River, are influenced by storm tides. Also influenced are reaches of the Robinsons Branch downstream from the Milton Lake Dam. The tidal reaches of the lower Rahway River system are displayed (in red) in Figures 1 and 2 below (reproduced from the Army Corps reports). The lower Rahway River has numerous flow constrictions along its winding path to the Arthur Kill, which may also exacerbate fluvial flooding.

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1 https://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/nj/frm/Rahway/Tidal/Rahway%20CSRM%20EconomicsAppendixB.pdf?ver=2017-05-31-121300-603

2 https://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/nj/frm/Rahway/Tidal/Rahway%20CSRM%20HydrologyAppendixCI.pdf?ver=2017-05-31-121427-543

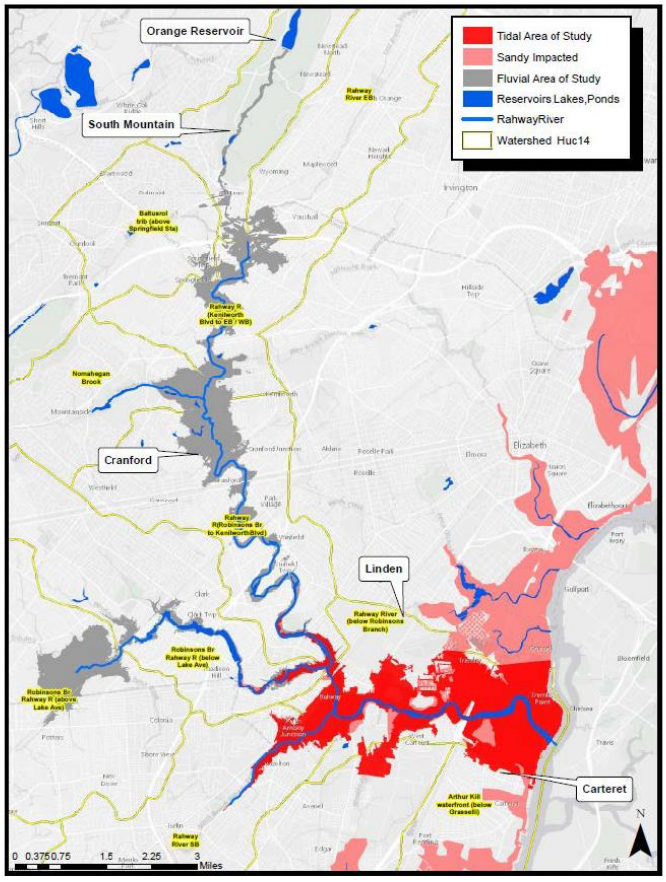

Figure 1: Rahway River Watershed Area

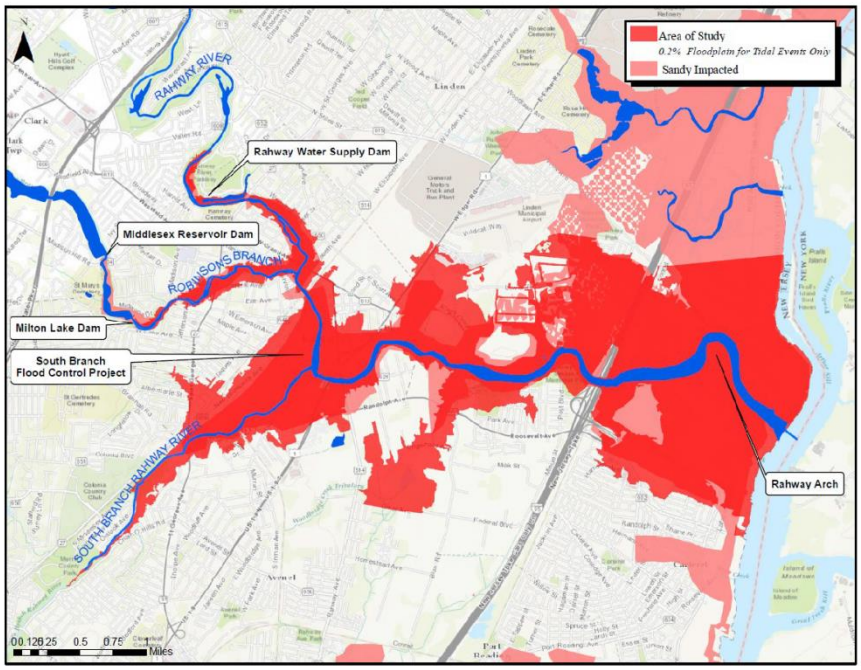

Figure 2: Rahway River Tidal Area

The U.S. Army Corps of Engineers has assessed historical storms and flooding impacts in the Rahway River basin, as summarized below. The fluvial flood of record is Tropical Storm Irene, which occurred on August 28, 2011 following previous rain storms. Record rainfall occurred during Irene, including 10.00 inches in Wayne, New Jersey. The flooding affected roads, including the heavily used Interstate 287 in Boonton where the northbound shoulder collapsed, the Garden State Parkway which flooded in Cranford from the Rahway River (USACE 2017). Peak flows of 8,620 cfs were recorded at the Rahway USGS gage. The corresponding recurrence interval for fluvial flows during Irene was over 100 years, and it was accompanied by a moderate (5-year) tidal flooding event.

Another major fluvial flood event occurred on September 15, 1999 (Tropical Storm Floyd). Within the Rahway River basin, the total rainfall at Cranford, NJ was 10.82 inches. Tropical Storm Floyd produced a peak flow of 5,590 cfs at the Rahway USGS gage.

Other notable storms which have caused Rahway River flooding occurred on20-24 September 1882, 30 July 1889, 31 July 1901, 25-26 August 1933, March 1936, 17-25 July 1938, 6-8 August 1938, 17-21 September 1938, 9-16 August 1942, 20 May 1943, 18 September 1945, 28 June 1946, 23-25 July 1946, 8 November 1947, August 1955, October 1955, September 1960, 12-13 March 1962, 21-22 September 1966, 28-29 May 1968, 26-28 August 1971, 13 September 1971, 2-3 August 1973, July 1975 and November 1977 (USACE 2016).

Tidal flooding is caused by coastal storms that propagate along the east coast during nor'easter and tropical storm/hurricane events. Tropical storms and hurricanes are warm-core, cyclonic systems that draw energy from ocean evaporation. Hurricanes pile up water against the coastline, and raise tide levels above normal ("storm surge"). While it has not occurred over the last century, a severe flood hazard (and wind damage) may occur if a hurricane's core region (of maximum winds) tracks near the City.

Nor'easters are large-scale, cold core, cyclonic systems that usually form in areas where strong surface temperature gradients coincide with a strong jet stream aloft. Intense winds generated by nor'easters also pile up water against the coastline -- especially when their passage stalls along the coast. Other factors contributing to such storm surges include falling atmospheric pressure levels, mildly sloping coasts and "setup" due to breaking waves.

The most extreme tidal flooding event occurred in 2012 during Super Storm Sandy, which transitioned from a large hurricane to an intense extra-tropical (nor'easter) storm that veered towards New Jersey. During Sandy, the U.S. Geological Survey measured a peak tidal elevation of 13.4 feet NAVD88 in the Arthur Kill (at Perth Amboy, NJ). The maximum recorded water level for the NOAA tide gage at Bergen Point West Reach, NY, which reflects the hydraulic conditions at the mouth of the Rahway River, was measured as 14.57 feet NAVD88 at 8:30 pm EDT. This storm tide level corresponds to 9.56 feet of storm surge above the predicted tide height[3].

[3] https://www.nan.usace.army.mil/Portals/37/docs/civilworks/projects/nj/frm/Rahway/Tidal/2020/Rahway%20Final%20FREA%2020200403.pdf?ver=2020-04-06-113140-243

Low-lying areas along the Arthur Kill and Lower Rayway River were inundated during this Storm. Figure 3 displays the peak extent of tidal flooding in Rahway during Super Storm Sandy based on storm tide measurements collected by the U.S. Geological Survey and Rutgers University's NJFloodMapper web portal (https://www.njfloodmapper.org/). Based on published scientific analyses conducted by NOAA, Super Storm Sandy corresponded approximately to a 295-year coastal storm event at Sandy Hook, New Jersey.

Besides Super Storm Sandy (2012), Rahway has experienced several lesser historic coastal storms in recent decades, including Hurricane Donna (1960); the Great Nor'easter of December 1992, and Tropical Storm Irene (2011). Figure 4 compares peak water levels for the ten highest recorded storm tides at NOAA's gaging station at the Battery, where peak storm tides are typically about 10% lower than in the lower Rahway River. Figure 4 suggests that the highest historic storm tides were about 3-4 feet lower prior to Super Storm Sandy. In Rahway, this corresponds to storm tide elevations of approximately 9 feet NAVD88. Thus, these less severe coastal storm events – which occur at around decadal time scales -- also caused flooding in low-lying areas of the City (i.e., where ground elevations are less than about 9 feet, NAVD88).

In the referenced studies conducted by the U.S. Army Corps of Engineers, the following tidal-flood-prone areas were identified. The confluence of the Rahway and South Branch Rivers at Edgar Road Bridge begins street flooding at a 2-year tidal-flood event by Essex Street in Rahway. Significant damages begin at the 10-year event, including the automotive businesses and residences, without raised foundations, between Route 1 and Milton Avenue. South Branch starts producing minimal damages to industrial areas at the 10-year flood at St. Georges Avenue and Elliot Street. Street flooding and residential damage in South Branch begins at the 50-year event at Leesville Avenue. Levee overtopping at South Branch and Rahway River currently begins slightly above the 100-year event. For future conditions that include some increase in flow and sea level, the levees will be overtopped before the 100-year event. Robinson's Branch has street flooding beginning at the 50-year event at the intersection of Central Avenue and St. Georges Avenue and at Hamilton Avenue. Significant damages beginning at the 5-year event occurs at the confluence with the Rahway River near the Rahway Arts District.

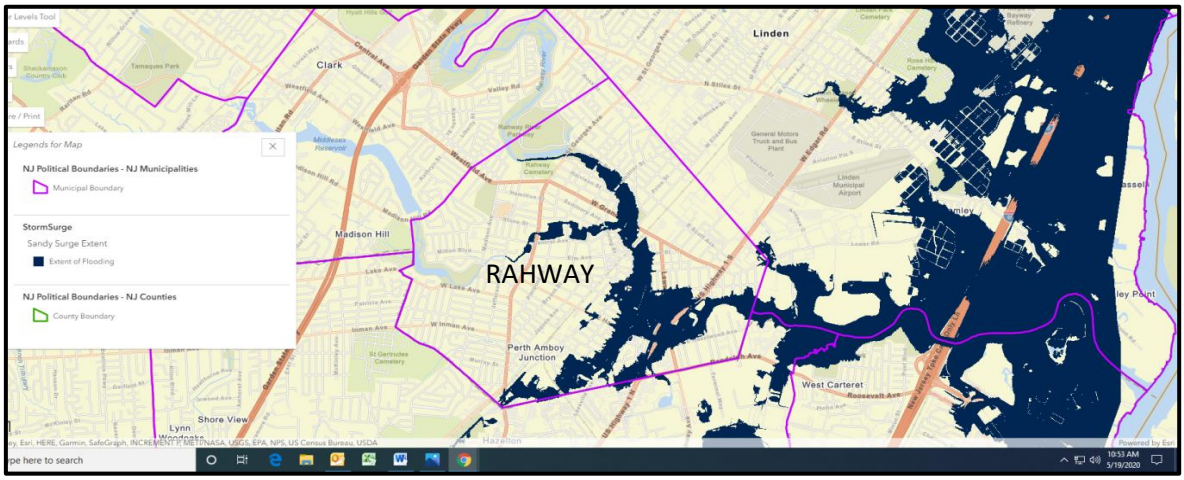

Figure 3: Super Storm Sandy Inundation Map (Source: USGS and NJfloodmapper.org)

The U.S. Army Corps analysis also reveals that the most severe fluvial flood events were not accompanied by the most intense coastal storms. That is, the available historical records indicate that 100-year fluvial flood events like Irene and Floyd have not occurred jointly with historic coastal storms like Sandy.

One of the best resources for determining flood risk in a jurisdiction (UCAHMP 2016) is Flood Insurance Rate Maps (FIRMs), which are produced by FEMA. The FIRM is the official map of a community on which FEMA has delineated both the special flood hazard areas (1% annual chance of flooding) and the risk premium zones applicable to the jurisdiction. The effective FIRM date for Union County is September 20th, 2006. The effective FIRM is the official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community. The DFIRM data released in 2006 included updates to the Flood Insurance Study (FIS) based on revised hydrologic and hydraulic analysis for the Rahway River that was completed in March 2006. This map is shown in Figure 5 below.

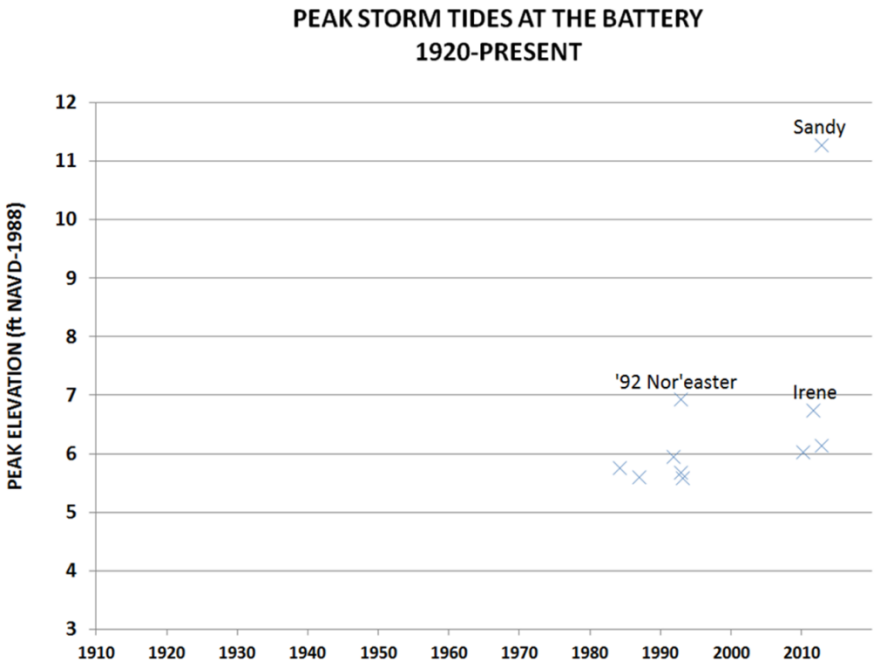

Figure 4: Historic peak storm tide elevations at the Battery

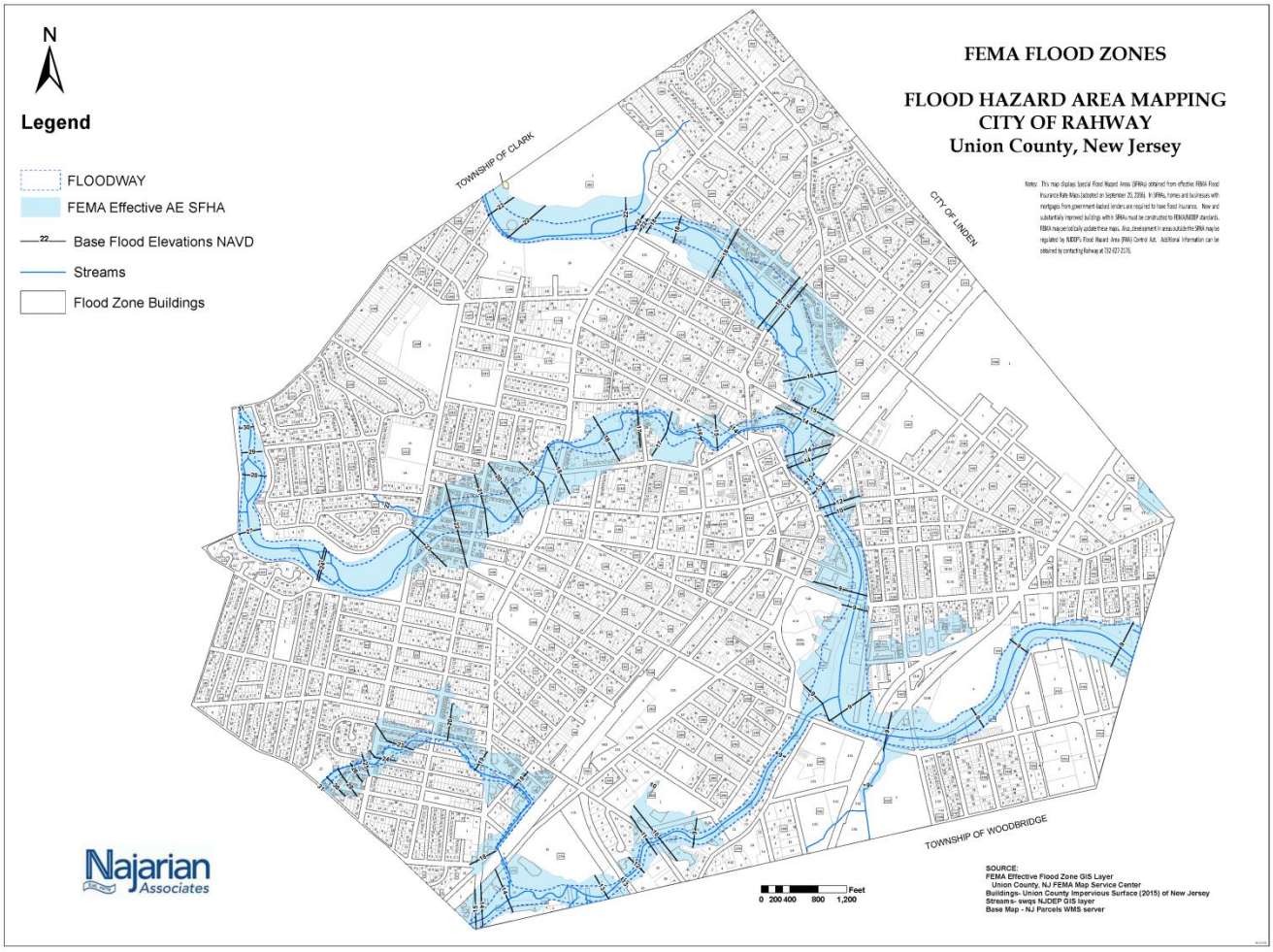

Figure 6: Effective FEMA Flood Insurance Rate Map for Rahway City