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Evaluation of vulnerability to floods of Glynn and Gwinnett Counties, Georgia USA

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Abstract

A systematic investigation was performed to evaluate the areas of inundation in Gwinnett and Glynn counties in Georgia, USA. To identify areas where benefited from the flood protection, 100-year, 200-year and 500-year of riverine flooding and previous hurricanes data were adopted for Gwinnett county and Glynn county, respectively. HAZUS 4.2 (Hazard United States) (FEMA, 2018), and ArcGIS 10.5 (Aeronautical Reconnaissance Coverage Geographic Information System) were used to identify the flooded areas, and this study evaluates the vulnerability of essential facilities (i.e., treatment plants and electric power facilities). It is observed that several wastewater treatment plants in Gwinnett County could be impacted by at least the100-year flood. The electrical power facilities in Glynn County are also found to be vulnerable to hurricanes. This evaluation can be used as the first step to develop more resilient counties by having better preparedness, Stormwater Management Plan, and more organized responses to flood events.

Keywords: HAZUS, ArcGIS, Vulnerability, Riverine flooding, Stormwater management plan.

Introduction

For coastal communities, the economic, social, and physical scars left behind by floods are devastating. A flood is one of the most dangerous natural disasters, and it happens when excessive water collects in one area[1]. Usually, the Gwinnett County gets 49.63 inches of rain per year according to the National flood Insurance Program. Its research has indicated that Gwinnett County has had eighteen floods occurrences records since 1995[2]. The research also indicates that the occurrence of flood has the potential to cause wreak havoc to the community. Statistically, the county can experience flooding every nine years, which equals to an 11 percent chance of flooding occurring in any given year[3]. A good example is the September 16 to 22, 2009 floods which caused flooding in rivers and rainfall-runoff due to long period of rainfall[4]. Eighteen Steam gages in the metropolitan Atlanta had flood magnitude higher than the estimated 0.2 percent by 500 years annual exceedance probability[5]. The Federal Emergency Management Agency (FEMA) reported 23 counties in Georgia as disaster areas due to the floods, which affected approximately 20,000 homes and structure with ten fatalities in Georgia[6]. U.S. Dept. of the Interior and U.S. Geological Survey reported that the property loss is approximately 193 million dollars[7].

Gwinnett County lies within the upper limit of three major watersheds, the upper Chattahoochee, the Oconee, and the Ocmulgee[8]. Also, Glynn is bounded to the north by Altamaha River and Mclntosh River, the east by the Brantley and Wayne counties[9]. The two counties lie within a series of barriers and are part of the Georgia Coastal Plain[10]. The geographical location of the two counties without a doubt makes them vulnerable to floods caused by a strong surge which occurs from tropical cyclones such as hurricanes, tsunamis and nor'easter in the northern hemisphere due to storms along the Coast of North America[11]. As a coastal county, the area is very flat, and drainage can be a problem. Further, due to the historic gradual formation by receding ocean and flooding over the years, the soil in this area is primarily sedimentary composed of sand and mud[12]. Further, Gwinnett County is the second most populated county in Georgia[15]. As the level of development increase with an increase in population in threat of floods increases[14]. Due to an increase in impervious surfaces, causes floods in places that did not previously exist, which results in higher vulnerability to floods[15,16].

In summary, we cannot prevent natural causes like rain and floods. However, we can minimize the devastating effects left behind by these floods, including loss of life and destruction of billions of dollars[17,18]. Therefore, these study objectives are to investigate the vulnerability of Gwinnett and Glynn Counties, which were affected by historic floods. Also, the study will examine the vulnerabilities and consequences of the distraction of essential facilities, such as electric power facilities and wastewater treatment plants, by flooding events in the two counties.

Methodology

HAZUS (Hazard United States) is a nationally applicable standardized risk assessment methodology developed by FEMA

(Federal Emergency Management Agency). The program adopts Geographic Information Systems Technology (ArcGIS 10.5) to evaluate physical, economical, and social impacts of floods, hurricanes, earthquakes, and tsunamis as well as visually show the effects of each disaster.

This study ran 100-year, 200-year, and 500-year riverine flooding scenarios in Gwinnett County and ran coastal flooding caused by hurricanes Irma and Michael in Glynn County. For these simulations, DEM (Digital Elevation Model) was used to provide a representation of the terrain surface created from a terrain's elevation data which is provided by USGS (United States Geological Survey).

Riverine Flooding in Gwinnett County: This study developed a stream network with segments of 1 square mile, which were used for the hydrologic analysis. Figure-1 shows terrain surface and locations of electric power facilities and wastewater treatment plants in Gwinnett County. 100-year, 200-year, and 500-year riverine flooding scenarios comprised this study. HAZUS calculated flood depths and floodplains for three different return period floods on the selected reaches in Gwinnett County. This study incorporated the information of locations for wastewater treatment plants and electric power facilities which should be protected from flooding with the floodplains delineated to investigate their vulnerabilities.

Coastal Flooding caused by Hurricane in Glynn County: Figure-2 represents terrain surface, shoreline, locations of power facilities and wastewater treatment plants in Glynn county. The initial water elevation is required to run Hurricane Model in HAZUS, and HAZUS manual suggests to estimate the initial water level by using NOAA tide forecasts plus pre-storm tidal anomaly (NOAA, 2013). The averaged water level was calculated using the predicted data by NOAA during the hurricanes Michael and Irma. The difference between observed and predicted tidal elevations of two days before the hurricane landfall was also calculated. The predicted and observed water elevation data at Fort Pulaski NOAA station was used because this station was available to store tidal elevation data during the hurricanes near the affected area. Figures-3 and 4 represent the predicted and observed tidal elevations at Fort Pulaski NOAA station during Hurricane Irma and Michael, respectively.

Figure-3 represents predicted and observed tidal elevations during hurricane Irma (from 9/11/2017 to 9/12/2017) at Fort Pulaski NOAA station. The averaged predicted tidal elevation during the hurricane was 3.63 feet, and the difference between the forecast and the observed water level two days before landfall was 0.40 feet. The initial water level was calculated as 1.27 feet, and this value was used to run hurricane model of HAZUS.

Figure-4 shows predicted and observed tidal elevations during hurricane Michael (from 10/10/2018 to 10/12/2018) at Fort Pulaski NOAA station. The averaged predicted tidal elevation during the hurricane was 0.19 feet, and the difference between the forecast and the observed water level two days before landfall was 0.73 feet. The initial water level was calculated as 0.92 feet, and this value was used to run hurricane model of HAZUS.

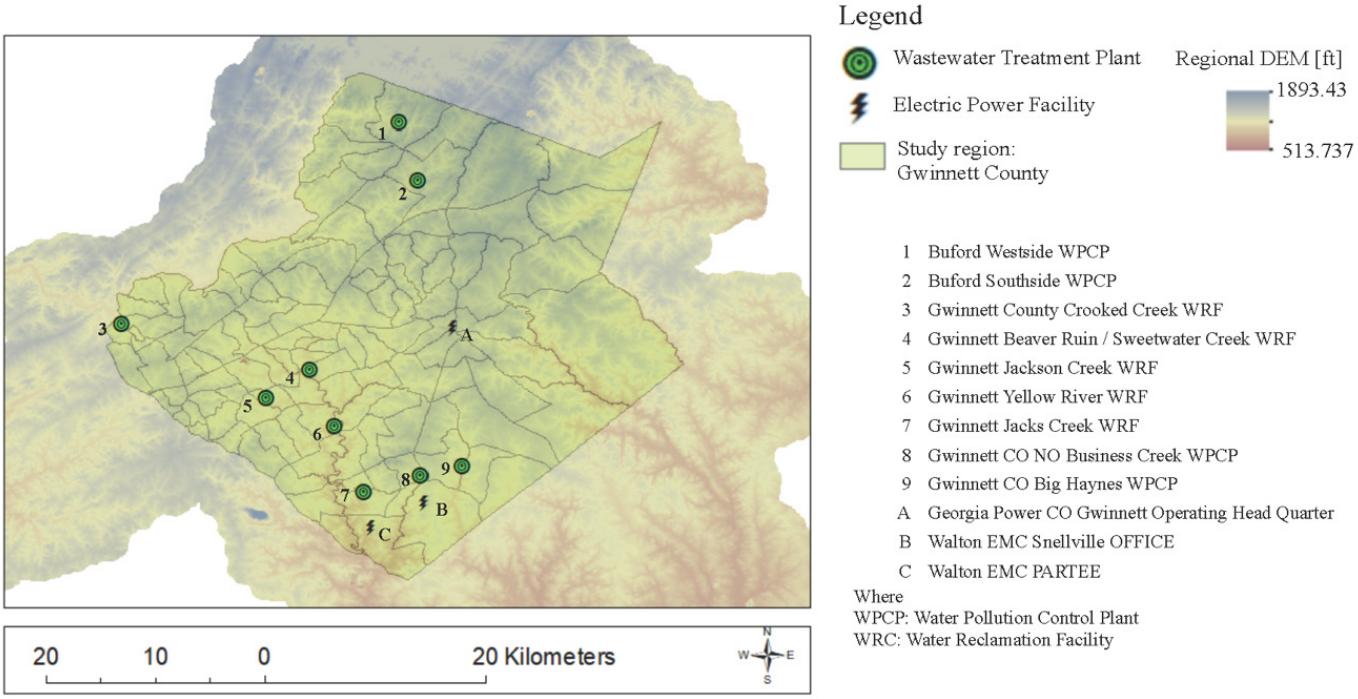

Figure-1: Terrain surface and locations of electric power facilities and wastewater treatment plants in Gwinnett County.

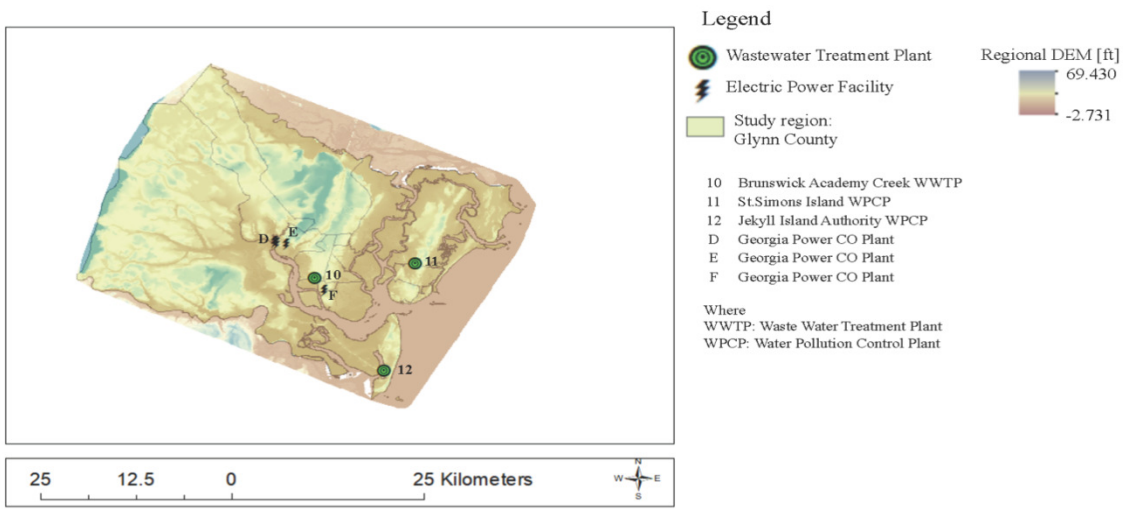

Figure-2: Terrain surface, ocean and locations of electric power facilities and wastewater treatment plants in Glynn county.

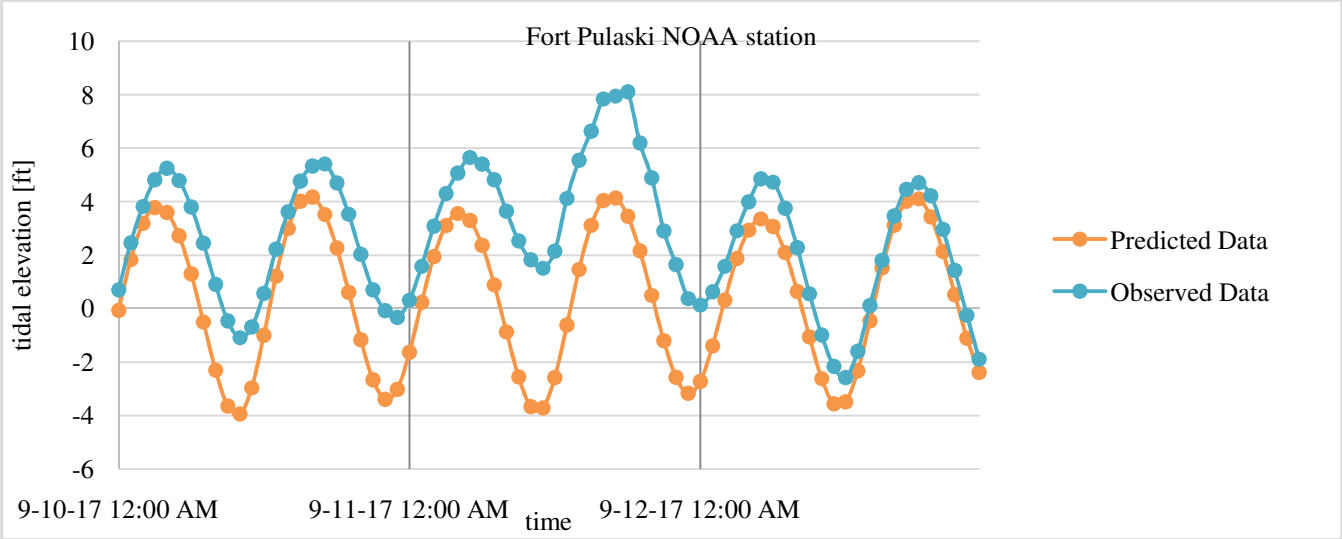

Figure-3: Predicted and observed tidal elevations during hurricane Irma.

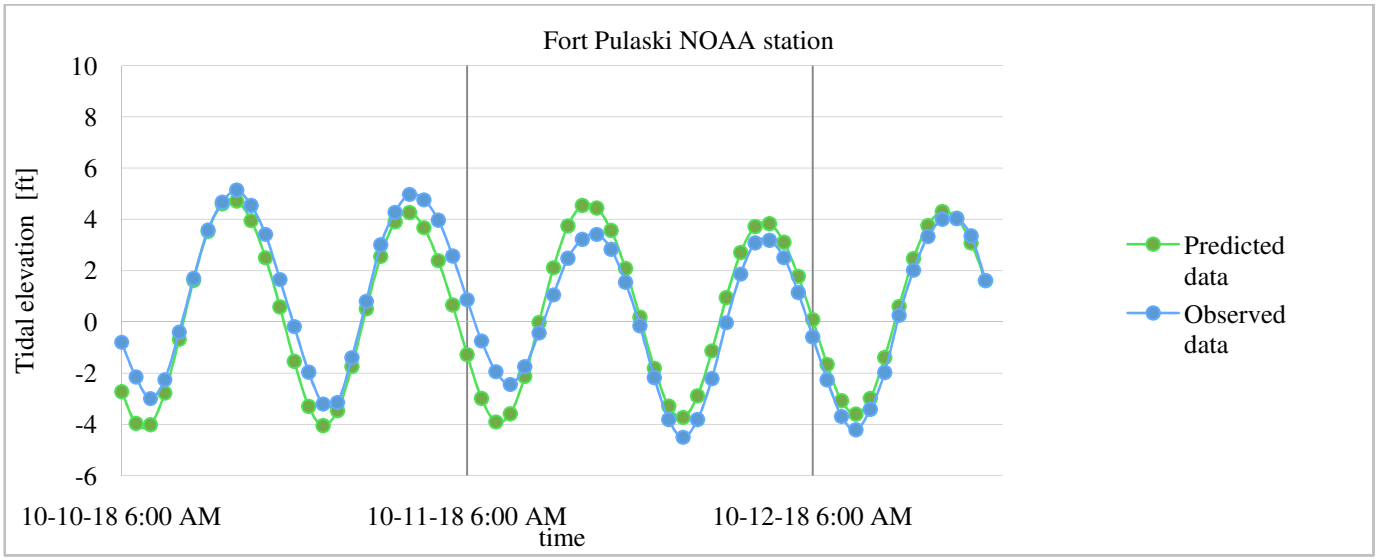

Figure-4: Predicted and observed tidal elevations during hurricane Michael.

These calculated initial water levels were used to run Storm Surge hazard analysis which can calculate surge elevation and significant wave height. This study run Coastal Surge as the hazard type and considered as Glynn County has moderate exposure which can be slightly protected by small islands or sandbars.

This study ran these hurricane simulations without waves which assumes depth-limited waves at the coastline rather than using significant wave heights.

Results and discussion

In the 100-year flooding in Gwinnett County, some flooding can be observed at the rivers in Gwinnett County, especially in the western region of the county. The 200-year and 500-year floods do not have a noticeably greater impact than the 100-year flood as shown in Figures-5, 6, and 7. Highest flood depth due to 100-year flood is 63.85 feet, even though 200-year flood and 500–year flood show 64.48 feet and 58.85 feet, respectively. The simulation may be improved by using fine resolution for employing DEM and developing stream network.

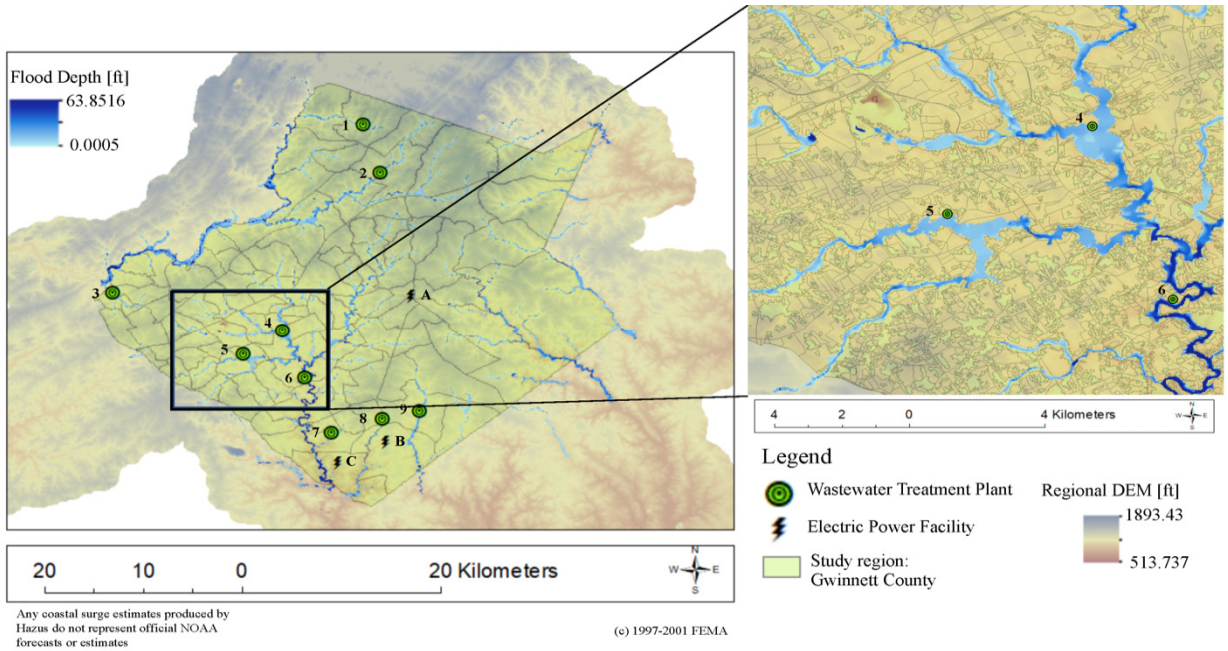

Figure-5: 100-year Floodplain in Gwinnett County.

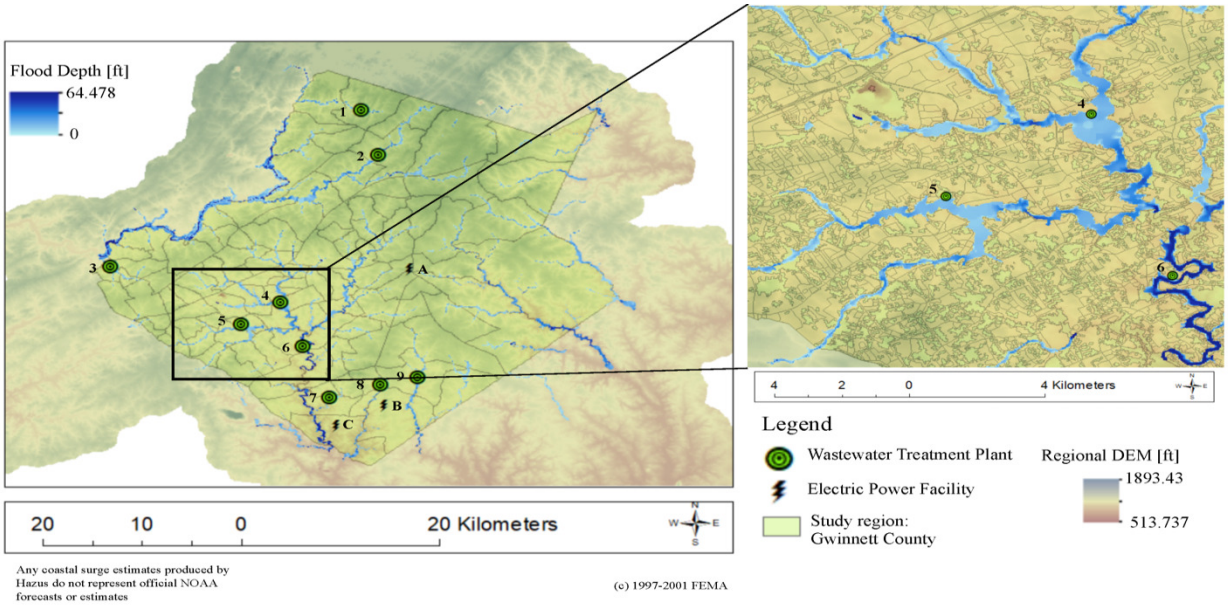

Figure-6: 200-year Floodplain in Gwinnett County.

NOAA reported that two wastewater pumping stations were shut down and wastewater treatment plants were flooded in September 2009 (NOAA, 2013). HAZUS results (Figures-5, 6, and 7) show that for the Gwinnett County floods, nearly all the wastewater plants are at risk of flooding, as they are all located near rivers. The Gwinnett County Yellow River Water Pollution site is the only wastewater treatment plant that is situated at a far enough distance to be not considered at risk of flooding. All the electric power plants are located at a far enough distance from any major rivers to be affected by riverine flooding.

Figure-8 and 9 present flood inundation maps due to Hurricanes Irma and Michael in Glynn County, respectively. HAZUS results show that nearly all the electric power plants are at risk of flooding from the hurricanes, as they are located near the coast. Glynn county suffered indeed the massive power outage during Hurricane Irma (AJC). It was reported that 200 Georgia Power customers lost power because of Michael, which is significantly less than the 39,000 customers who lost power during Irma. All the wastewater treatment plants are at risk of flooding as well, except for the St. Simons Island Water Pollution Control. For the Hurricane Irma simulation, that wastewater plant is far away from any flooding, so it is at no risk of flooding. Whereas, the wastewater plant is in danger of flooding due to Hurricane Michael.

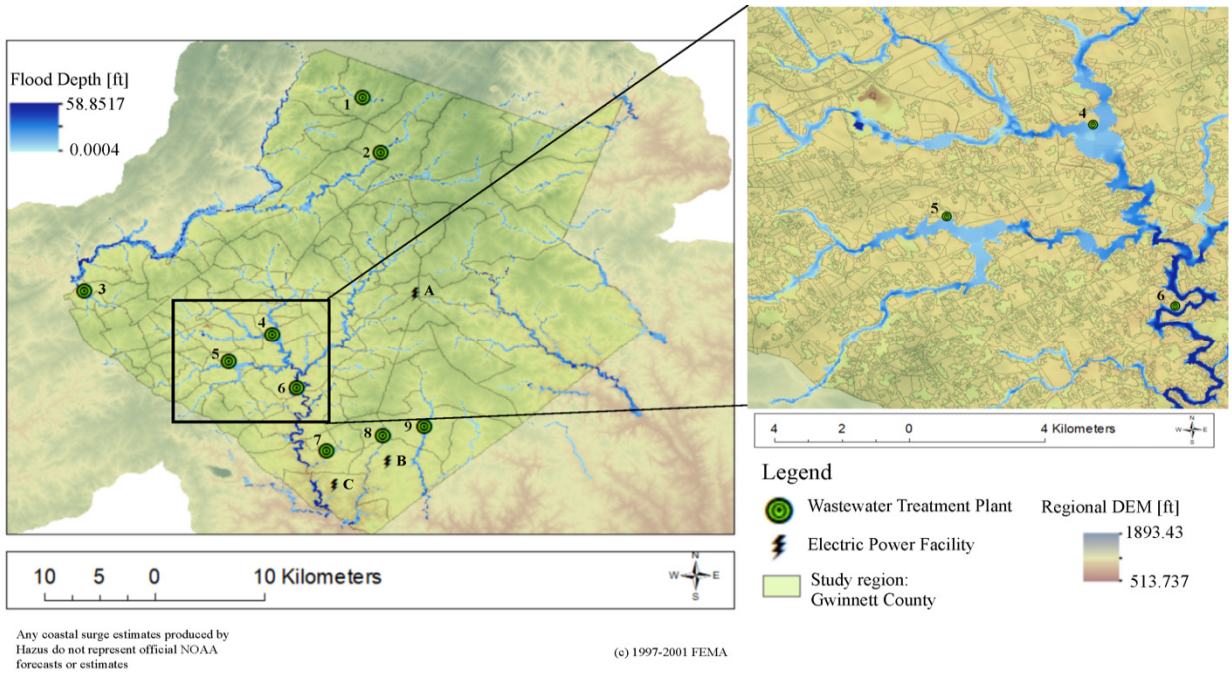

Figure-7: 500-year Floodplain in Gwinnett County.

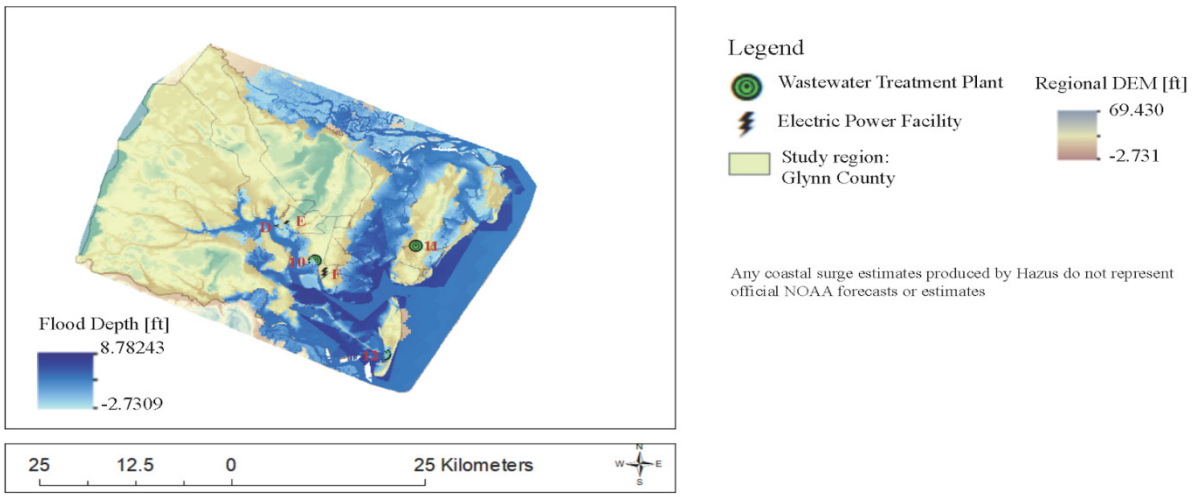

Figure-8: Hurricane Irma inundation in Glynn county.

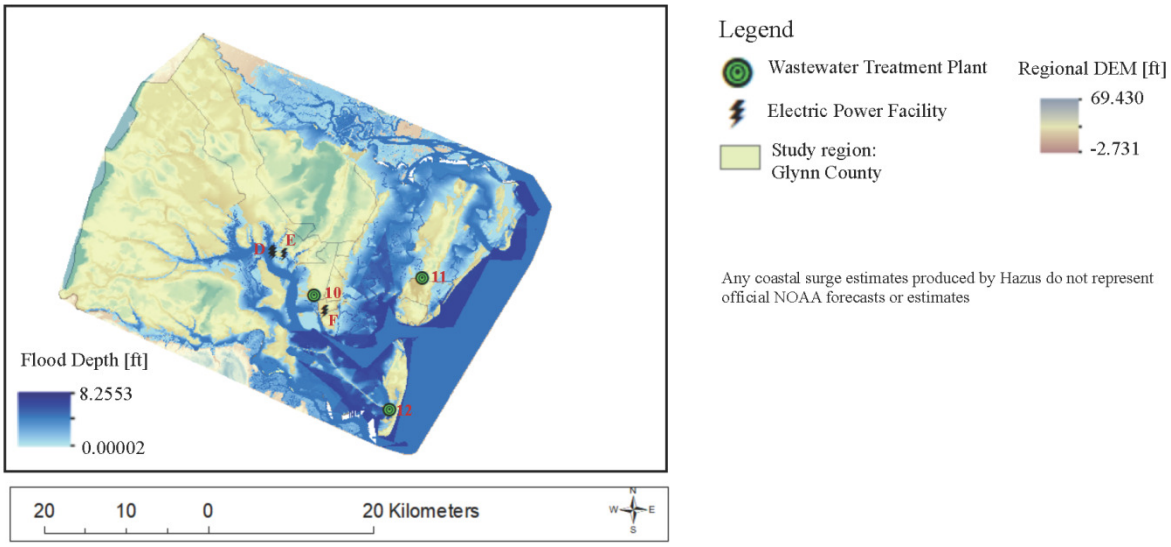

Figure-9: Hurricane Michael inundation map in Glynn county.

Conclusion

This study delineated the inundation area in Gwinnett County and Glynn County by considering previous historical flooding. It is concluded that most wastewater treatment plants in Gwinnett County are vulnerable to riverine flooding; therefore, the local wastewater treatment plants, Environmental Protection Division, and Georgia Department of Natural Resources need to develop plans to protect their facilities from flooding.

Electric power facilities and Jekyll Island Authority Water Pollution Control Plant in Glynn County are also identified as vulnerable to even Tropical Storm. This result could be used for preparing a damage prevention plan of Hurricane or Tropical Storm. To prevent future outages, Georgia Power should consider more resilient power facilities in Glynn county. Moreover, all inundation maps can be used to build a residence evacuation plan and Storm water Best Management Plan of Hurricane or Tropical Storm.

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