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Everglades West Watershed Case Study

Basin 17

08/1/2020

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Executive Summary

Flooding is the most common and costly disaster in the United States. Over 98% of counties in the entire United States have experienced a flood and just one inch of water, causing up to $25,000 in damage (FEMA 2018). Flooding can impact a community's social, cultural, environmental, and economic resources, so making sound, science-based, long-term decisions to improve resiliency are critical to future prosperity and growth. To meet the longer-term goals to protect life and property, in 1990, FEMA created the National Flood Insurance Program's (NFIP) Community Rating System (CRS) program, a voluntary program for recognizing and encouraging community floodplain management activities. The Florida Department of Emergency Management (FDEM) contracted with FAU to develop data to enable local communities to reduce flood insurance costs through mitigation and resiliency efforts by improving watershed management plans. There are several steps to address the development of watershed plans, including developing a watershed planning template and development of support documents to establish risk associated with community risk within the watershed.

The effort discussed herein focusses on the development procedures for a screening tool to assess risk in the Collier/Lee/Big Cypress Basin (#17) basins, a watershed located in Southwest Florida that combines readily available data on topography, ground, and surface water elevations, tidal information for coastal communities, soils, open space and rainfall to permit an assessment of the risk of inundation of property. Such knowledge permits the development of tools to allow local agencies to develop means to address high-risk properties.

1.0 Introduction

Basin 17 is the Everglades West Coastal region. The basin is located in Southwest Florida within the boundaries of Collier County and Lee County as shown in Figures 1 and 2. Both counties are coastal regions with water on the West Coast. Collier County residency includes Naples, Marco Island and Everglades City. The County is almost wholly within the basin. The east coast of this region is an area known as the Big Cypress Preserve, which consists primarily of wetlands. Flood control and water management in this region is operated and maintained primarily by the South Florida Water Management District (SFWMD). In Lee County, Sanibel Island, Fort Myers, Cape Coral and the northern portion of Fort Myers are excluded from the study of Basin 17 since they are south of the Caloosahatchee Basin. However, Estero, and Bonita Springs remain in Basin 17.

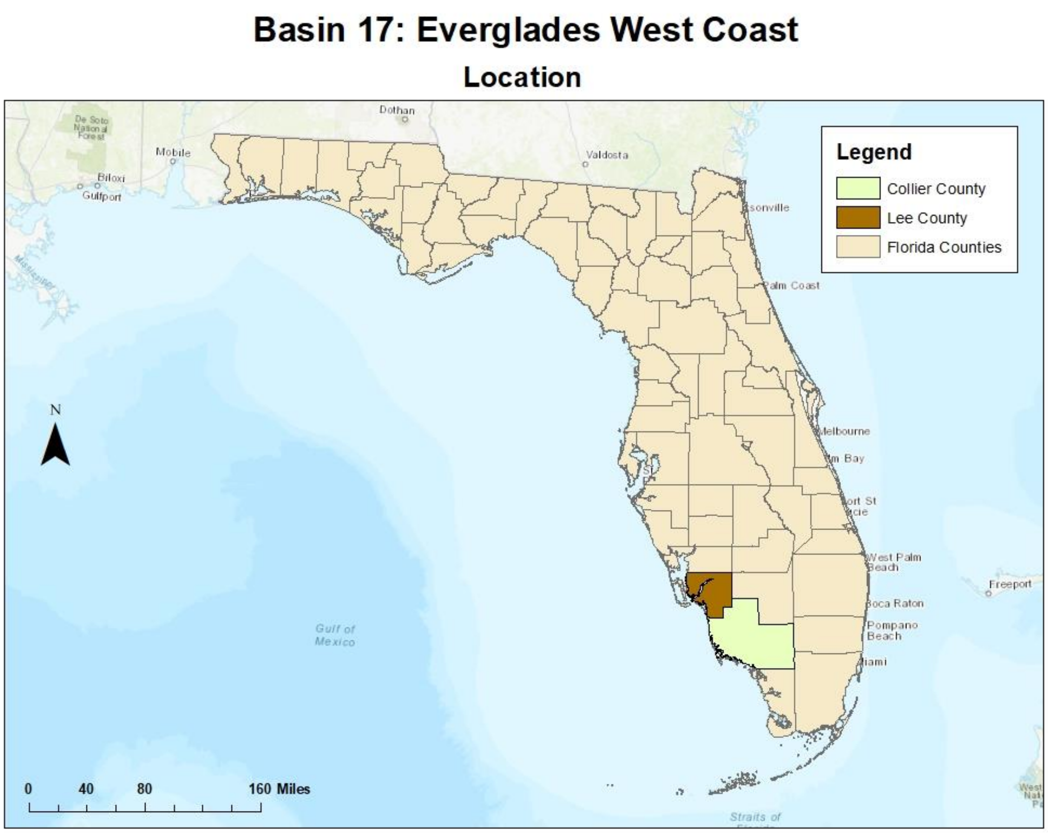

Figure 1: Location of Counties

Basin 17: Everglades West Coast

Basin Location

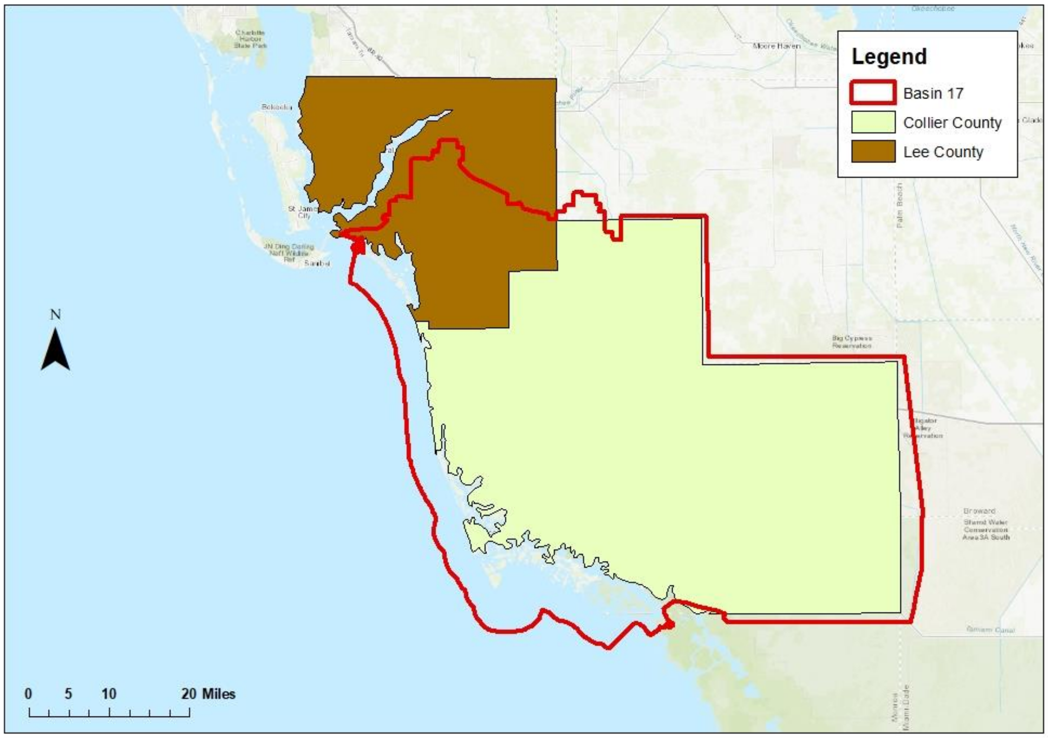

Figure 2: Location of Basin

2.0 Summary of Watershed

2.1 General Description of Watershed

In South Florida, water supply, water quality, and health of the Everglades ecosystem are intrinsically linked. When attempting to evaluate the ecological health of Southeast Florida, one must look at the entire southern portion of the peninsula of Florida. Historically there were no barriers or canals to direct or control the path of water except a minor connection created by Native Americans between the Caloosahatchee and Lake Okeechobee for transportation purposes (Figure 3).

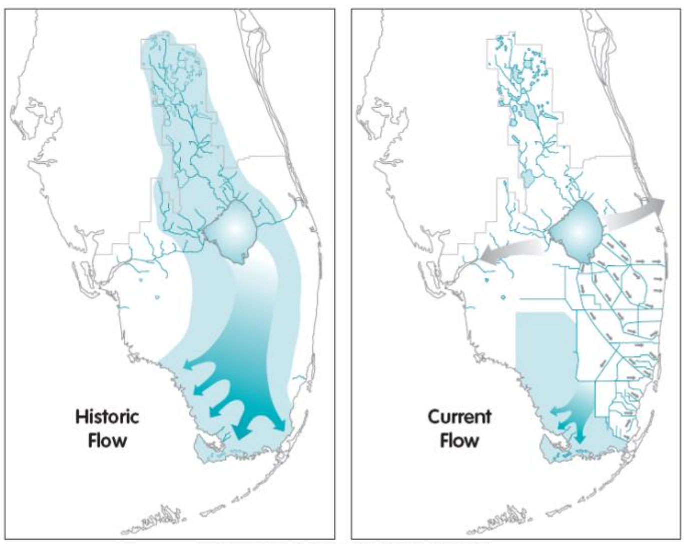

Figure 3: Change in natural flow paths in South Florida (SFWMD, 2020)

The next modifications to the South Florida landscape were constructed in the 1880s by Hamilton Disston with the dredging of the Caloosahatchee River and the creation of drainage canals in the Kissimmee Upper Chain of Lakes. The dredging was conducted in order to drain the land to facilitate agricultural production and urban development. The C-44 Canal and the associated locks and structures were constructed between 1916 and 1928. This canal provided a navigable connection between the east and west coasts of Florida. It connects Lake Okeechobee to the south fork of the St. Lucie River and makes the St. Lucie Estuary one of the major outlets for water draining from the Upper Kissimmee and Lake Okeechobee basins.

The first efforts to contain Lake Okeechobee involved construction of a low levee and three drainage canals running south from Lake Okeechobee, the Miami, North New River, and Hillsboro canals between 1913 and 1917. In 1930, during the aftermath of the Storm of 1928, which pushed water out of the shallow lake and drowned thousands of people, the federal government authorized the US Army Corps of Engineers (USACE) to build the Herbert Hoover Dike. Over the next seven years, a series of levees, culverts, and locks were built to contain the lake, including 67 miles of dikes along the southern shore, effectively halting natural waterflows out of the lake to surrounding areas. In 1938, the USACE began to regulate lake levels, and lake inflows and outflows were altered to include structures and channelization to more effectively move water in and out of the lake. Modifications to the outlets on the east and the west sides of the lake made the St. Lucie and Caloosahatchee rivers the primary outlets from the lake.

However, due to a series of back-to-back hurricanes in 1946 and 1947 and resulting significant flooding in South Florida, the need for additional features to manage excess water became evident. In response to these conditions, the State of Florida requested assistance from the federal government. As a result of that request, the Central and Southern Florida Flood Control Project (C&SF Project) was authorized by the U.S. Congress in 1948. Subsequently, the USACE produced a comprehensive water management plan for flood control that became the blueprint for the project to drain the land quickly to tide to allow for urban and agricultural development. It took approximately 20 years to implement the project features, canals, levees, pump stations, and other structures that were built in the 1950s and 1960s. The channelization of the Kissimmee River was completed in 1971.

By 1969, over 1800 miles of primary canals were constructed to reduced groundwater levels along the coast, which enabled the development that exists today. The canals serve as flood protection for low lying areas because the currently drain by gravity to the ocean. Figure 4 shows the canals in the SFWMD service area. These areas would be flooded in the summer months without the canals. However, as a result of the canals reducing groundwater levels, combined with lessened historical flows to the Everglades and less water standing in the Everglades during the summer months. In addition, the need to control Lake Okeechobee levels requires discharges through the

St. Lucie River and Caloosahatchee watersheds. The timing of these discharges are historically different than the natural system, creating disruptions in water quality and supply.

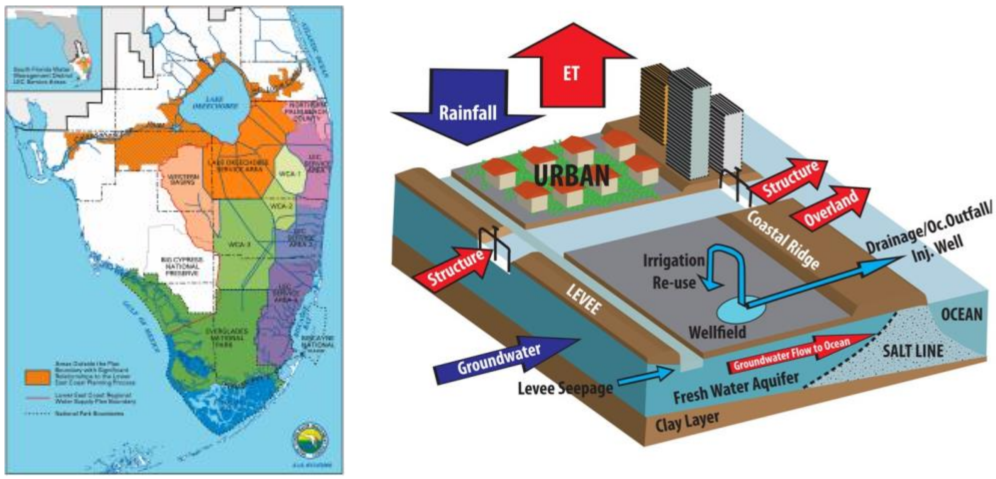

Figure 4. South Florida Water Management District LEC service area and drainage pattern after C&SF drainage improvements (SFWMD, 2020 for figure on the left)

As a result, south Florida and the Caloosahatchee watershed landscapes have been dramatically altered by construction of this elaborate system of canals, dikes, levees, flow control structures, pumps, and other water control facilities. These changes also allowed south Florida to be one of the largest metropolitan areas in the United States, and for the Fort Myers area to develop to nearly 1 million people at present.

The watershed also affects local flood management. Currently, rain falls on impermeable land where the water collects in pools or runs off rapidly where development has taken place. Stormwater is collected locally in neighborhoods in swales, ponds, small lakes, ditches and small canals. These are connected through canals and conduits to the secondary system under the jurisdiction of local drainage districts or city or county governments, which in turn connect to the major waterways controlled by SFWMD and USACE. The highly engineered stormwater drainage system and water control structures have effectively enabled management (lowering) of water tables to permit development.

2.1.1 Climate/Ecology

Similar to most of South Florida, the southwest region of Florida has a subtropical climate. The region has both a wet season and a dry season. Collier County and Lee County being in the same region each have on average 266 sunny days per year. There is a slight difference in the amount of precipitation per year. Collier County averages 54 inches of rain per year, while Lee County averages 53 inches of rain per year.

Big Cypress in Collier County is considered to be an Area of Critical State Concern (ACSC) as it is estimated to be about 800,000 acres between Collier, Miami-Dade, Hendry and Monroe County. This area is considered to be one of the South Florida Ecosystems that needs to be maintained to conserve environmental resources and the natural beauty of the region.

2.1.2 Topography and Soils

The majority of Collier County is represented by wetlands. Wetlands serve many purposes, including acting as recharge areas, filters for contaminates and buffers that mitigate temperature changes in adjacent areas. Wetland integration into watershed management is an approach that integrates wetland ecosystem management with traditional water and watershed management goals and techniques. It manages water resources, taking into account the functions and values of wetlands, and it manages wetlands in broader water regime and ecosystem contexts.

In South Florida, as a result of hydrologic modifications over the past 100 years, the natural storage and buffering capacity of wetland areas in the basin have decreased. As a result, water levels in the watershed can rise substantially in short periods of time. The water levels occur outside desirable ranges either too high or too low with rapid water level fluctuations. Wetland areas are shown in **Error! Reference source not found.** as developed from the National Land Cover Database (NLCD) of nationwide data on land cover. The database is designed to provide cyclical updates of United States land cover and associated changes.

The county is relatively flat with a decreasing slope towards the coastal regions. There are four different overall groups that are used for describing the soils within Basin 17. The categories are soils of man-made areas, soils of flatwoods, sloughs and hammocks, soils of prairies, swamps and marshes, and soils of tidal areas. All of the soil groups are either level or nearly level with poorly drained soils.

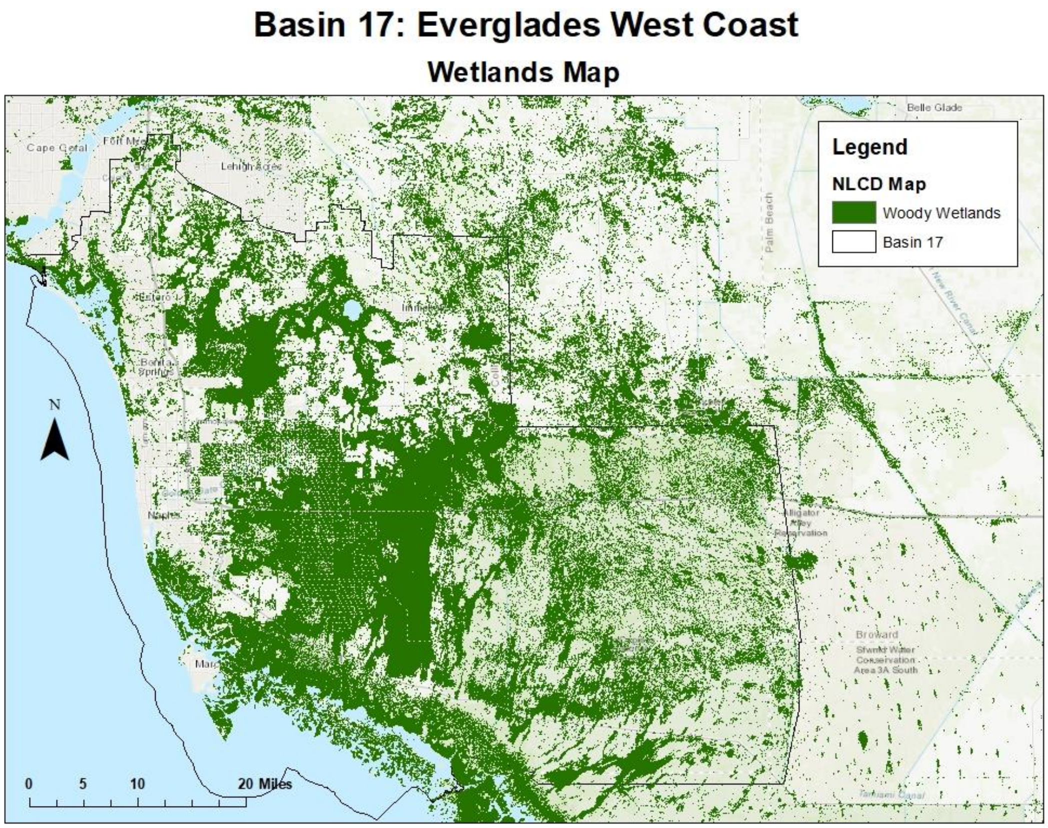

Figure 5: NLCD Wetland Database

2.1.3 Boundary/Surface Waters

Basin 17 is connected to the Gulf of Mexico on the west coast of both Collier County and Lee County. The area within Collier County and Lee County that are under observation are broken down into three different sub basins as shown in Figure 6. The northern area contains the Lee Couty Communities. Much of this area is developed and drains to the Gulf of Mexico via canals and waterways. The central basin contains the communities of Immokalee to the north, and the

Cities of Naples and Marco Island on the coast. The area includes the Cocohatchee and numerous canals designed to drain the Golden Gaate Estates, at one point he largest subdivision in the world (most of the basin). The southern half of the Golden Gate Estates was acquired by the federal government as a preserve. The coastal water is useful for drainage of the top and middle subbasins. The coastal region boundary of the middle basin is made up of the Ten Thousand Islands. The eastern subbasin covered by the Big Cypress National Preserve and contains little development.

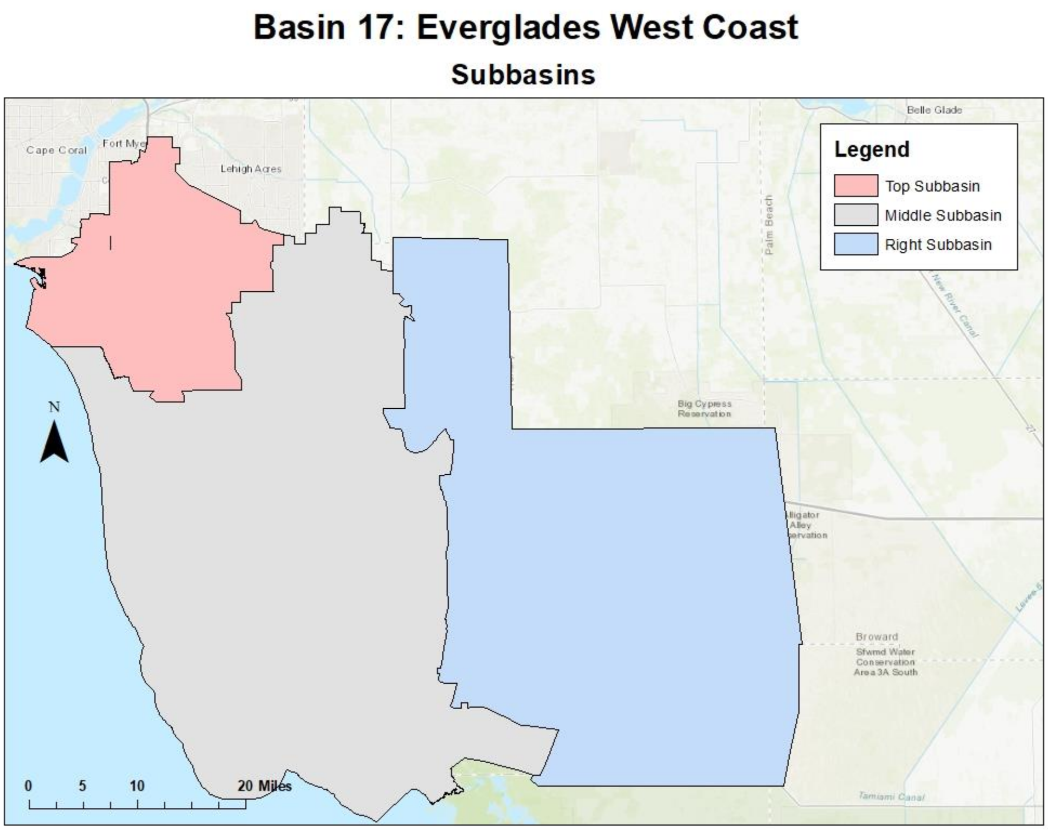

Figure 6: Subbasins

2.1.4 Hydrogeological Considerations

The entire South Florida plain is underlain by beds of porous limestone that absorb water standing on the land during the wet season (mostly in the Everglades). These limestone formations contain large volumes of fresh water - perhaps more than in any other limestone formation in the eastern

United States. A geologic profile of south Florida has been developed based on drilling data from USGS (Figure 7).

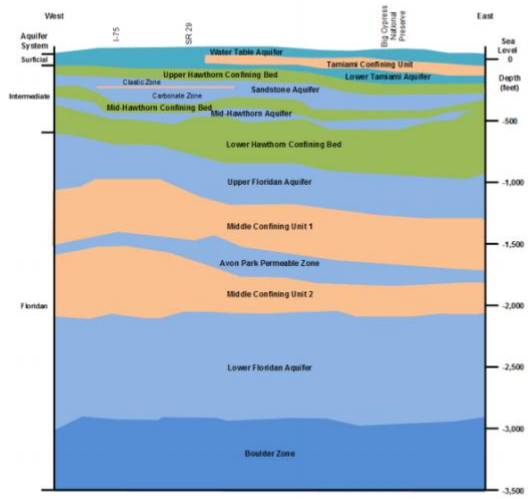

Figure 7. Hydrogeological profile of southwest Florida (Meyer, 1989)

The uppermost formation generally encountered along the southwest coast is a series of Pleistocene Age deposits that occur throughout most of South Florida and consists predominantly of fine to medium-grained quartz sand, with varying amounts of shell, detrital clays and organic constituents. Thickness of the sand is variable in the area, but averages approximately 40 feet. Under the surficial sand lies a series of fossiliferous, sandy limestones, which are part of the Anastasia or Fort Thompson formation.

Throughout the Lower West Coast Planning Area, the surficial (SAS) and intermediate aquifer systems (IAS) historically served as the major sources of fresh groundwater for Public Water Supply (PWS), Recreational/Landscape Irrigation (REC), and Agricultural Irrigation (AGR). However, past and present analyses of the SAS and IAS indicate it is a limited water resource in many areas. The SAS (and its associated wetlands) depends on rainfall for aquifer recharge. During dry conditions, recharge diminishes, drainage persists, and irrigation and other demands increase, compounding stress on the SAS and wetland systems. Typically, the IAS is recharged by seepage from above or laterally. The Surficial and Lower Tamiami aquifers within the SAS are the primary water sources for irrigation and agricultural users, as well as a major source for PWS in Collier and Lee counties. As such, the shallow aquifers are critically important to the region.

Throughout the LWC Planning Area, there are no consistent downward or upward trends in SAS water levels; however, individual wells may show temporal trends.

There are 4 different types of soil groups and their categories as mentioned in the Topography and Soils subsection:

1. Soils of Manmade Areas are the urban land areas that were filled or excavated to support development. These soils of manmade areas primarily used a mixture of Udorthents-Holopaw-Immokalee (5.5% of Collier County). These regions are nearly level lands with poorly drained soils. Sandy soils or loamy soils within these areas were created naturally or came from the fill. This can be seen in Naples, Immokalee, Marco Island and throughout some portions of the Golden Gate area.
2. Soils of the flatwoods, sloughs and hammocks have a variety of differences in soils that could be within a given region. Soil type mixes for these areas were determined to be roughly Pineda-Boca-Hallandale (22.3%), Immokalee-Oldsmar-Basing (18.9%), Holopaw-Malabar-Basinger-Immokalee (9.2%), and Holopaw-Wabasso-Winder (6.1%). These soil types as well tend to be on nearly leveled lands and contain poorly drained soils.
3. Soils of prairies, swamps and freshwater have a variety of different soil types used. Soil type mixes for theses areas are Boca-Riviera-Copeland (15.8%), Ochopee-Pennsuco (5.9%), and Winder-Riviera-Chobee (4.4%). These soil types are nearly leveled lands with poorly or very poorly drained soils. Most of these regions have loamy soils on top of limestone bedrock.
4. Soils of tidal areas are still nearly level, but have both very poorly drained and moderately well drained soils. The types of soil mixes in the tidal areas are Durbin-Wulfert-Canaveral (10.2%) and Kesson-Estero-Peckish (1.7%). The Canvaveral soil is the component that is moderately well drained.

2.1.5 Special Features

More than half thebasin is protected wetlands and federal property. Collier County has tried to limit development intensity east of CR 951, but development pressure continues to build. The Ten

Thousand Island chain, Fakahatchee Strand, Big Cypress Basin and other natural features contain among the world's most diverst biospheres, including many endangered plants and animals. The Ten Thousand Island chain is a major incubators for small fish and wildlife. The Florida Panther preserve north of the South Blocks of the Estates is an indication that the remanant panther populations are home in Collier County.

Beaches are present along the entire western edge fo the basin. The Gulf of Mexico provides a moderating influence on the immediate coastal climate.

2.2 Socio-economic Conditions of the Watershed

2.2.1 Demographics

The 2015 Census Block Groups in Florida, obtained by 2014-2018 American Community Survey (ACS), was used with ArcMap's Select by Location function to determine demographic estimations within the boundary of Basin 17. Basin 17 houses a total population of 566,125 people in 224,365 households. Of the total population, 278,249 (49%) are male and 287,876 (51%) are female.

Further breakdown of the population shows that 16.3 % of the population is under 18 years old, 4.1% are between 18 and 21 years old, 7.8% are between 22 and 29 years old, 9.7% are between 30 and 39 years old, 9.9% is between 40 and 49 years old, 19.5% are between 50 and 64 years old, while the remaining 32.7% is made up of those over 65 years old. The racial breakdown can be seen to be 68.4% White, 23.2% Hispanic, 5.6% Black, 1.7% Asian and 1.1% Other.

2.2.2 Property

The majority of Basin 17 consists of Fakahatchee State Park, Florida Panther National Wildlife Refuge, Big Cypress National Preserve and national resource protection areas. From the west coast of Collier County, there are land use areas indicated as urban residential subdistricts in the City of Naples and the Golden Gate area. Within the region of Basin 17, there are 343,381 housing units with 119,016 vacancies. From the total housing units, 49.3% is single-family residencies and

43.2% is multi-family residencies. Of the occupied housing units, 74.7% is owner occupied and 25.3% is renter occupied.

The median household income for Collier County is $62,407, while the mean household income is $101,492. Lee County is relatively lower with a median household income of $52,052 and mean household income of $74,000. Lee County is near the average household incomes for Southwest Florida, while Collier County is above the average. Median household income for Southwest Florida is $53,636 and mean household income is $79,499.

2.2.3 Economic Activity/Industry

Economic activity within Collier and Lee County are retail trade, accommodation/ food services, health care/ social assistance and construction. Most of these industries had a higher supply for industry jobs than the national average. Occupational earnings in Collier County were either at or just below the national average, while Lee County had been on an increasing trend for the average annual pay from 2010 to 2018 according to the Bureau of Labor Statistics. Key targets of industry for these regions included corporate headquarters, manufacturing, life sciences and information technology.

3.0 Watershed Analysis

3.1 Data Sets

3.1.1 Topography

The topography was created by using Lidar DEM Technology obtained from USGS. The mapping was by mosaicing 3-meter resolution tiles together to fill gaps in the digital elevation model (DEM). Big Cypress Preserve and surrounding wetlands did not have 3-meter DEM available, so the 10-meter DEM was substituted. The DEM data in Figure 8 shows a downward sloped elevation towards the coast. The higher elevations were found in the north eastern region of Collier County near Immokalee. The average elevation for the basin is 11.7 feet.

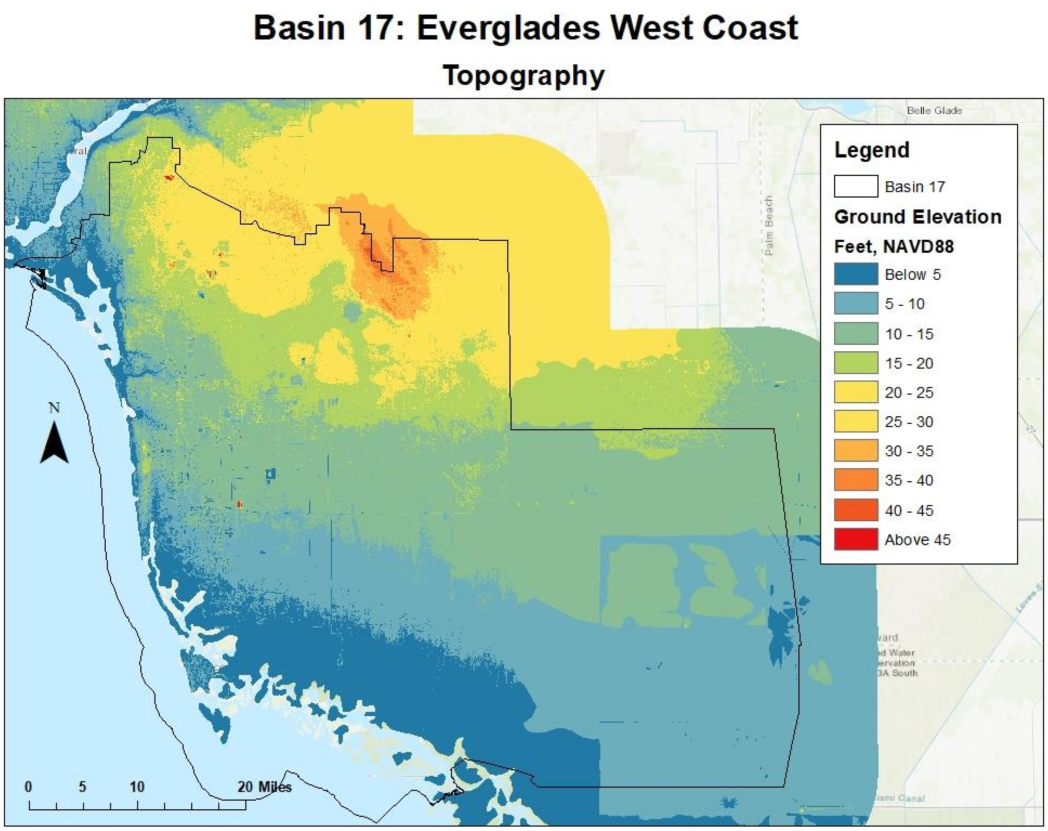

Figure 8: Basin 17 Topography

3.1.2 Water Table

Throughout Collier County and Lee County there were a total of 82 surface water gauges, 105 groundwater wells and a tidal station. Figure 8 shows the collected groundwater wells, surface water gauges and tidal station that were selected to complete a water table layer for Basin 17. All values for wells and gauges taken on October 27th 2017 were above the tidal station value of 0.503 feet NAVD88.

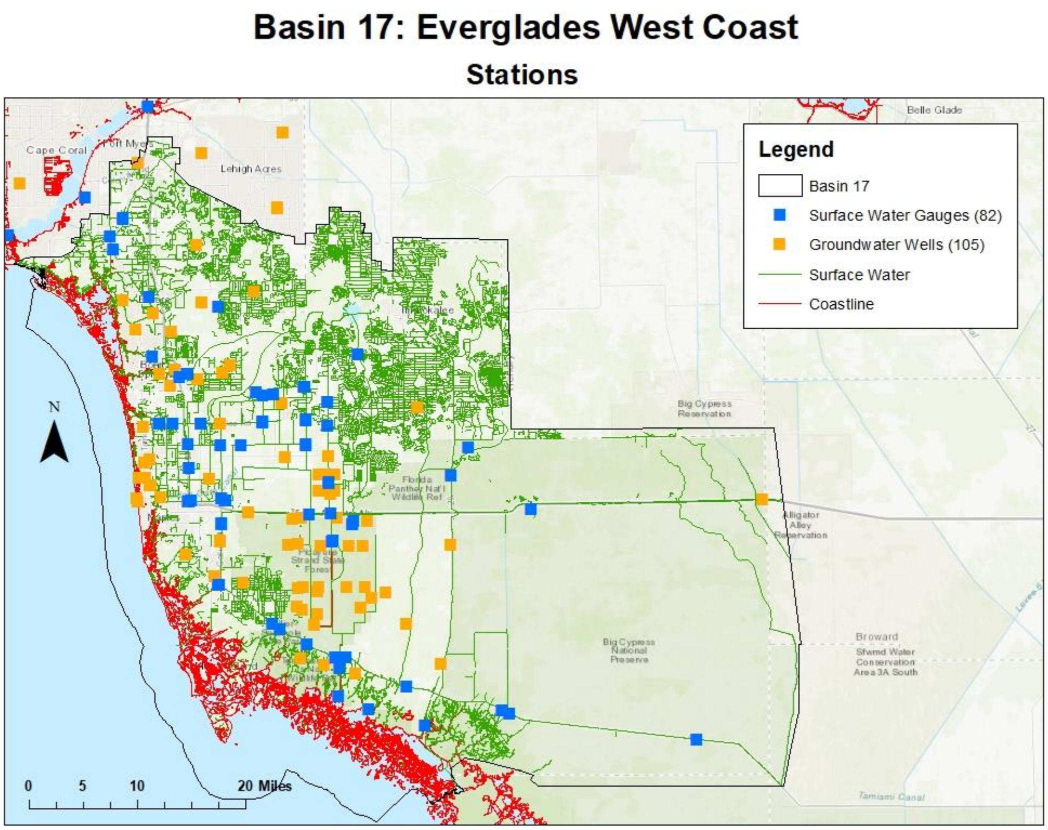

Figure 9: Basin 17 Groundwater Wells and Surface Water Gauges

Determining water table elevations throughout the watershed requires spatial interpolation and extrapolation methods as well as modeling. Since the high groundwater table greatly contributes to flooding in the region, it is necessary to expend the additional effort to incorporate this factor into the model. Observed water levels are only available at single locations, groundwater wells and surface water stations. The South Florida Water Management District's DBHYDRO database was used to access their station observation data. The groundwater wells are sparsely distributed, while surface water stations are distributed throughout the watershed along canals and in Lake Okeechobee. Additionally, NOAA's Fort Myers tidal station was used to determine the elevation of tides along the coastline.

Groundwater wells are used as identification of the depth to the water layer in different locations throughout the region. There is a positive correlation between the groundwater depth and the tides as noted by Romah (2011), Bloetscher and Wood (2016). The surface water gauges represent the water levels of or near rivers, lakes, canals and streams. an intermediate step, a spatial interpolation method called Empirical Bayesian Kriging was used to estimate the water levels between surface water stations. The resulting elevation prediction surface is referred to as the local minimum water table (MINWTE) in literature. Only surface water elevations were used in this interpolation; consequently, the result underestimates the true water table elevation in areas where there are no surface water features and must be adjusted to compensate for higher groundwater elevations. Second, the depths from the land elevations to the local minimum water table elevations were calculated. The two surfaces, MINWTE and depth-to-MINWTE, represent independent variables, or predictors, in the multiple linear regression model. The dependent variable, which is predicted, is the true water table elevation representing both groundwater and surface water. At each of the groundwater wells, the observed water table elevation, predicted MINWTE elevation, and depth-to-MINWTE were determined and used in the multiple linear regression model.

In this region of Florida, groundwater and surface water are closely related and influence one another. Their close interaction is attributed to the high groundwater table and low land elevations. For this reason, both ground and surface water were incorporated into the calculation of the water table elevation by using the multiple linear regression model. The predicted water table elevation, shown on the map in Figure 10, shares a similar spatial pattern with the land elevation in the DEM;

however, the water table sits a few feet below the land surface. This is attributed to the fact that groundwater typically follows topography and the water table is shallow in this region of Florida. The values for the water table elevation were increasing toward the north eastern regions of the basin with the highest water elevation being near Immokalee as seen in Figure 10.

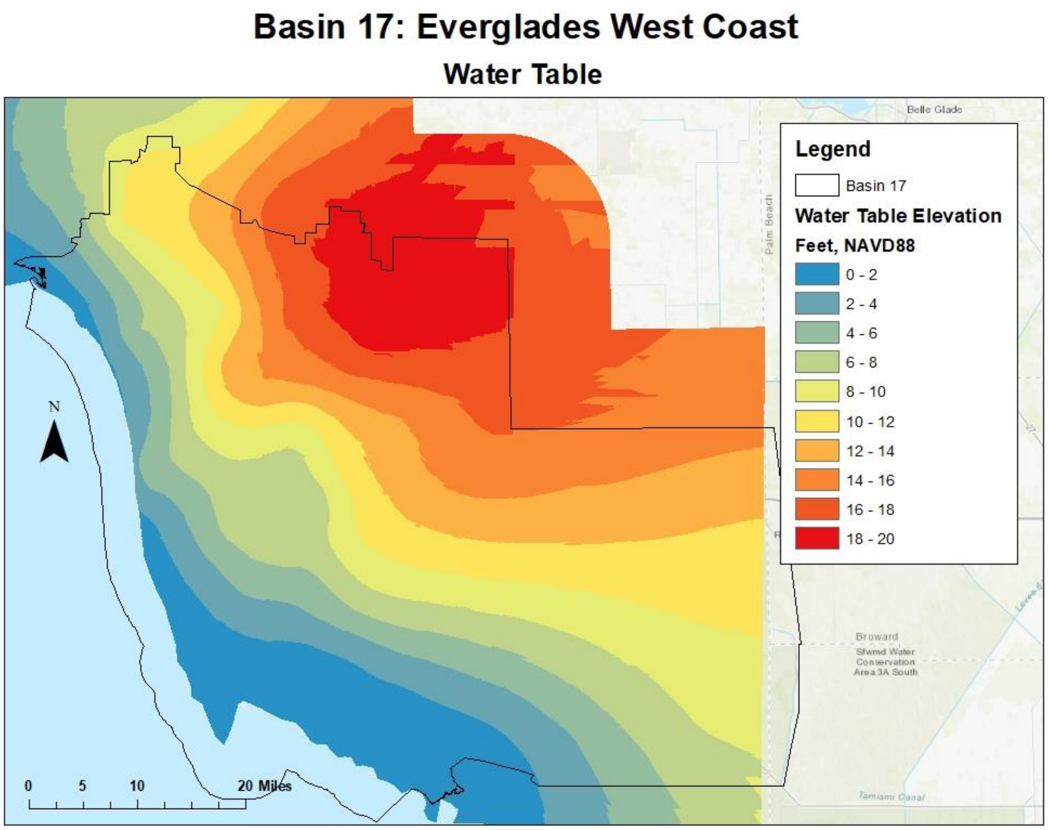

Figure 10: Basin 17 Water Table

3.1.3 Open Space

An impervious mask is used to identify areas that may be artificial structured or paved. In Figure 11, it can be observed that the majority of the impervious regions are roadways, parking lots or other urban areas that are built up for land development. Water within the impervious regions will not be able to penetrate the soil and will produce runoff.

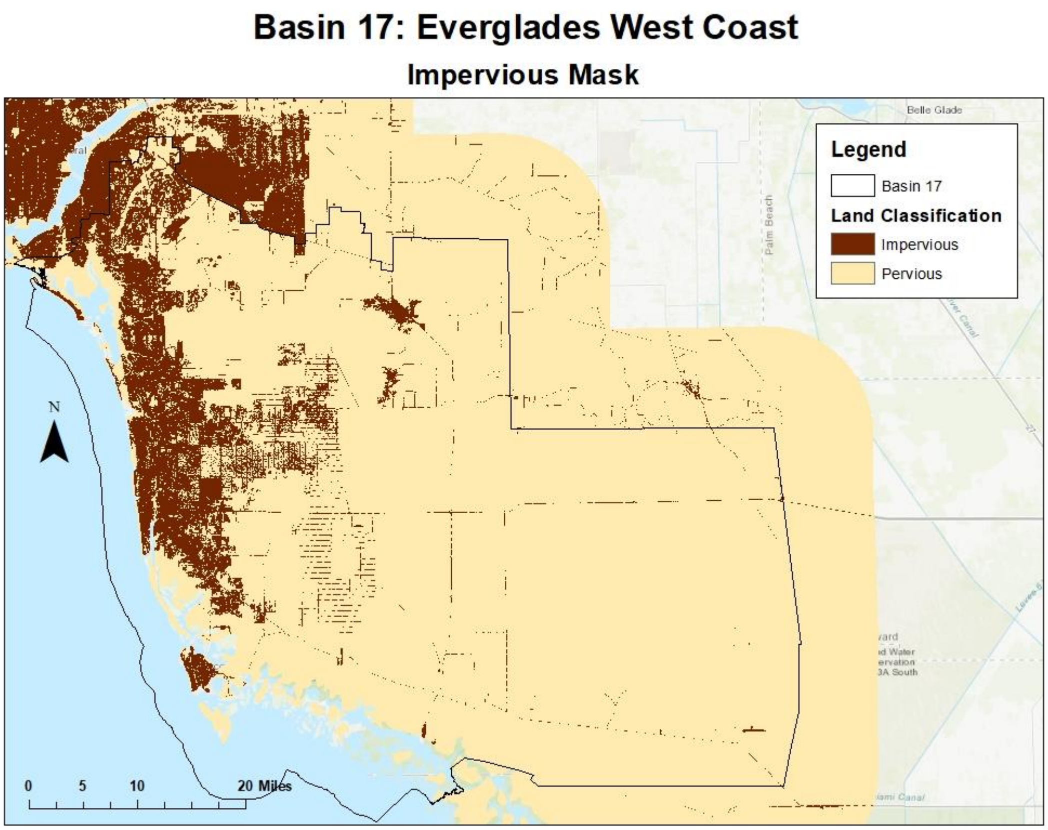

Figure 11: Basin 17 Impervious Mask

Similarly, a water mask is used to identify regions that may have an excess of water such as rivers, lakes, ocean or wetlands. For Collier County, most of the areas labeled as “Water” in Figure 12 are wetlands or oceanic coastal regions. The biggest wetland is the Big Cypress National Preserve to the east border of Collier County. West of the Big Cypress National Preserve is more wetlands identified as the Fakahatchee Strand State Preserve, Picayune Strand State Forest and the Florida Panther National Wildlife Refuge. The northern central region of Collier County also contains the Audubon Corkscrew Swamp Sanctuary. All of these regions are identified to be water by the water mask used for Basin 17.

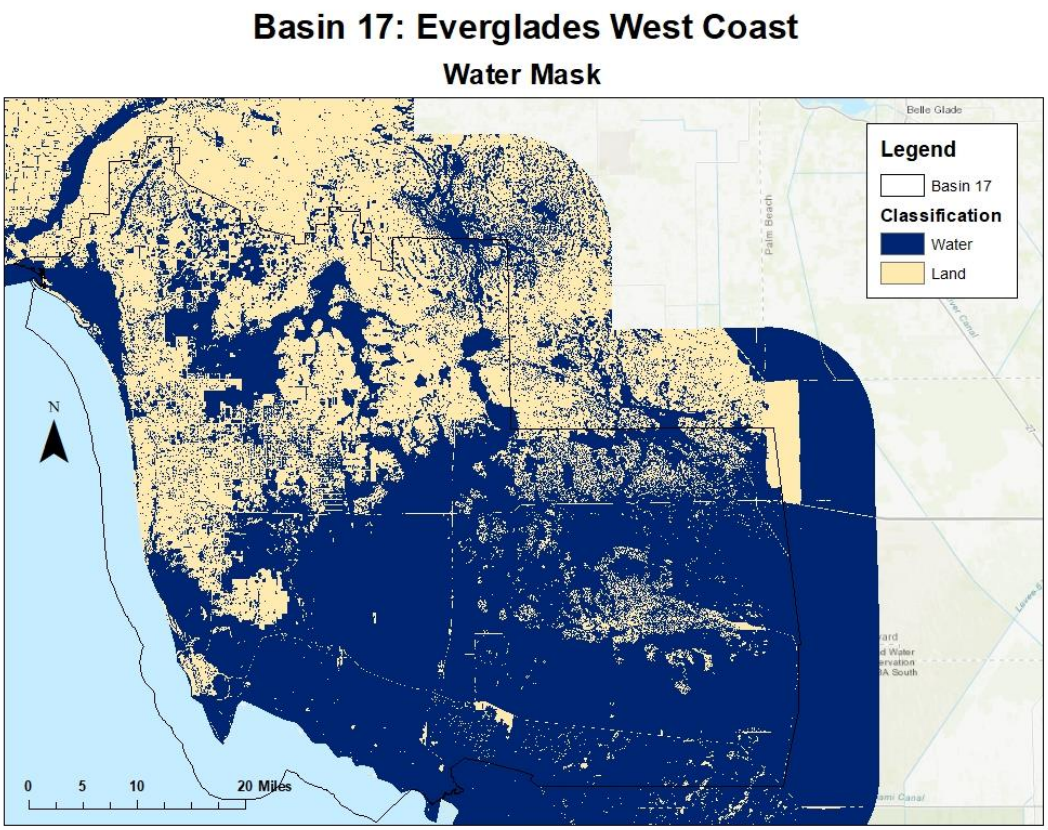

Figure 12: Basin 17 Water Mask

3.1.4 Soil Capacity

An unsaturated zone was able to be created using the elevation and water table data. The unsaturated zone tells us the depth of the soil at a specific location. The results obtained from the unsaturated zone can be observed in Figure 13. Coastal regions tend to have little to no unsaturated soil. Most regions in the northern area of Collier County have high unsaturated zones.

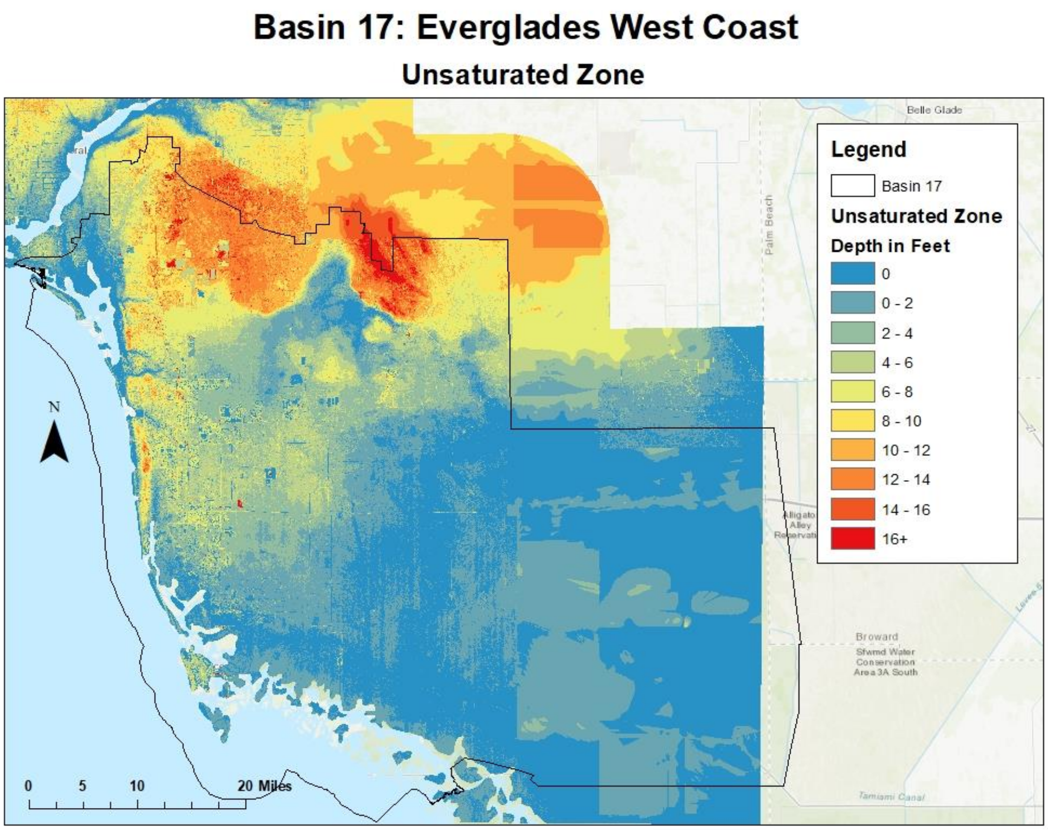

Figure 13: Basin 17 Unsaturated Zone

The soil capacity layer is used to determine the percentage of the water holding capacity of the soil in different regions throughout the basin. The area of the Big Cypress Preserve and other wetlands have no recorded capacity. However because the area is primarily swamp, it was assumed that this soils were poorly graded muck/sand. Other regions that may have no water holding capacity may be rivers, streams, lakes, oceans or other wetland regions as seen in Figure 14.

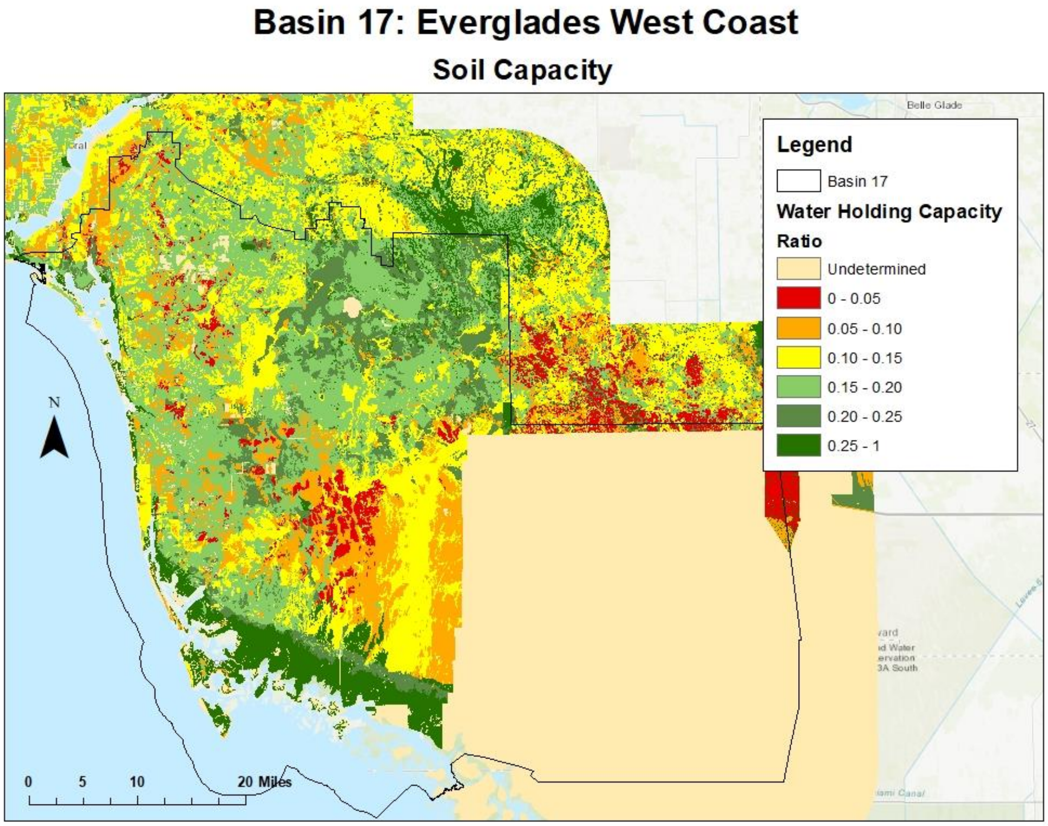

Figure 14: Basin 17 Soil Capacity

The soil storage layer was created using the water mask, impervious mask, unsaturated zone, soil capacity and a unit conversion from feet into inches. The soil storage capacity identifies regions as having no storage capacity if the region was labeled as water, impervious, having no unsaturated soil depth or having no water holding capacity. A zero value in any of the prior maps would identify as having no storage capacity. Basin 17 does not contain much area that contains any soil storage capacity as observed in Figure 15.

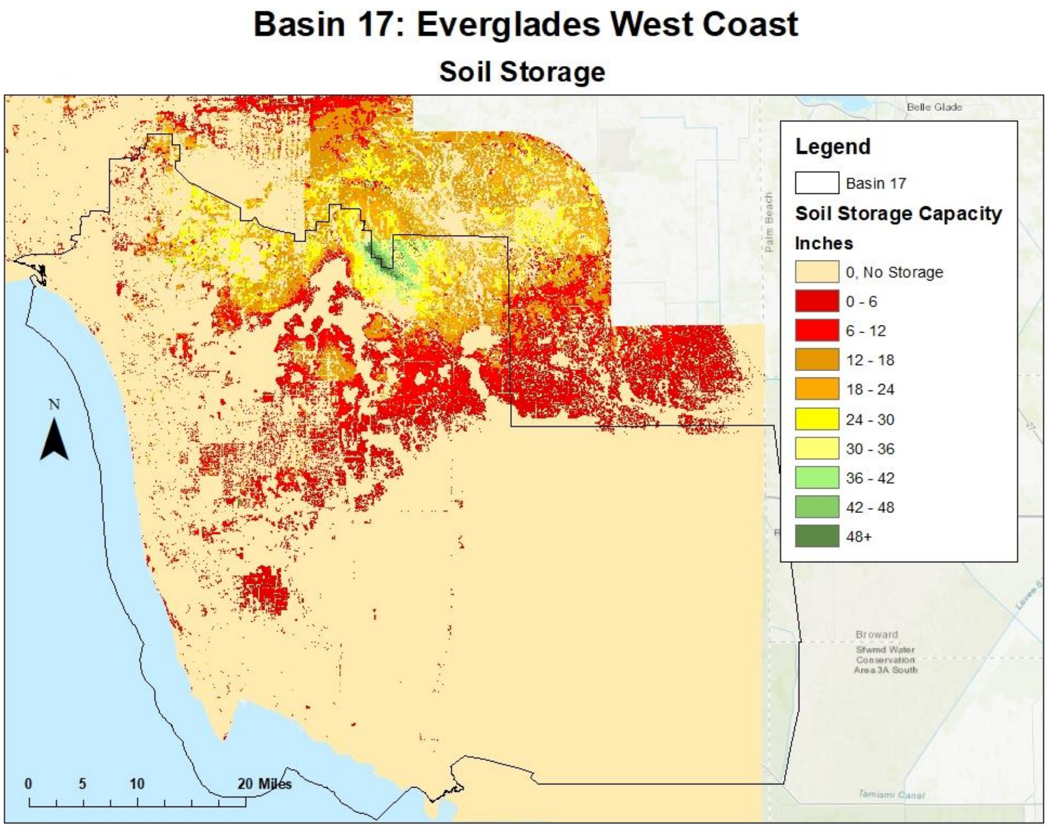

Figure 15: Basin 17 Soil Storage

3.2 Modeling Protocol

There are many contributing factors to flooding in the Caloosahatchee Watershed, including the low land elevations, high groundwater table, and low soil storage capacity. To accurately identify land areas within the watershed that are vulnerable to flooding, all these factors were included in the flood risk model. The previously discussed datasets were used to calculate input parameters needed to run a flood simulation model called CASCADE 2001, which was developed by the South Florida Water Management District. The advantage of this model is that it incorporates several characteristics unique to each watershed, including the topography, groundwater, surface water, tides, soil type, land cover, and rainfall. By following FAU's modeling protocol for the Caloosahatchee Watershed, all the necessary input parameters to run CASCADE 2001 were either directly calculated or derived from existing datasets.

The initial processing of data for Basin 17 was done using the ArcMap software, a type of geographic information system (GIS). The DEM data was obtained in smaller portions with 3-meter resolution. The data had to be joined together using a function called Mosaic to New Raster. For Basin 17. Similarly, data gaps in the Collier County Big Cypress Preserve region that were filled with 10-meter resolution data using Mosaic to New Raster as precise elevation data in this region was not able to be obtained.

The next portion was collecting the groundwater well information for Collier County and Lee County from DBHydro, which is a type of environmental data obtainable from the South Florida Water Management District (SFWMD). The records of the wells, positioning and depth were obtained for October 27th 2017. The project required data in the datum of NAVD88 so the VertCon Program from NOAA was used to convert the NGVD29 data obtained from SFWMD to NAVD88. The same procedure was done to find surface water gauges throughout the region. Tidal data was obtained from NOAA to find the highest point of the tides at the 8725110 Naples, Gulf of Mexico, FL tide station. Next, points were digitalized across the entire border of the basin every mile and another layer at 10 miles out from the border at distances of a mile. After obtaining the data for groundwater, surface water and tidal stations the data is able to be krigged together. Kriging is a form of interpolation done using GIS technology. Empirical krigging was used to produce the best results for a water table for Basin 17.

Using SFWMD maps the sub basins for the region were able to be obtained, but were changed slightly to fit the entirety of Basin 17. After obtaining the three sub basins, the canal data was used to find the longest path for drainage of each basin. The distance was recorded and used with an estimated velocity of 2 feet per second to determine the estimated time of concentration needed for the water to drain from each basin.

Using the function of Raster Calculator under Map Algebra, topography data values were subtracted by the water table to create the soil depth or unsaturated zone. Raster Calculator function was used again to multiply the values of the unsaturated zone, water mask, impervious map, soil capacity and 12 inches per foot to calculate the soil storage capacity. Next, the Extract by Mask function is used on the topography, soil storage and precipitation shapefiles to create individual values for each sub basin. By right clicking the properties and source of each file, the low, high and mean values are able to be determined.

At this point, the Cascade software is being run using general dimensionless unit hydrology method for a 3-day 25-year rainfall event. The time of concentration, area in acres, topography, soil storage and precipitation of each file is used as an input for cascade as shown in Figure 16. Running Cascade will give values for the high headwater height for each sub basin. Given the headwater height the Z-score can be predicted using Equation 1 in Raster Calculator.

Equation 1: Obtaining Z-Score

((Headwater Height – Lidar DEM Elevation) / 0.46)

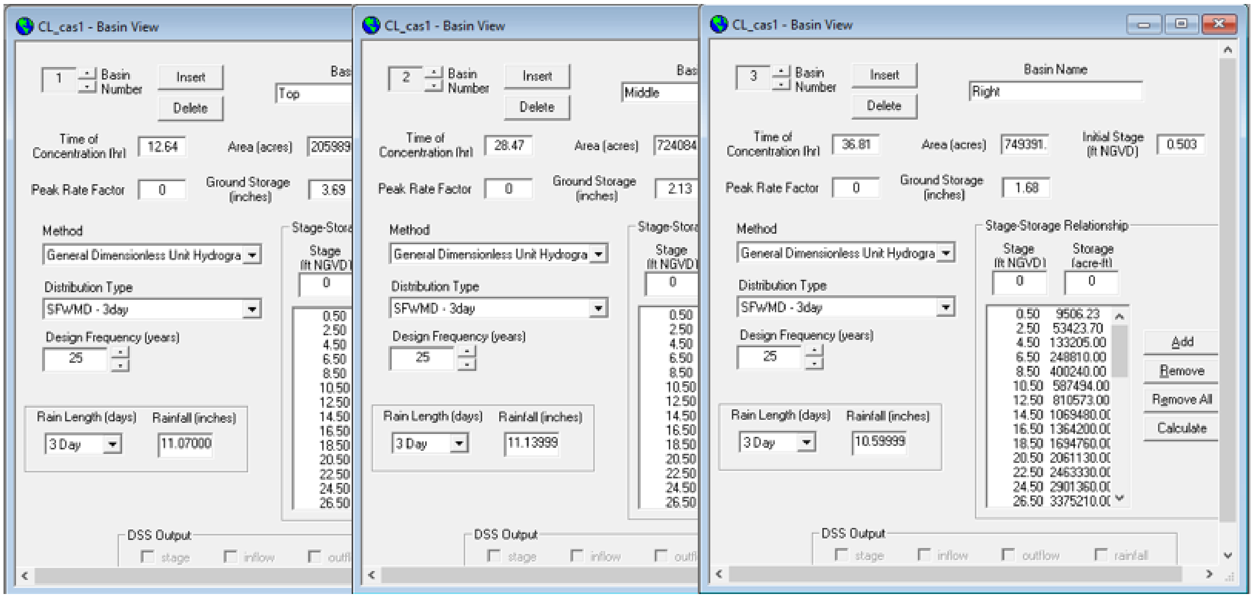

Figure 16: Setting up Cascade

3.3 Modeling Results

3.3.1 Cascade Results

After following FAU's modeling protocol, all required input parameters for CASCADE 2001 were calculated. The input parameters represent factors that influence flooding; for example, the topography, groundwater table elevation, and soil storage capacity. The original datasets and derived surfaces are GIS-compatible, so direct measurements and zonal average statistics were used to calculate the input parameters for each subwatershed. The drainage structures' information was obtained from the U.S. Army Corps of Engineers, the organization operating and maintaining these structures (USACE, 1993). The results for the headwater are 8.15 ft for top basin, 10.23 ft for middle basin and 10.21 ft for the right basin as shown in Table 1.

Table 1: Cascade Inputs and Results

	Top			Middle			Right		
	DEM	Ground Storage	Precipitation	DEM	Ground Storage	Precipitation	DEM	Ground Storage	Precipitation
Low	-4.12	0	10.68	-4.12	0	10.15	-0.954	0	9.72
Mean	14.51	3.69	11.07	9.33	2.13	11.14	11.58	1.68	10.6
High	98.25	125.802	11.07	120.18	250.2	11.73	82.72	162.46	11.48
Area (Acres)	205989			724083			749393		
Time of Concentration (hr)	12.64			28.47			36.81		
Headwater Height (ft)	8.15			10.23			10.21		

3.3.2 Vulnerability to Flooding

Under these constraints, the CASCADE 2001 model simulates the rise of floodwaters during a 3-day 25-year storm. The goal is to obtain the maximum headwater height in each subwatershed as any land areas below this elevation will be flooded. The identification of flood-prone areas within the Watershed is crucial to inform the decision-making process of prioritizing and allocating funding. Figure 17 shows the results obtained from using ArcMap and Cascade to predict the likelihood of flooding in Basin 17 during a 3-day 25-year event. The likelihood of flooding is obtained by using Z-scores to represent confidence levels. Common confidence levels used were z-scores of less than 0 are under 50% likelihood, Z-scores of 0.675 are 75% likelihood and Z-scores above 1.282 are over 90% likelihood. The areas around the coast of the basin all have the highest likelihood of flooding. The Big Cypress Preserve is considered as water due to the vast majority being wetlands.

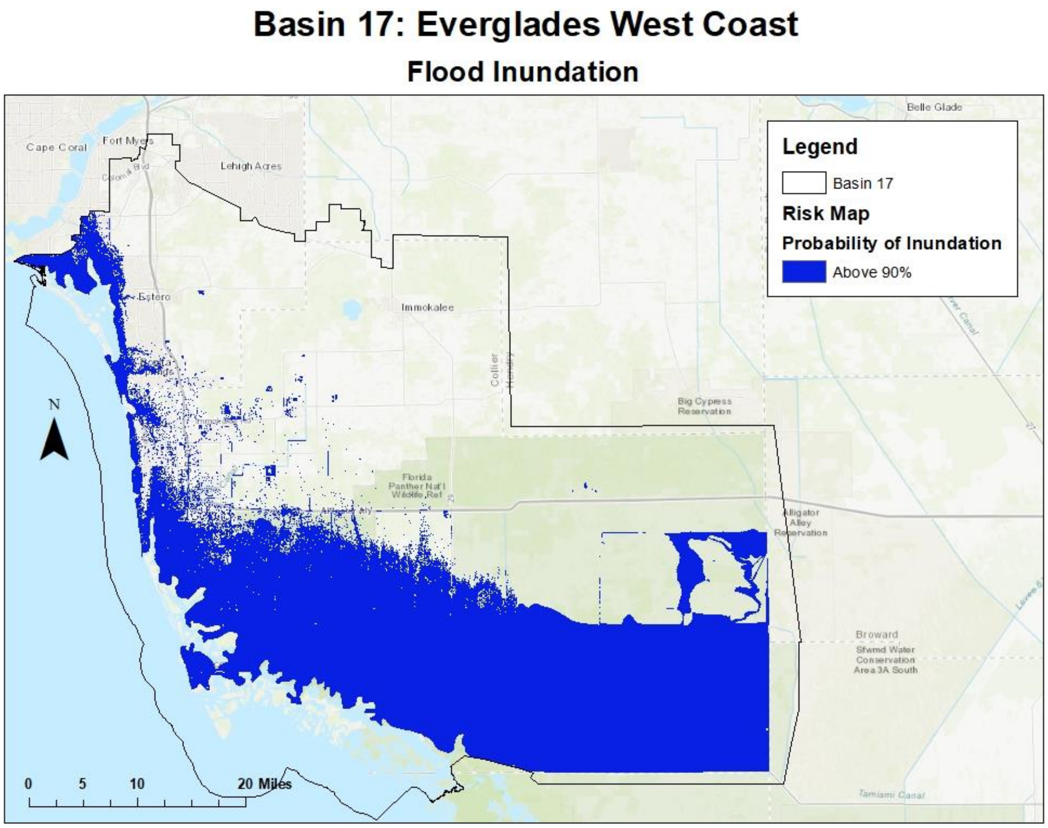

Figure 17: Basin 17 Flood Inundation

3.3.3 FEMA Flood Map

FEMA publishes Flood Insurance Rate Maps (FIRMs) that show the flood risk within a given area. Areas of high risk are Special Flood Hazard Areas (SFHA). These regions can be identified by the type of flood zone starting with the “A” or “V”. The high risk areas tend to have a 1% annual chance of flooding and a 26% chance of flooding over a 30-year mortgage. Areas of moderate to low risk are identified by “B”, “C”, or “X.” These regions tend to have a 0.2% chance of annual flooding.

Table 2: FEMA and FAU Comparison

Description	Total Area (mi^2)
FEMA's high-risk region based on the 100-year flood event (1%-annual-chance Flood Hazard Areas)	917.26
FAU's high-risk region based on the 3-day 25-year storm event (Above 90% probability of inundation)	2190.75
Overlap between the high-risk regions designated by FAU and FEMA	908.06

For FAU's maps, the 90% flood calculation includes 917.26 mi_2 of the property which is compared to the FEMA 1% annual chance value of 2190.75 mi_2. The overlay between the two layers was indicated to be 908.06 mi_2. In part the FAU model does not identify the South Blocks of the Estates ad always flooding – only the south end which matches historical. Likewise FEMA Maps track show floddign throughout the north block of the Estates and Immokalee, which is higher ground. The FAU mapping protocol take sthisinot account. .

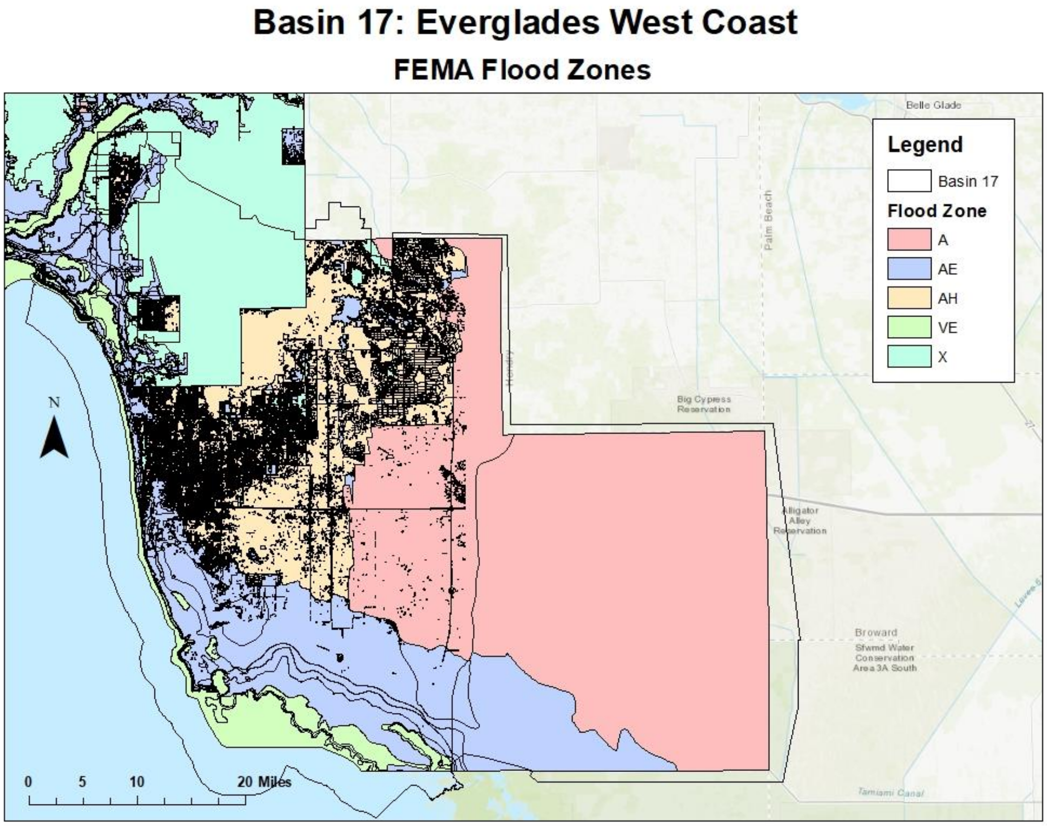

Figure 18: FEMA Flood Map

3.3.4 Repetitive Loss

Figure 19 shows a comparison of the flood map and reptititive loss property locations for the basin. The loss areas coincide with the areas predicted by the FAU model as being at risk for flooding. Note the repetitive loss maps are more similar to the FAU maps than the FEMA flood maps.

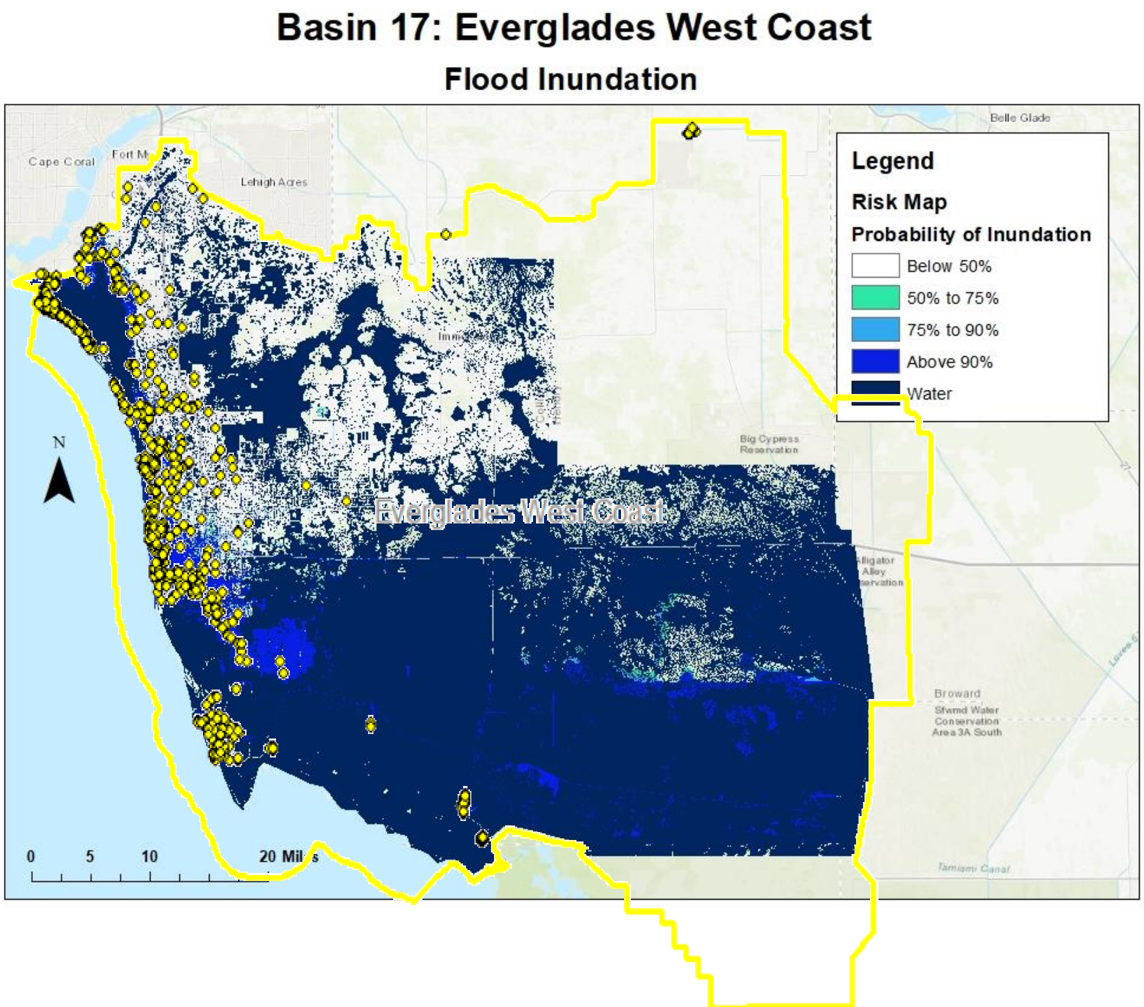

Figure 19: Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU

3.4 Drill down in Developed Areas Loss

Figure 20 shows the areas of the basin that are developed and flooded so further drill down could be conducted. The drill down maps show the Fort Myers Beach (1), Bonita Springs (2), North Naples (3), Naples (4), and Marco Island (5) drill down areas of critical importance.

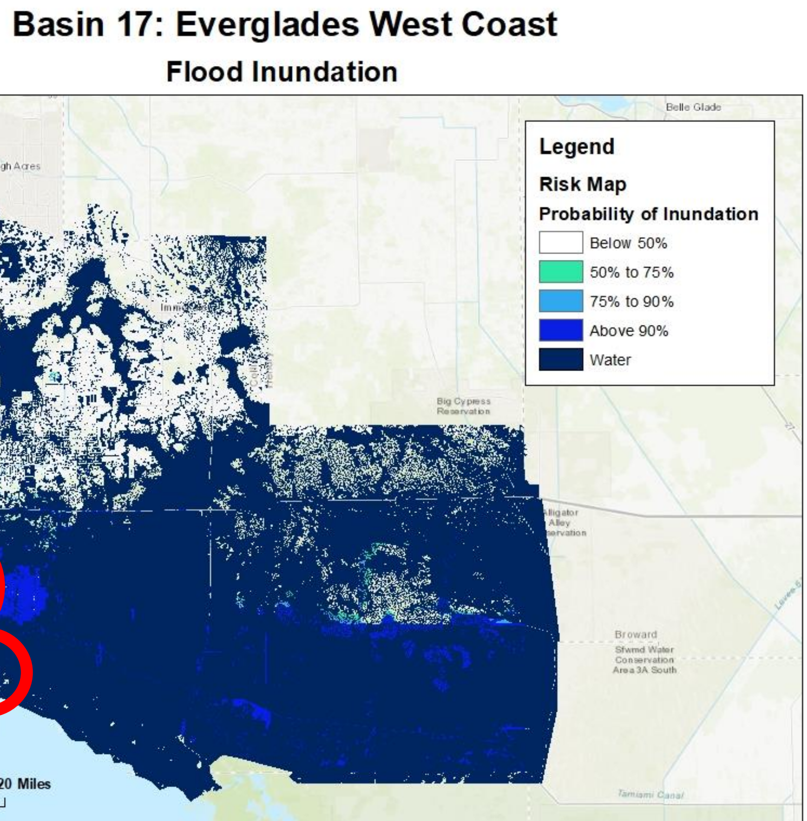

Figure 20: Location of Drilldown Areas

3.4.1 Fort Myers Beach

Fort Myers Beach was identified as a regional location for the drilldown area within Basin 17. Fort Myers Beach is a small town located in the near the center of Lee County, just south of the Caloosahatchee River. Fort Myers Beach is not the direct observation of this breakdown, as islands like Estero Island, where Fort Myers Beach is located, are expected to have high risk of flooding. Areas located within 10 miles of Fort Myers Beach are expected to have a high likelihood of flooding with 25 years as shown in Figure 21.

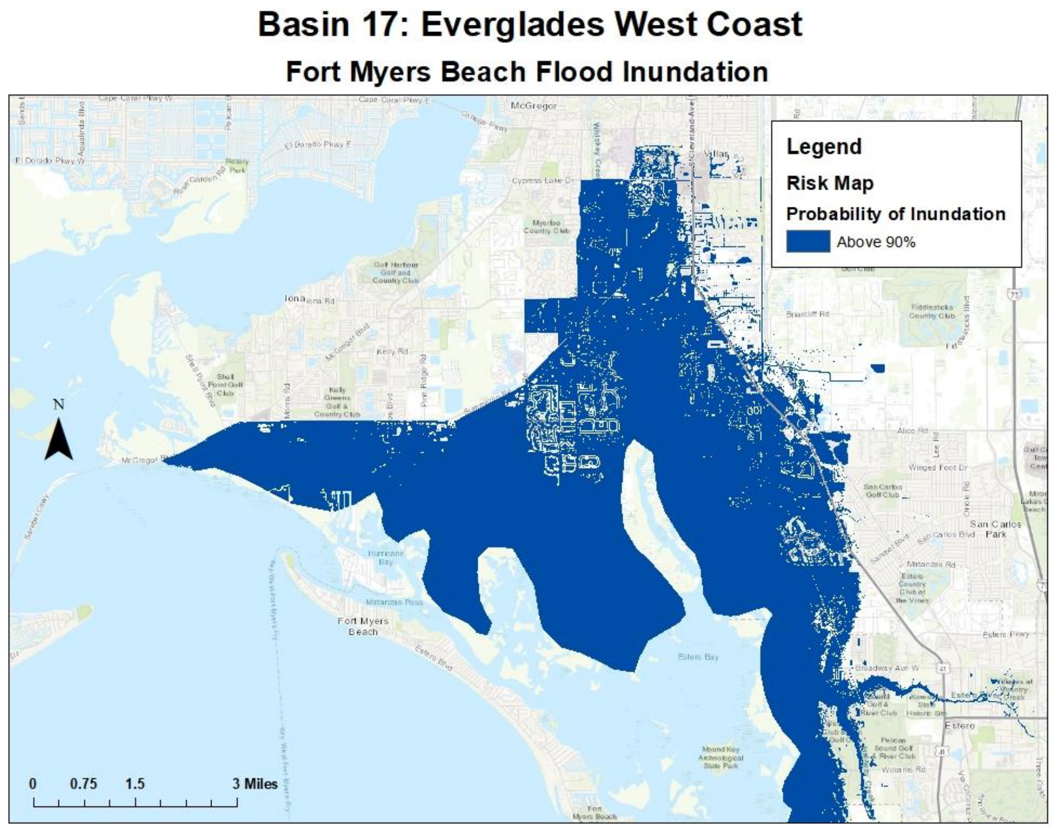

Figure 21: Fort Myers Beach Drilldown

3.4.2 Bonita Springs

Bonita Springs was another selection for the area of the drilldown area within Basin 17. Bonita Springs is located in the southern portion of Lee County, just above the border with Collier County. Most of the coastal regions have over 90% chance of flooding inundation and follows into the innercoastal regions as well. Flooding in this region has a high likelihood as shown in Figure 22.

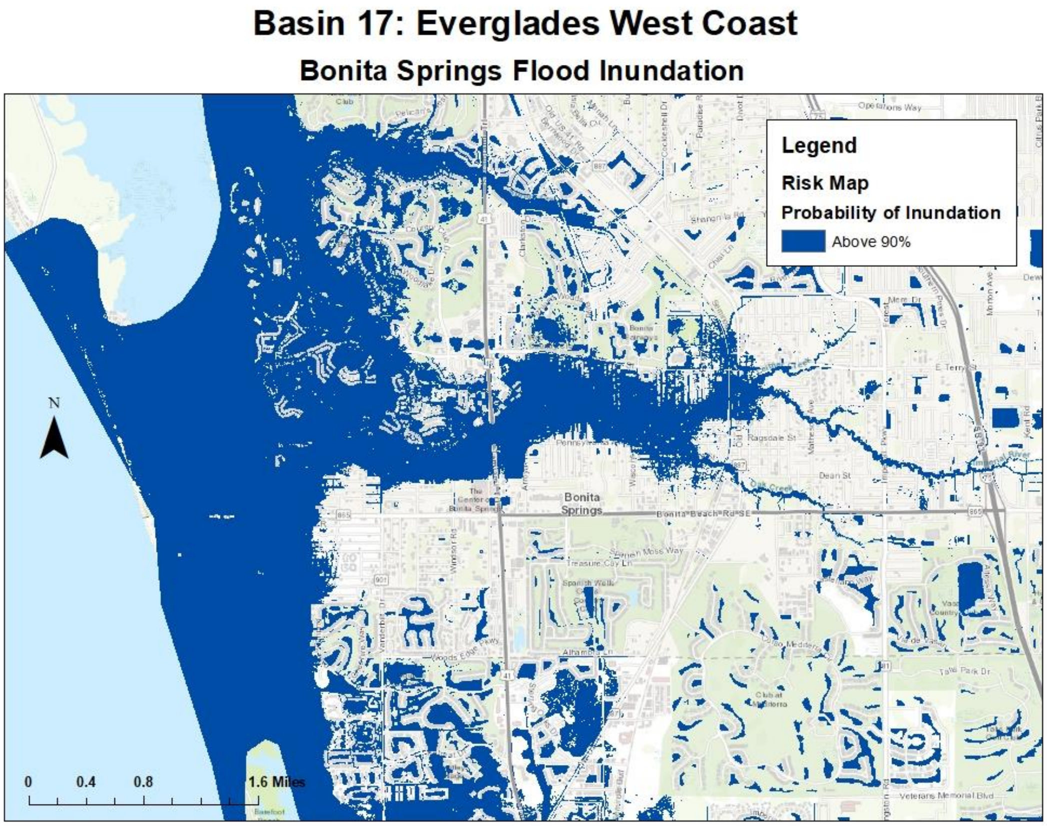

Figure 22: Bonita Springs Drilldown

3.4.3 North Naples

North Naples was another area selected to be of importance as a drilldown area within Basin 17. North Naples is a region in Collier County between Bonita Springs and Naples. Similar to Bonita Springs, the majority of the high risk flood likelihood is near the coastal and innercoastal regions. Small islands and property near the water can be seen to be affecte in Figure 23.

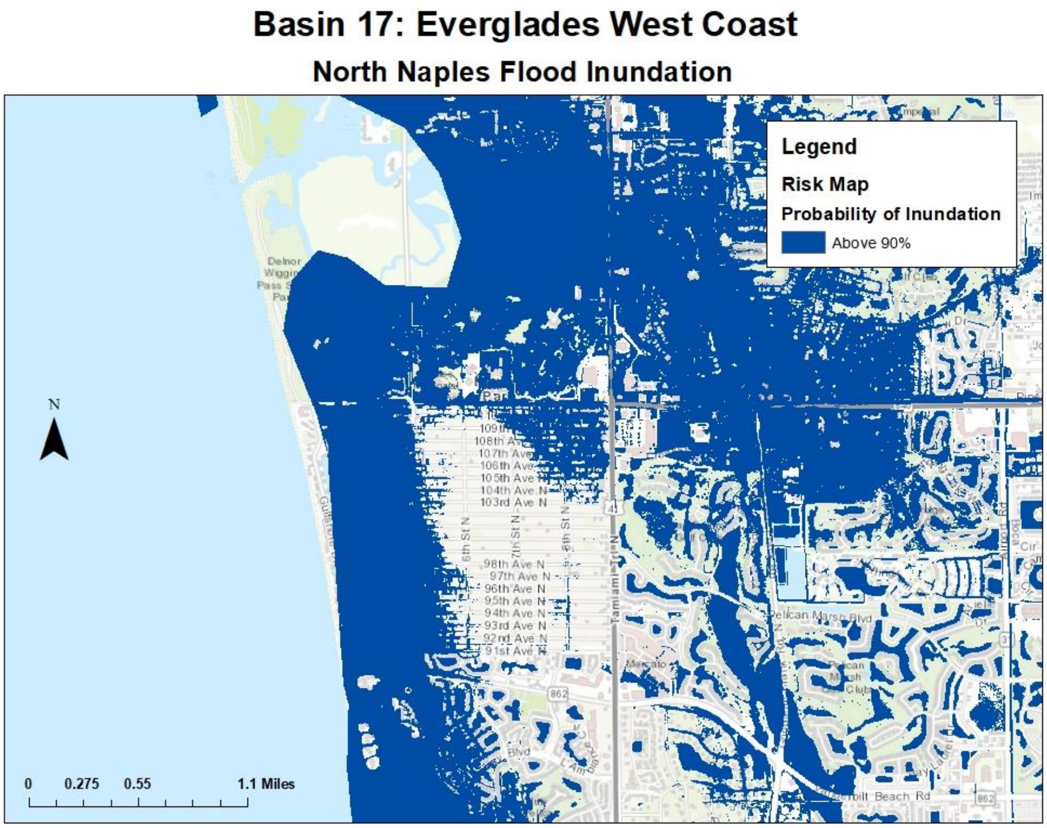

Figure 23: North Naples Drilldown

3.4.4 Naples

Naples was indicated to be a location for the drilldown area within Basin 17. Naples is located in the central portion of Collier County. Naples is a bigger and more populated area than most, however it still contains a probability of over 90% chance of flooding inundation throughout. Flooding is to be expected with 25 years according to the modeling of inundation.

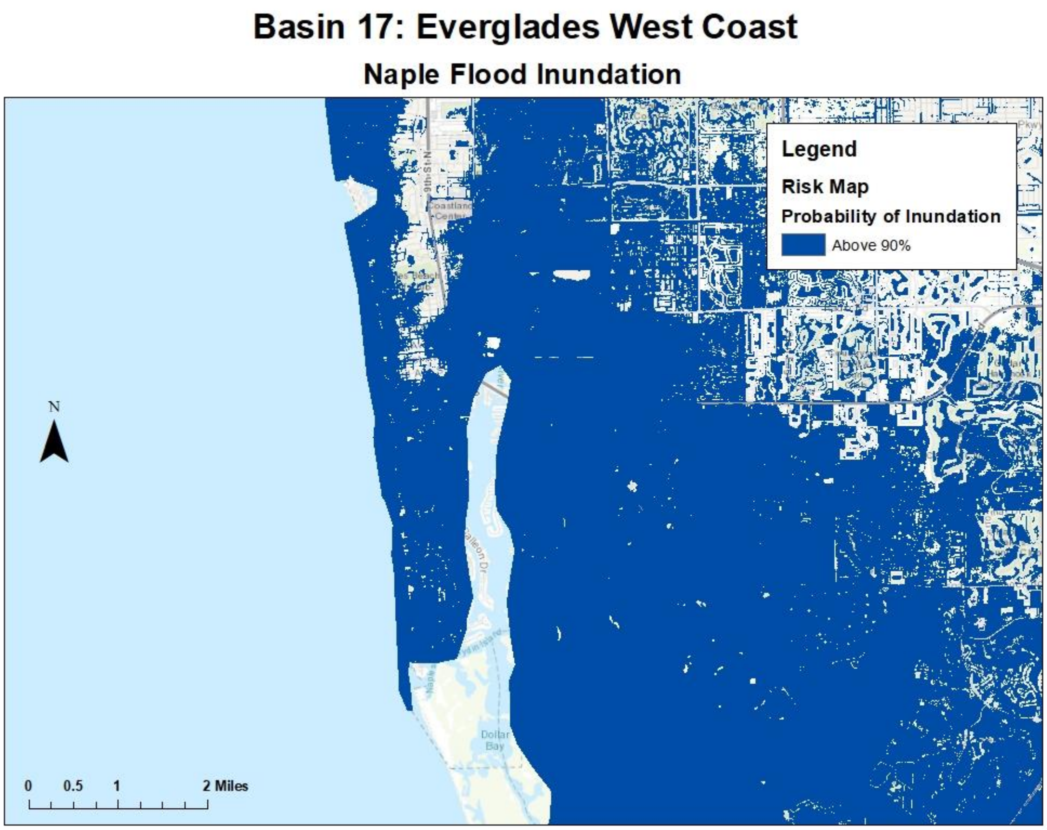

Figure 24: Naples Drilldown

3.4.5 Marco Island

Marco Island was selected as one of the locations for the drilldown area within Basin 17. Marco Island is located in the southern portion of Collier County, just south of the city of Naples. As expected of an island, there is an over 90% chance of flooding inundation in almost all of Marco Island. This signifies that within 25 years that there is a very high change of flooding on Marco Island. Events like hurricanes or tropical storms will also raise the likelihood as well.

Basin 17: Everglades West Coast

Marco Island Flood Inundation

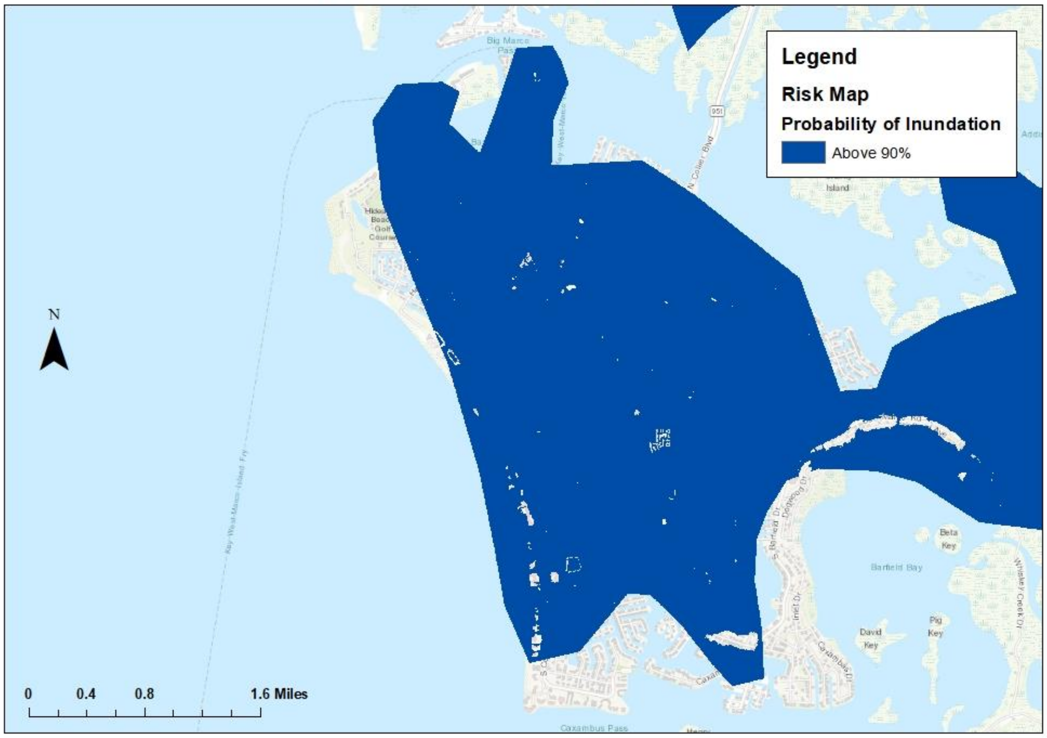

Figure 25: Marco Island Drilldown

4.0 Conclusion

FDEM contracted with FAU to develop a screening tool of flood risk areas for 29 watershed basins. The effort discussed herein focusses on the development procedures for a screening tool to assess risk in the Collier/Lee/Big Cypress Basin (#17) basin, a watershed located in Southwest Florida that combines readily available data on topography, ground, and surface water elevations, tidal information for coastal communities, soils, open space and rainfall to permit an assessment of the risk of inundation of property. The basin shows widespread flooding due to low elevation proximity to the Gulf of Mexico coast and extensive sensitive areas that currently received extensive environmental protection. A drilldown to the local communities indicates that the major developments are floodprone. The specific considerations, modeling, and analysis of the Collier/Lee/Everglades West watershed were discussed to support the development of a comprehensive watershed management plan. The management plan will inform local efforts to prioritize funding for future mitigation and resiliency planning to protect vulnerable communities and infrastructure. Solutions to improve flood resiliency in theis basin will yield long term benefits.

5.0 References

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