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Nassau/St. Mary's - Watershed Case Study

TMDL BASIN 14

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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 having 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. Nearly 3.6 million policyholders in 1,444 communities participate in the CRS program, but this is only 5% of the over 22,000 communities participating in the NFIP.

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 developing watershed management plans. There are several steps to address the development of watershed plans including the development of 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 Nassau and Baker County, Florida, a watershed located in Northeast Florida that combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, soils, open space and rainfall to permit an assessment of the risk of inundation of property in the County. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties.

1.0 Introduction

Nassau County is the northeastern most county in Florida. It includes the cities of Fernandina Beach, Callahan, Yulee, Hillard, and Nassau Village-Ratliff, along with others. Nestled beneath is Baker County. This county contains the cities of MacClenny, Glen Saint Mary, and more. Both are considered coastal counties, with Nassau having a population of 88,000 and Baker county at 29,000. The major watershed connecting them is the Nassau-St. Mary’s Watershed. The Nassau-St. Mary’s Watershed being spread between Georgia and Northeast Florida.

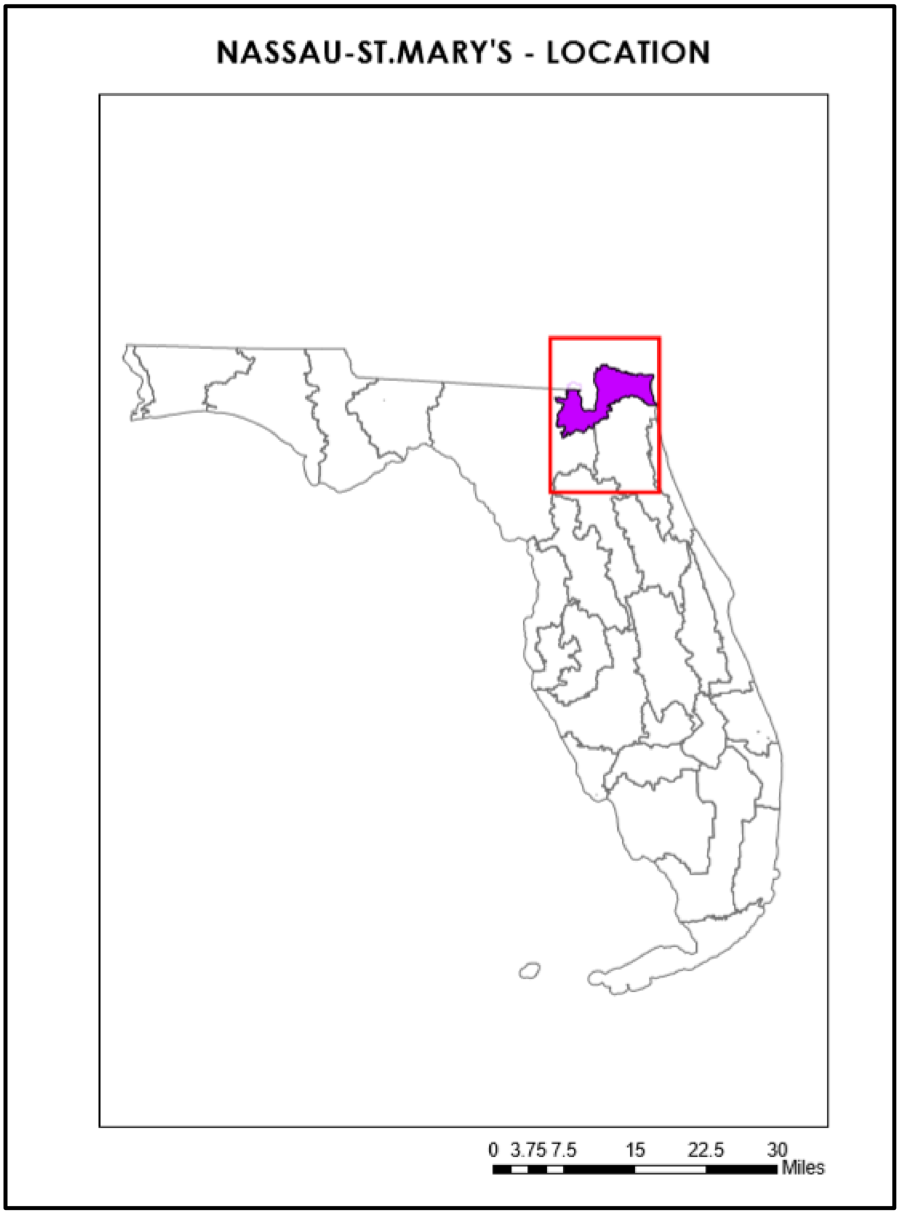

Figure 23. Location of Nassau- St. Mary's River Basin

2.0 Summary of Watershed

2.1 General Description of Watershed

2.1.1 Climate/Ecology

Northeast Florida is a part of the South Atlantic Coastal Plain ecoregion. This area has a large variety of species and ecological communities. There are a variety of ecological systems such as fall-line sandhills, rolling longleaf pine uplands, wet pine flatwoods, small streams, large river systems, rich estuaries, isolated depression wetlands, Caroline bays, and the Okefenokee Swamp. There are other systems such as maritime forests on barrier islands, pitcher plant seepage bags and Altamaha grit (sandstone) outcrops. This area gets roughly 50 inches of rain per year for about 113 days per year (bestplaces.net).

2.1.2 Topography and Soils

The natural features within Nassau River specifically contain low lying coastal plains with tidal marshes to the east, and forested wetlands with uplands to the west and north (sjrwmd.com). The sub-basin slopes fall between one percent in the western portion of the watershed to less than 0.1 percent for sub-basins in found in the eastern portion of the basin. In the western sub-basins, Surface elevations tend to range from 35 to 80 feet NGVD. Eastern sub-basins near the Atlantic Ocean generally range from 3 to 25 feet NGVD.

There are 83 individual soil types found within the Nassau River Basin. Most of these soils have been assigned a dual hydrologic soil grouping, representing a drained and undrained condition generally representing runoff improvements to the basin due to development or agricultural improvements. The Nassau river basin is mainly unimproved, and thus most of them are poorly drained.

2.1.3 boundaries/Surface Water

The St. Mary's River experiences three physical changes from one end to the ocean. Its headwaters, from Okefenokee Swamp, and the Pinhook Swamp, start narrow and twisting (law.ufl.edu). Some vegetations surrounding the area include cypress and tupelo trees and white sandbars. The river widens at the middle with swamps and sandy bluffs from Traders Hill to the U.S. 12 bridge. The lowest section is dominated by tides, where reverse flows occur twice daily. This goes from the U.S. 17 bridge to Cumberland Sound, where freshwater and saltwater marshes are prevalent.

2.1.4 Hydrogeological Considerations

The Floridan aquifer system is one of the major sources of ground-water supplies in the United States, for many it is the sole source of freshwater (pubs.er.usgs.gov). This underlies all of Florida, southern Georgia, and pieces of Alabama and South Carolina. This amounts to roughly 100,000 square miles, with 3 billion gallons of water per day being withdrawn from the aquifer. This is a system of hydraulically connected carbonate rocks – mainly limestone and some dolomite – which ranges from Late Paleocene to Early Miocene. There is varying thickness from a featheredge where more than 3,500ft are cropped out where is aquifer is deeply buried. In north Florida, there is little permeability contrast within the aquifer system. As a result, the Floridian is effectively one continuous aquifer. Low-permeability clastic rocks overlie most of the aquifer. Its permeability comes from openings that vary from fossil hashes and networks of many solution-widened joints to large cavernous openings in karst areas. Transmissivities are highest (greater than 1,000,000 ft squared per day) in the unconfined karsts areas of central and northern Florida. The dominant feature of the Floridian flow system, before and after ground-water development, is the Upper Floridian aquifer springs. Here, almost all occur in unconfined and semiconfined parts of the aquifer in Florida. Before ground-water development, spring flow and point discharge to surface-water bodies was roughly 88 percent of the estimated 21,500 cubic ft per second total discharge. The current discharge (early 1980s) is close to 24,100 cubic ft per second, with 75 percent of which is spring flow and discharge to surface-water bodies, 17 percent is withdrawal from wells, and 8 percent is diffuse upward leakage. Pumpage has been supplied by the diversion of natural outflow from the aquifer system and by induced recharge instead of loss of water from aquifer storage. All of the gallons pumped by the aquifer, has resulted in long-term regional water-level declines of more than 10 ft in northeast Florida, west-central Florida, and the panhandle. Saltwater has encroached due to this pumping as well. Water chemistry is reliant on the flow and proximity to the freshwater-saltwater interface. In the unconfined or semiconfined areas where flow is vigorous, dissolved-solids concentrations are low (less than 250 milligrams per liter). Where the system is more tightly confined, flow is more sluggish and concentrations are higher.

2.2 Socio-economic Conditions of the Watershed

2.2.1 Demographics

Baker county has a population of 27,537, a poverty rate of 17.2 percent, a median age of 37.1, a median household income of $59,506, and majority of the population is white, at just over 80 percent, followed by black individuals just under 20 percent.

Nassau county has a population of 78,435, a poverty rate of 11.4 percent, a median age of 44.9, a median household income of $64,294, and a majority of the population is white, at just over 80 percent, followed by black individuals just below 10 percent (datausa.io).

2.2.2 Property

Majority of the area is residential; the average property value falls around $162,000.

2.2.3 Economic Activity/Industry

Employment indicates the watershed includes farming, conservation, forestry, and tourism. There is significant agriculture in the watershed, with most available property not developed.

3.0 Watershed Analysis

3.1 Data Sets

3.1.1 Topography

Figure 2 shows the results of the LiDAR 3-meter DEM processed conducted for the watershed. There are some differences between St. Mary's and Nassau in terms of elevation. St. Mary's has lower elevations towards the southwestern portion, and higher elevations towards the top, by the Florida – Georgia border. Nassau experiences a more east to south drop, with the western side being the highest elevation and the eastern towards the ocean being the lowest. The areas around the main rivers are higher for both sections and get lower as they go away from the bodies of water.

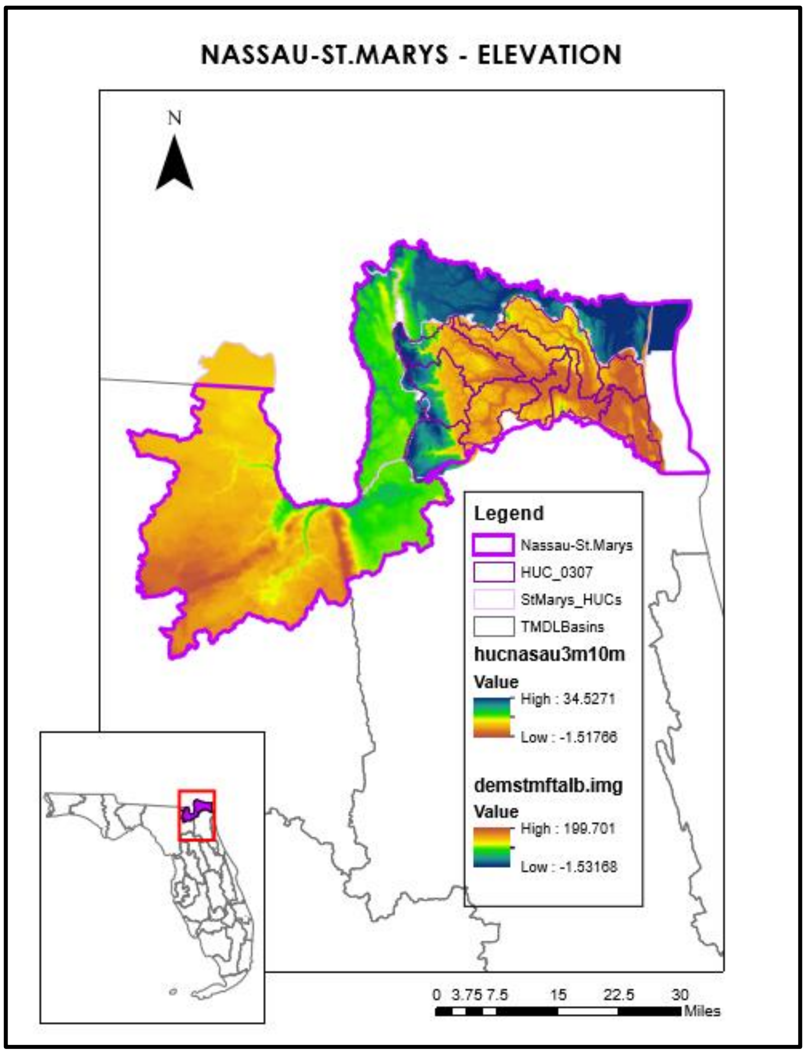

Figure 24. Elevations for the Nassau-St .Mary's River Basin

The areas with the highest elevations belong to Mills creek and Upper alligator, which are located in the northern most part of the Nassau Basin, seen in table 1. Mills Creek and Lofton Creek have the largest area. The catchments were separated by the bodies of water within them, as well as by the location of water stations. Table 2 shows that Upper St. Mary's River has the largest max height and area. This is located at top right corner of Florida

Table 7. Elevations for Nassau River watershed

Catchments

FID	Shape *	Id	Name	Acres	Rowid	NAME *	ZONE-CODE	MIN	MAX	RANGE	STD
0	Polygon	1	Pumpkin Hill Creek	23352.548285	1	Pumpkin Hill Creek	1	-4.979195	62.943794	67.922989	5.76952
1	Polygon	2	South Amelia River	14373.484505	2	South Amelia River	2	-2.736552	70.235283	72.971835	7.253851
2	Polygon	3	Nassau River	16075.081422	3	Nassau River	3	-3.115671	48.002411	51.118082	11.090811
3	Polygon	4	Upper Nassau River	14414.749507	4	Upper Nassau River	4	-1.930839	54.860123	56.790962	9.087648
4	Polygon	5	Lofton Creek	33936.866084	5	Lofton Creek	5	-1.914408	98.046562	99.96097	9.645947
5	Polygon	6	Plummer Creek	27430.676254	6	Plummer Creek	6	-1.300003	43.523582	44.823585	7.434324
6	Polygon	7	Mills Creek	36122.192012	7	Mills Creek	7	-0.547405	113.277725	113.82513	26.926722
7	Polygon	8	Upper Alligator	30065.070854	8	Upper Alligator	8	0.26411	109.798775	109.534665	25.875071
8	Polygon	9	Thomas Creek	27615.469587	9	Thomas Creek	9	-0.131184	44.81604	44.947224	6.270769
9	Polygon	10	Upper Thomas Creek	25836.186488	10	Upper Thomas Creek	10	0	109.798775	109.798775	21.640732

Table 8. Elevations for St. Mary's River watershed

zon_dem

Rowid	PLANUNIT	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN
1	Upper St. Marys River	1	18705951	1767131585.643747	37.448017	199.700897	162.25288	121.249099
2	Middle St. Marys River	2	3553270	335673692.790084	0.726452	111.437454	110.711002	70.395128
3	Lower St. Marys River	3	4948602	467489244.411034	-1.531683	111.338661	112.870344	18.315878

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3.1.2 Groundwater

The lowest concentration of groundwater occurs to the east, by the Atlantic Ocean, seen in Figure 3. This may also translate into Georgia. This also means that the highest level of groundwater occurs further inland. This may mean that there is less porous rock near the ocean – probably to reduce immediate flooding of beaches as well as the organic formations, and more porous rocks more inland. There is also the potential for there to be more water features being carried inland for more freshwater. Mills creeks has the highest level of groundwater, as seen in Table 3.

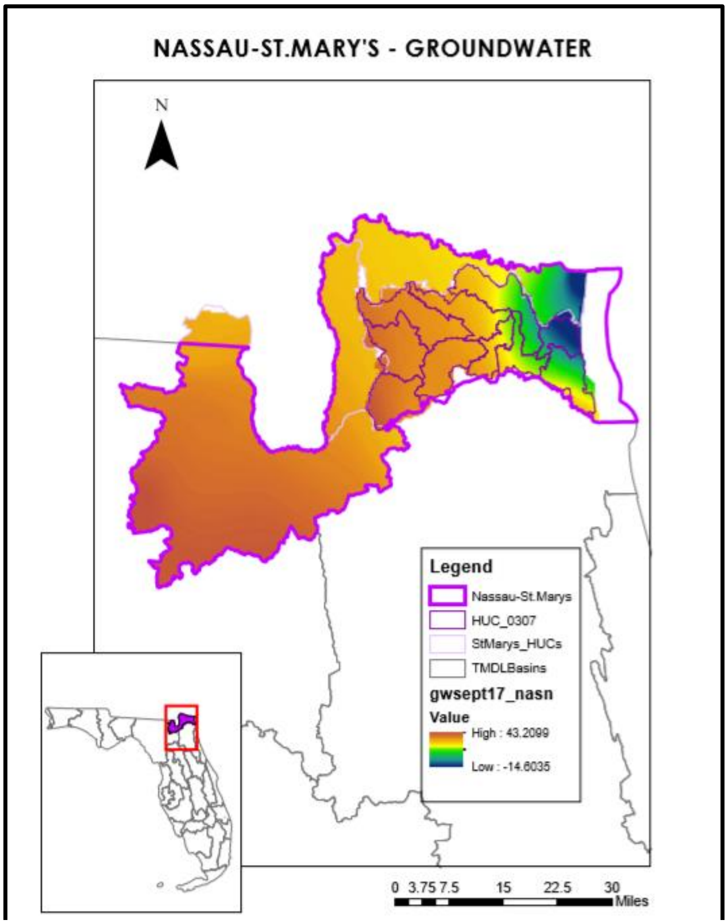


Figure 3. Groundwater for the Nassau-St. Mary's Basin

Table 9. Groundwater for Nassau River Basin

GW_nasSep17

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD
1	Pumpkin Hill Creek	1	373	93250000	19.446842	35.800377	16.353535	28.860383	4.001896
2	South Amelia River	2	231	57750000	10.135199	28.598085	18.462887	18.543318	4.005125
3	Nassau River	3	262	65500000	26.309916	35.919655	9.609739	31.008861	2.217352
4	Upper Nassau River	4	229	57250000	29.438351	38.560989	9.122639	34.763363	2.654392
5	Lofton Creek	5	547	136750000	21.956934	37.37442	15.417486	31.041202	4.363141
6	Plummer Creek	6	448	112000000	29.92835	38.75267	8.82432	36.443534	1.840821
7	Mills Creek	7	582	145500000	37.151176	40.579727	3.428551	38.93439	0.757374
8	Upper Alligator	8	487	121750000	38.79081	40.654961	1.864151	39.48181	0.507628
9	Thomas Creek	9	444	111000000	36.404343	38.879227	2.474884	38.476771	0.510245
10	Upper Thomas Creek	10	419	104750000	38.671989	43.101433	4.429443	40.354801	1.202206

3.1.3 Surface Waters

Figure 4 includes a map of the surface waters in the Nassau/St. Mary's watershed, along with the locations of the 21 groundwater stations, 7 surface water stations and 1 tidal gauge. Groundwater stations were adequately found throughout the entire watershed (See Figure 5), while surface water stations were only found in the outlet of the watershed. These were chosen based on the date 08/04/2018, which contained the highest recorded water levels of the active stations and reduced influence of unusually large storm events on the watershed.

Catchments

FID	Shape *	Id	Name
0	Polygon	1	Pumpkin Hill Creek
1	Polygon	2	South Amelia River
2	Polygon	3	Nassau River
3	Polygon	4	Upper Nassau River
4	Polygon	5	Lofton Creek
5	Polygon	6	Plummer Creek
6	Polygon	7	Mills Creek
7	Polygon	8	Upper Alligator
8	Polygon	9	Thomas Creek
9	Polygon	10	Upper Thomas Creek

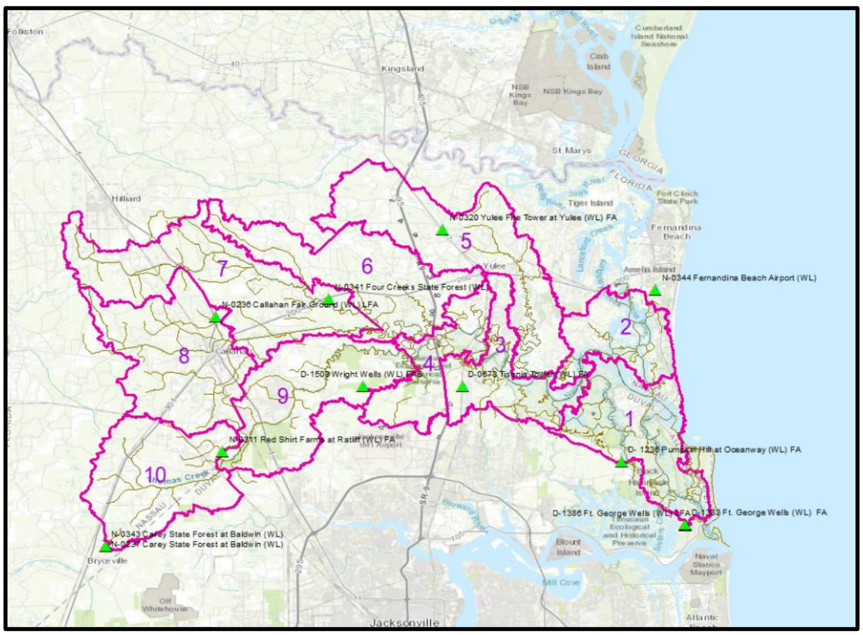
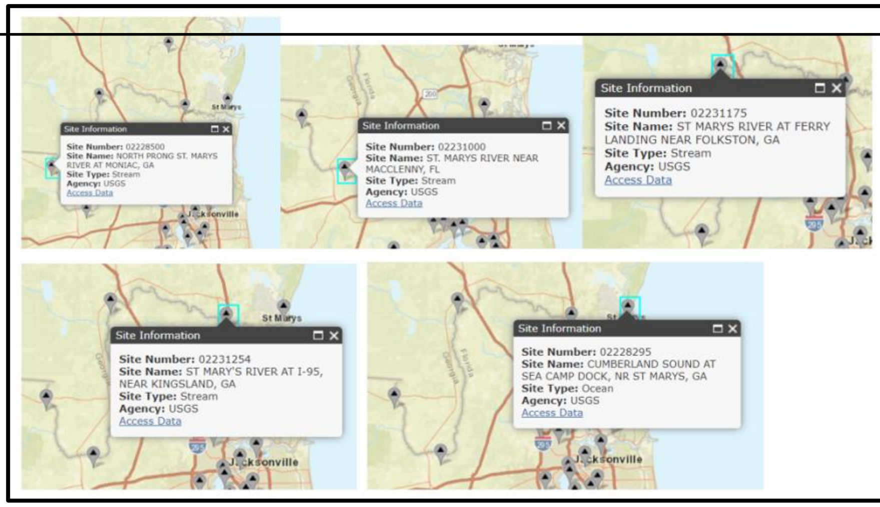


Figure 4. Water Stations for the Nassau HUC Basins



StMarys_StationNames.csv

StationID	StationName	Long_DD	Lat_DD	Date	Lat_DMS	Long_DMS	WL_ft_date	WL_max_Dec	Lat_DD	Long_DD
2228500	NORTH PRONG ST. MARYS RIVER AT MONIAC, GA	82.230556	30.5175	12/19/2018	30°31'03"	82°13'50"	10.12	10.73	30.518	82.231
2231000	ST. MARYS RIVER NEAR MACCLENNY, FL	82.081667	30.358611	12/19/2018	30°21'31"	82°04'54"	12.65	13.04	30.359	82.082
2231175	ST MARYS RIVER AT FERRY LANDING NEAR FOLKSTON, GA	82.024167	30.783056	12/21/2018	30°46'59"	82°01'27"	6.76	6.79	30.783	82.024
2231254	ST MARY'S RIVER AT I-95, NEAR KINGSLAND, GA	81.654444	30.077222	12/20/2018	30°44'38"	81°39'16"	3.05	3.33	30.077	81.654
2228295	CUMBERLAND SOUND AT SEA CAMP DOCK, NR ST MARYS, GA	81.47136	30.76433	12/20/2018	30°45'51.6"	81°28'16.9"	4.07	4.58	30.764	81.471
2321000	NEW RIVER NR LAKE BUTLER FLA	82.274167	29.998056	12/21/2018	29°59'53"	82°16'27"	8.13	8.87	29.998	82.274

Figure 5 Water stations in St. Mary's River Basin and measured water levels

3.1.4 Impervious

Figure 6 represents the water holding capacity. In the Nassau section there are significantly more urban areas than in St. Mary's. A lot of these urban areas are found near bodies of water, including the Atlantic Ocean. Figure 6 includes the impervious areas, primarily roads and structures. These are areas where water cannot seep into the soil, and as a result may travel on the surface.

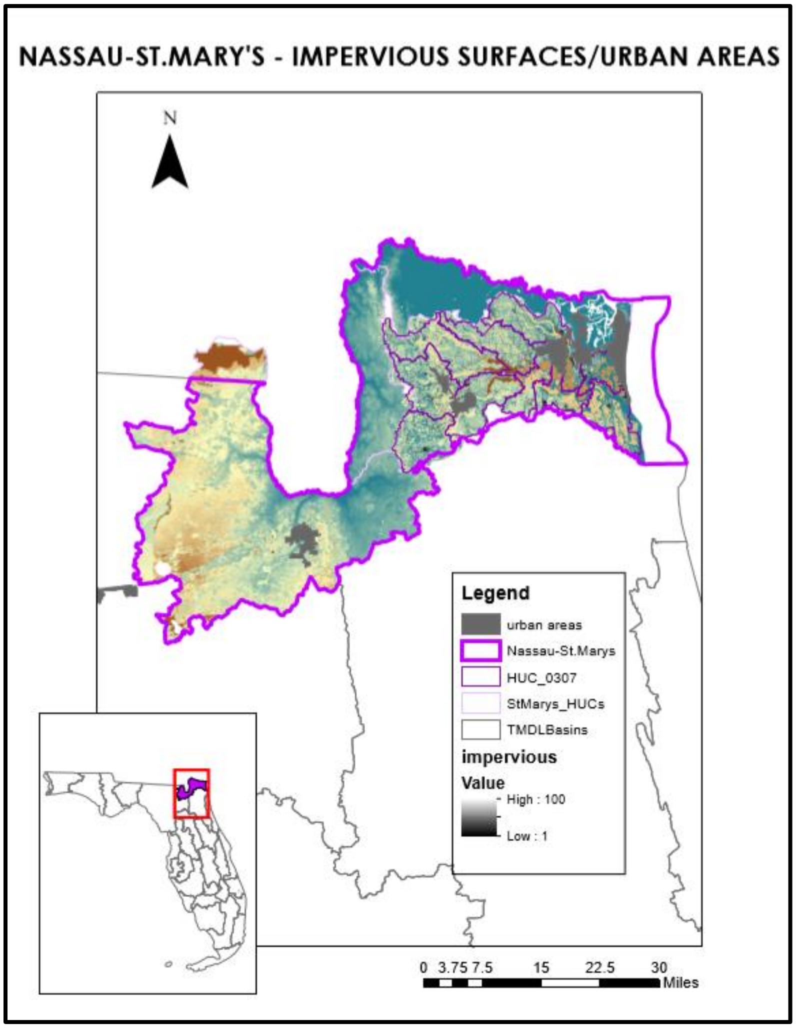


Figure 6. Water Holding Capacity and Impervious surfaces in the Nassau-St. Mary's River Basin

3.1.5 Precipitation

Figure 7 represents rainfall 25-year/ 3 day precipitation event. Both sections follow the same pattern. St. Mary's and Nassau have lower rainfall intensity inland, and higher rainfall intensity closer to the Atlantic Ocean. The variation between 2 inches at the most, is a common trend in Florida because the state is surrounded by water on three sides. Although there is that difference from the ocean inland, it is not as significant. South Amelia River receives the most rainfall, but they all fall within an inch of each other, while Upper Alligator and Upper Thomas Creek receive the least rainfall, seen in Table 4. Table 5 shows that Lower St. Mary's River receives the most rainfall. This is also the lowest point of the river. Upper St. Mary's River receives the least amount of rainfall.

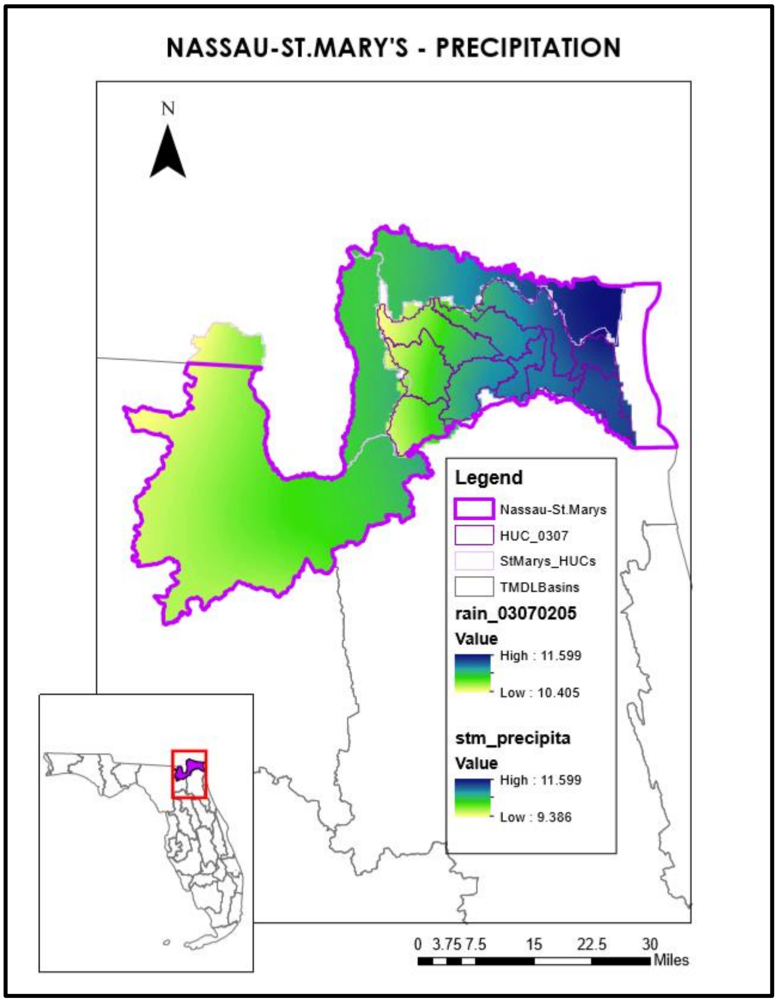


Figure 7. Rainfall levels for the Nassau-St. Mary's River Basin

Table 10. Precipitation for Nassau River Basin

rain_zonal

Rowid	NAME	ZONE-CODE	RANGE	STD	RAIN_MIN	RAIN_MAX	RAIN_MEAN
1	Pumpkin Hill Creek	1	0.087	0.018851	11.293	11.38	11.343402
2	South Amelia River	2	0.214999	0.048877	11.291	11.506	11.405974
3	Nassau River	3	0.123	0.027958	11.2	11.323	11.250371
4	Upper Nassau River	4	0.092	0.017551	11.159	11.251	11.205866
5	Lofton Creek	5	0.41	0.108653	10.972	11.382	11.214538
6	Plummer Creek	6	0.545	0.126459	10.699	11.244	11.058112
7	Mills Creek	7	0.713	0.202647	10.408	11.121	10.783812
8	Upper Alligator	8	0.487	0.112616	10.469	10.956	10.739054
9	Thomas Creek	9	0.302999	0.071608	10.887	11.19	11.072809
10	Upper Thomas Creek	10	0.432	0.108985	10.504	10.936	10.696514

Table 11 Precipitation for the St. Mary's area

zon_precipita

Rowid	PLANUNIT	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN
1	Upper St. Marys River	1	2388	0.16582	9.386	10.68	1.294001	9.938679
2	Middle St. Marys River	2	458	0.031803	10.271	10.668	0.397	10.398395
3	Lower St. Marys River	3	631	0.043816	10.315	11.599	1.284	10.948513

3.1.6 Open Space

The open space map (Figure 8) is from the USGS NLCD 2016 land cover dataset and the open lands are displayed in the map.

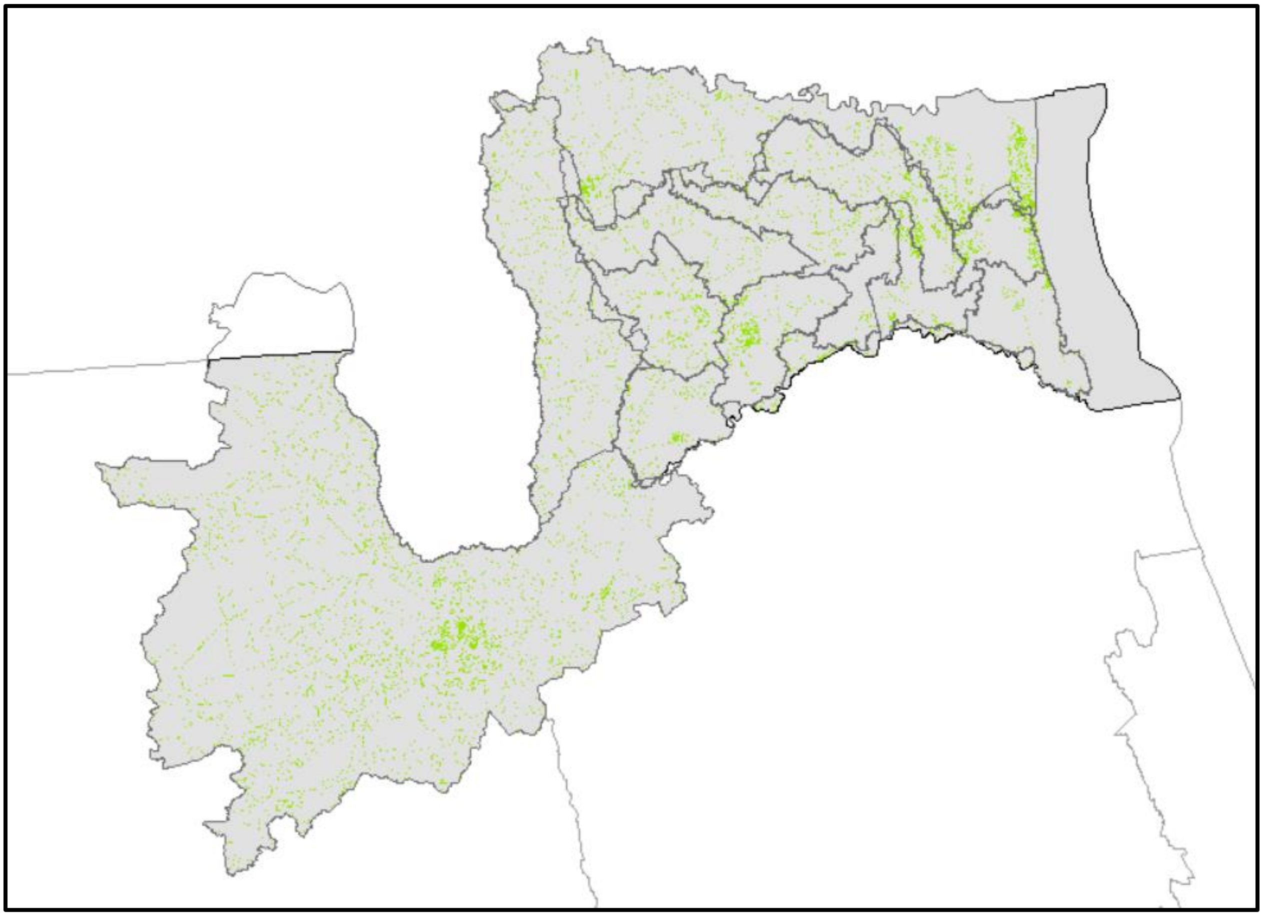


Figure 8. Open Space Map for Nassau and St. Mary's River Basin

3.1.7 Soil Depth

Much like precipitation, these two sections follow a similar pattern. The soil depth is lower towards the ocean and higher the more inland you go. There is also less soil depth at the border of Florida and Georgia. The soil depths also start lower and get higher the further you go from rivers and streams (see Figure 9).

Figure 10 shows the water storage in the St. Mary's and Nassau area. There is more water storage closer towards the major bodies of water. There is less water storage inland for St. Mary's than Nassau. The border of Florida and Georgia has more water storage or more concentration of water storage.

Mills Creek contains the largest value for ground storage in the Nassau Basin, seen in Table 6. Upper St. Mary's River has the largest value for ground storage in the St. Mary's basin. This also has the largest area size, seen in Table 7.

Figure 11 shows the water holding capacity of the St. Mary's and Nassau areas. There is a higher amount of water holding closest to rivers in the Nassau basin, and more towards the Atlantic Ocean for both St. Mary's and Nassau. Most of the area contains a low water holding capacity.

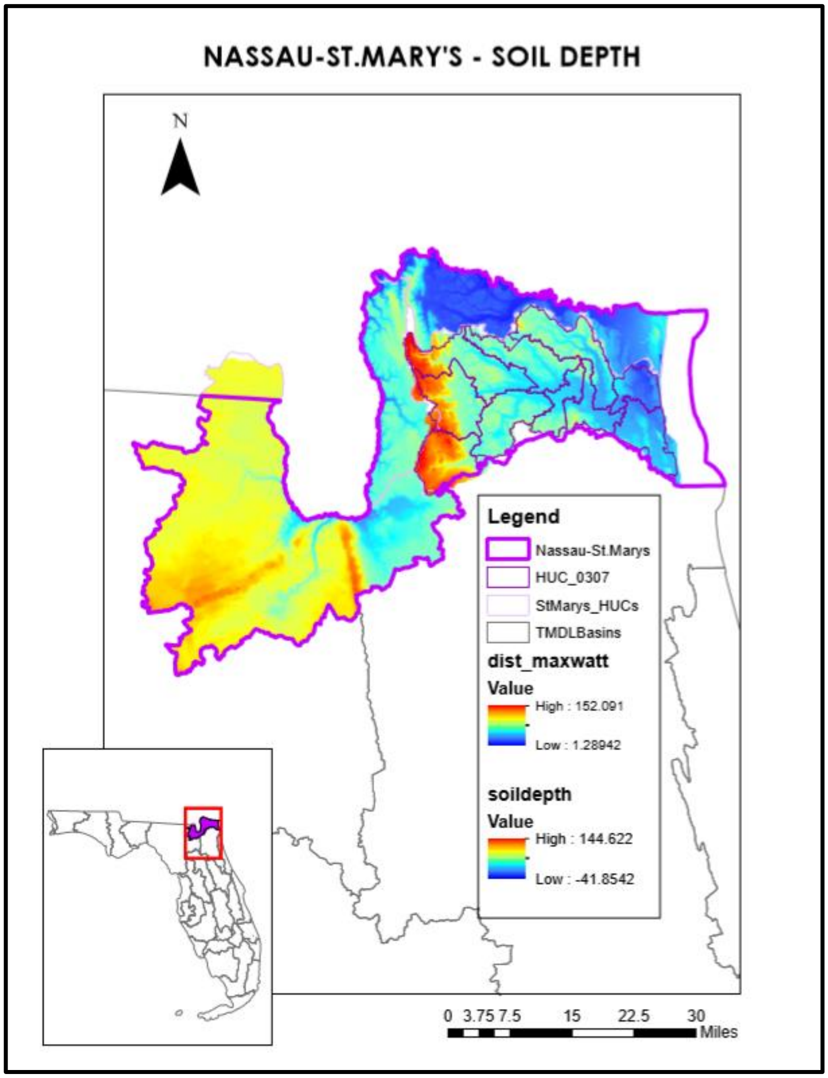


Figure 9. Varying soil depth for the Nassau-St. Mary's River Basin

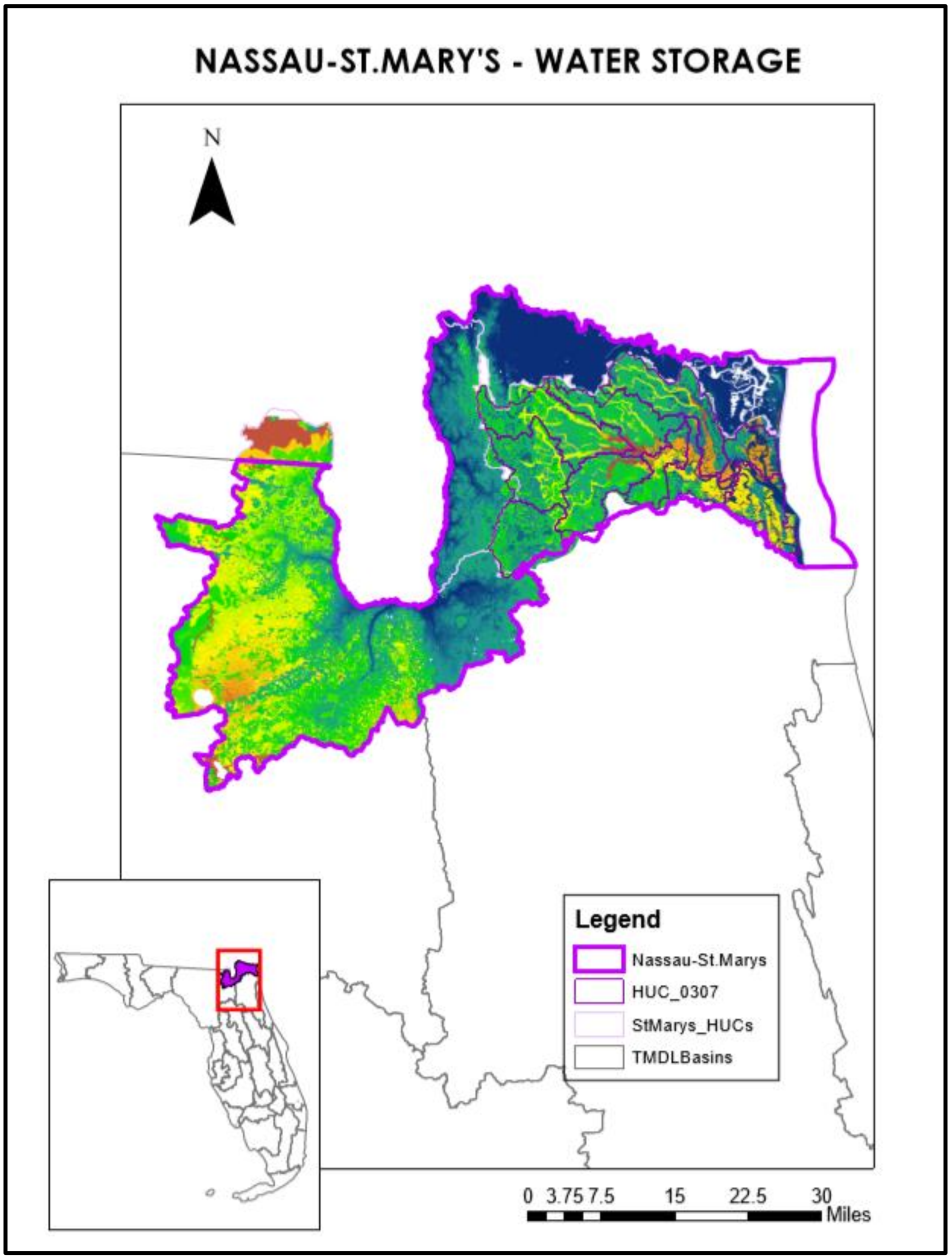


Figure 10. Water Storage for the Nassau-St. Mary's River Basin

Table 12 Ground storage for Nassau Basin

grndstornassau

Rowid	NAME	ZONE-CODE	AREA	MIN	MAX	RANGE	MEAN	STD
1	Pumpkin Hill Creek	1	93485100	0	3.704007	3.704007	1.220545	0.941699
2	South Amelia River	2	58113700	0	4.218253	4.218253	0.774257	0.794331
3	Nassau River	3	64997800	0	5.785513	5.785513	1.590195	1.081355
4	Upper Nassau River	4	58025300	0	4.626583	4.626583	1.98145	0.937576
5	Lofton Creek	5	136547100	0	6.47803	6.47803	1.601948	0.990406
6	Plummer Creek	6	111001400	0	5.677613	5.677613	1.919213	0.908964
7	Mills Creek	7	145954300	0	6.822776	6.822776	2.587056	1.297084
8	Upper Alligator	8	121453900	0	6.584131	6.584131	2.670058	1.393213
9	Thomas Creek	9	111585300	0	5.079456	5.079456	1.964785	0.913701
10	Upper Thomas Creek	10	103895400	0	8.713582	8.713582	3.116665	1.55943

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Table 13 Ground storage for St. Mary's River Basin

zon_grndstore

Rowid	PLANUNIT	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN
1	Upper St. Marys River	1	17280036	1728003600	0	111.209656	111.209656	26.496474
2	Middle St. Marys River	2	3275688	327568800	0	27.547253	27.547253	9.1592
3	Lower St. Marys River	3	4168419	416841900	0	31.424904	31.424904	1.258398

3.2 Modeling Protocol

The modeling of the watershed was done using ArcGIS, ArcHydro, and Cascade software. The 3-meter DEM and other maps were created by clipping the obtained layers to the 5-mile buffer of the watershed. A 5-mile buffer was used instead of the original boundary, as to remove any inconsistencies or abnormalities that could occur near the edges of the watershed. The groundwater layer (Figure 5) was created by using the kriging method in ArcGIS software, which utilized the water levels that were found by the groundwater stations, surface water stations, and tidal gauges.

Figure 11 shows the quantity of the soil storage that was computed in preparation for the final flooding data. This was created by using the expression *DEM - groundwater layer * 12 * soil storage capacity*. The areas with the lowest storage were found along the coast and in the middle, which correspond low elevation and the presence of water (ex. rivers, swamps). The areas with the highest amount of soil storage over 8 inches were found in drier parts of the inland, along with areas in higher elevation.

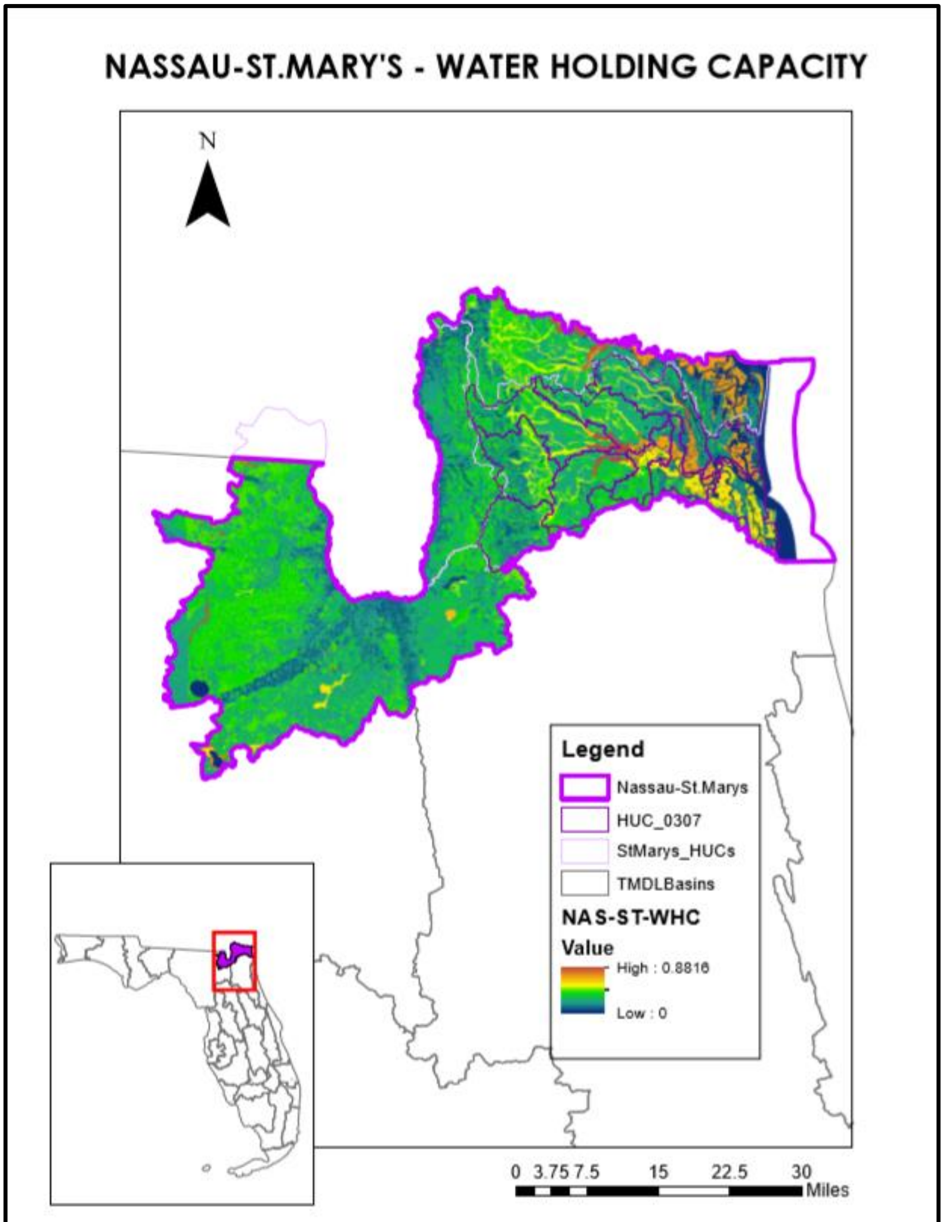

Figure 11. Water Holding Capacity for the Nassau-St. Mary's River Basin

ArcHydro was then used to generate the catchments within the watershed, which also included the drainage lines and drainage points for each of the catchments. This was done to determine the direction and the longest drainage path for the catchments to understand where water would flow from areas of higher elevation to areas of lower elevation. The average rainfall, average soil storage, initial drainage elevation, maximum ground elevation, and area in acres was then calculated for each catchment for use in Cascade software in order to calculate the maximum headwater height for each catchment in preparation for the flood inundation. Once the headwater height was obtained from each catchment, the expression *(Headwater Height – DEM Elevation) +/- 0.46)* was used to calculate the Z-score for the entire watershed, which was assigned a probability of flood inundation for the entire watershed.

3.3 Modeling Results

3.3.1 Watershed pathways

There are many contributing factors to flooding, 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, all the necessary input parameters to run CASCADE 2001 were either directly calculated or derived from existing datasets. Several surfaces were derived from the data and used to determine characteristics of the watershed, which represent the primary contributing factors to flooding. While a contributing factor such as the land elevation in the watershed can be directly observed using data collection methods such as LiDAR, other factors require further data processing and modeling.

CASCADE 2001 is a multi-basin hydrologic/hydraulic routing model developed by the South Florida Water Management District (SFWMD). The model develops solutions by basin. A basin is defined as an area where all the water that falls via rainfall stays in an area and travels to an outlet. The areas of the basin and the longest time it takes the runoff to travel to the most distance point to reach the point of discharge must be estimated. Rainfall is also needed. The catchments and waterway flow paths that were produced from ArcHydro as shown for the Nassau/St. Mary's watershed can be found in Figure 12.

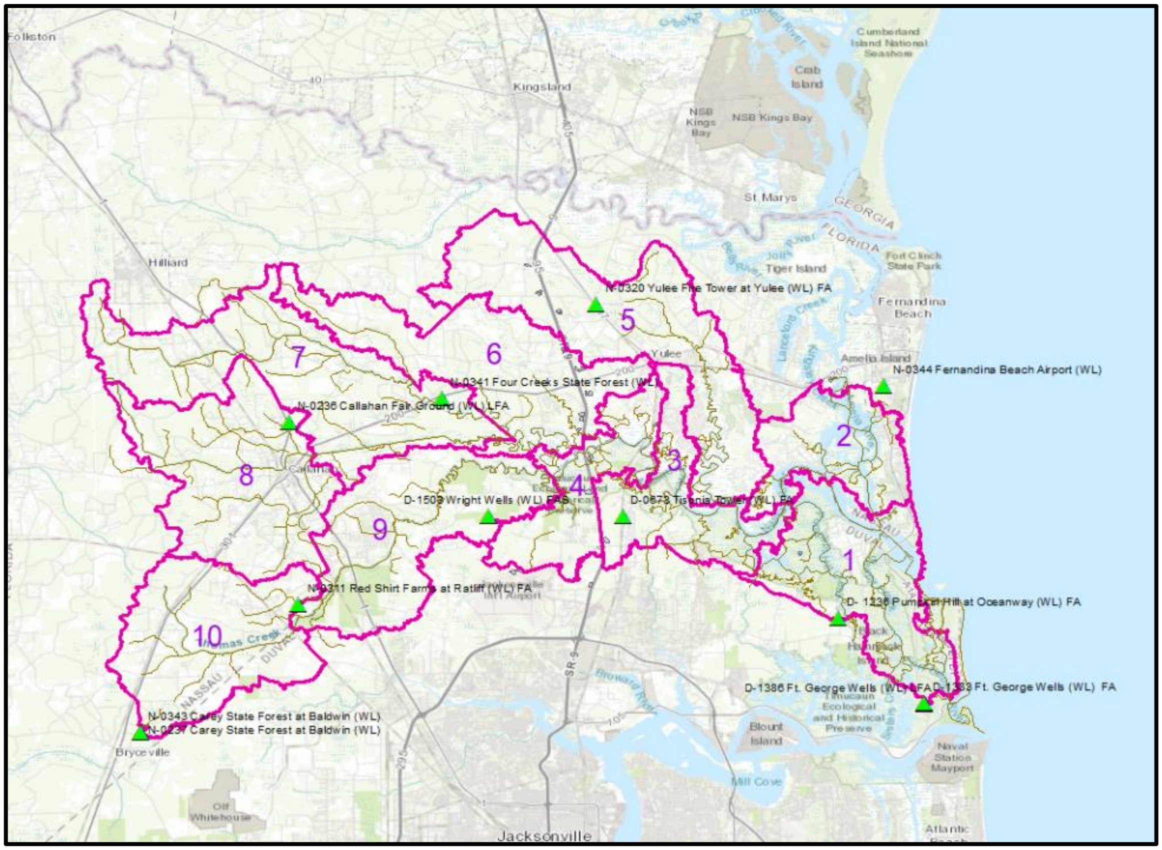

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Figure 12 Catchments and flow paths in the Nassau/St. Mary’s watershed.

3.3.2 Cascade Results

The final results from Cascade can be seen in Figures 12-24, which displays the predicted headwater height for each of the catchments, along with the area in acres, mean rain, mean soil storage capacity, initial stage, and the maximum elevation from ArcGIS and ArcHydro. The mapping for the Nassau and St. Mary’s basins used the information from the watershed analysis.

1. Area: Basing this information on the DEM values, which were derived from merging the smaller catchments into larger ones, the area was determined and converted to acre-ft.
2. Offsites: These were given to each catchment. Which offsite, was determined by where the water body drained into.
3. The initial stage: This was determined by finding the outlets
4. Ground storage: Data came from soil storage/ ground storage tables
5. Time of concentration: determined by dividing the longest river length by 3600
6. Rainfall: Data was used from precipitation tables

7. Stage-Storage relationship
8. Structure: Initial stage values were used for gravity structures

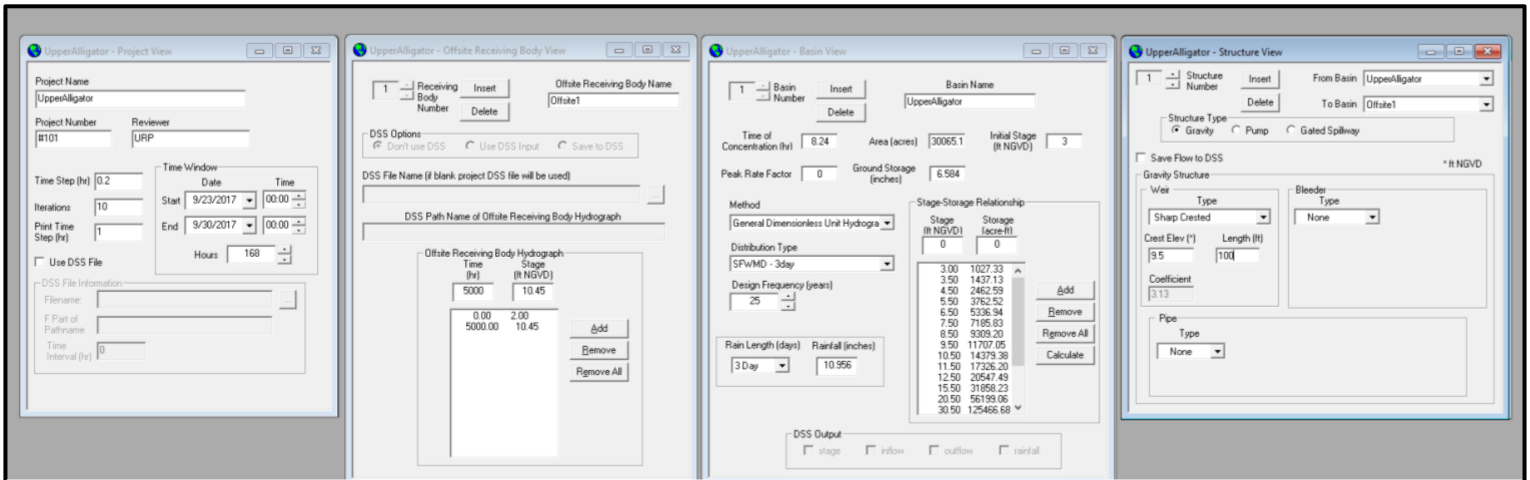

Figure 13. Cascade run for Upper Alligator in Nassau

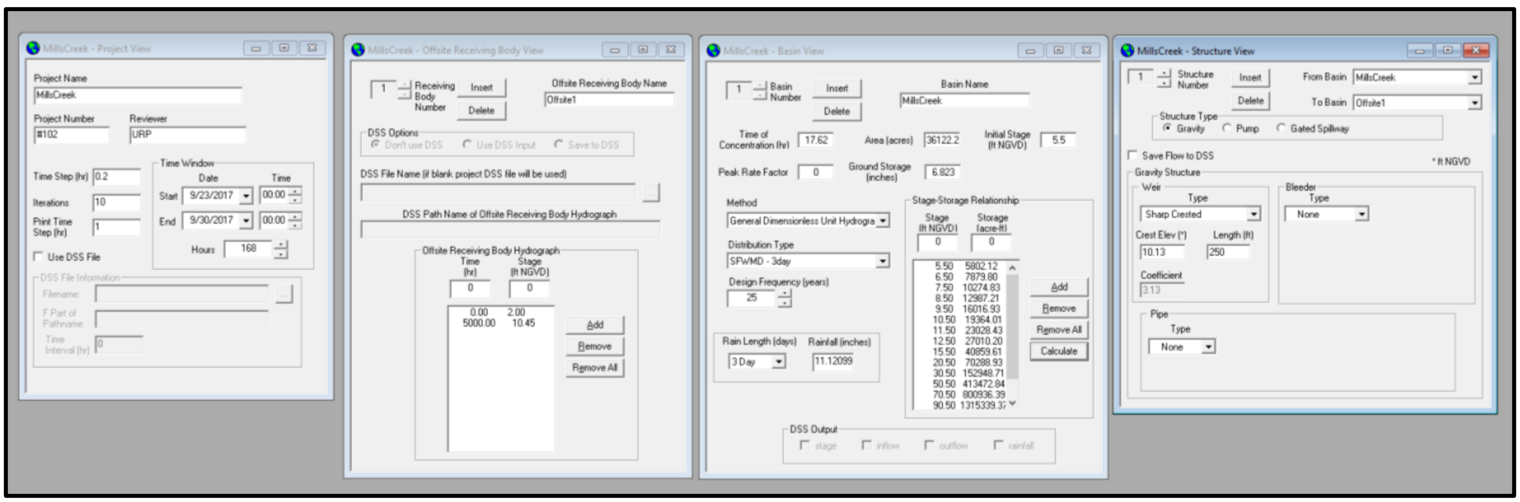

Figure 14. Cascade run for Mills Creek in Nassau

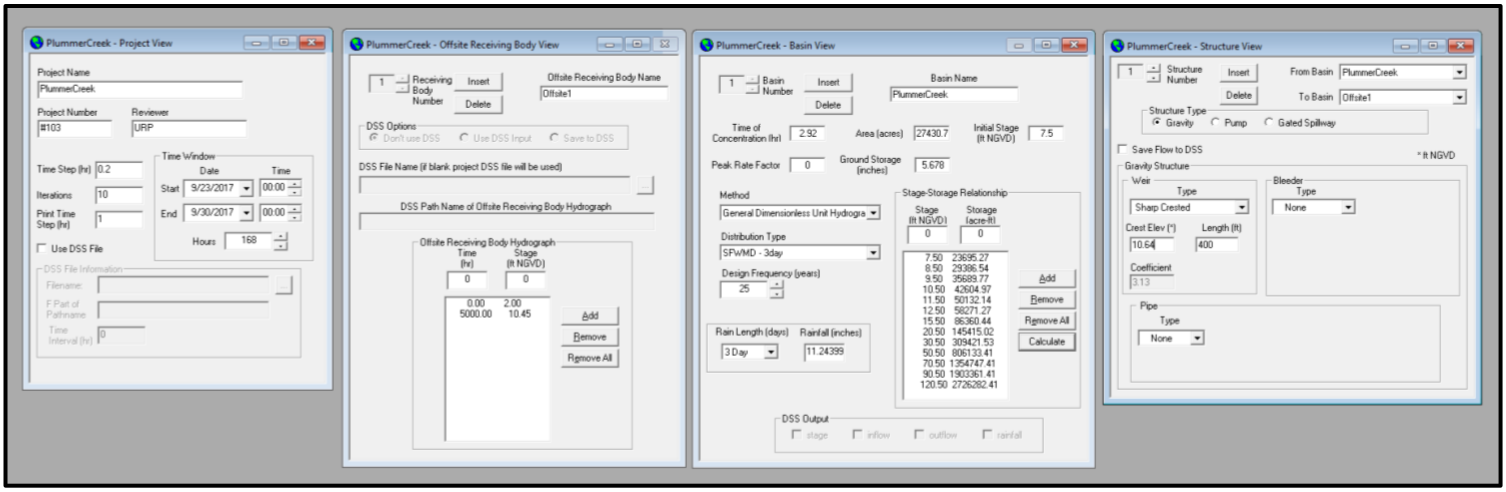

Figure 15. Cascade run for Plummer Creek in Nassau

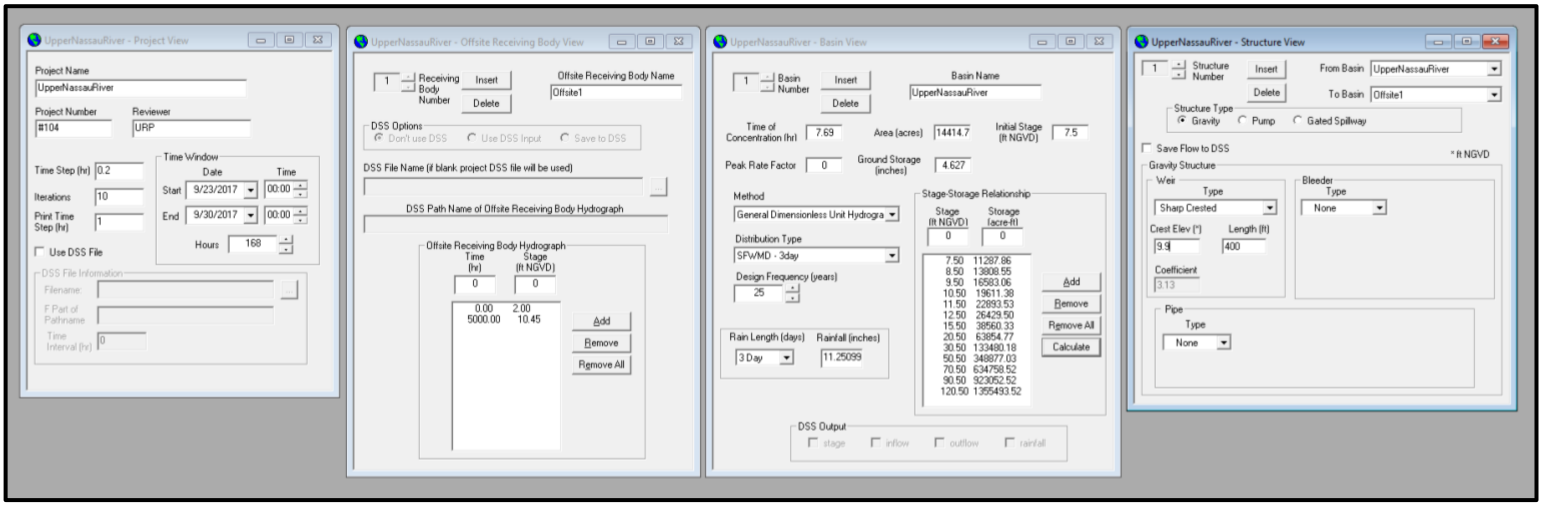

Figure 16. Cascade run for Upper Alligator River in Nassau

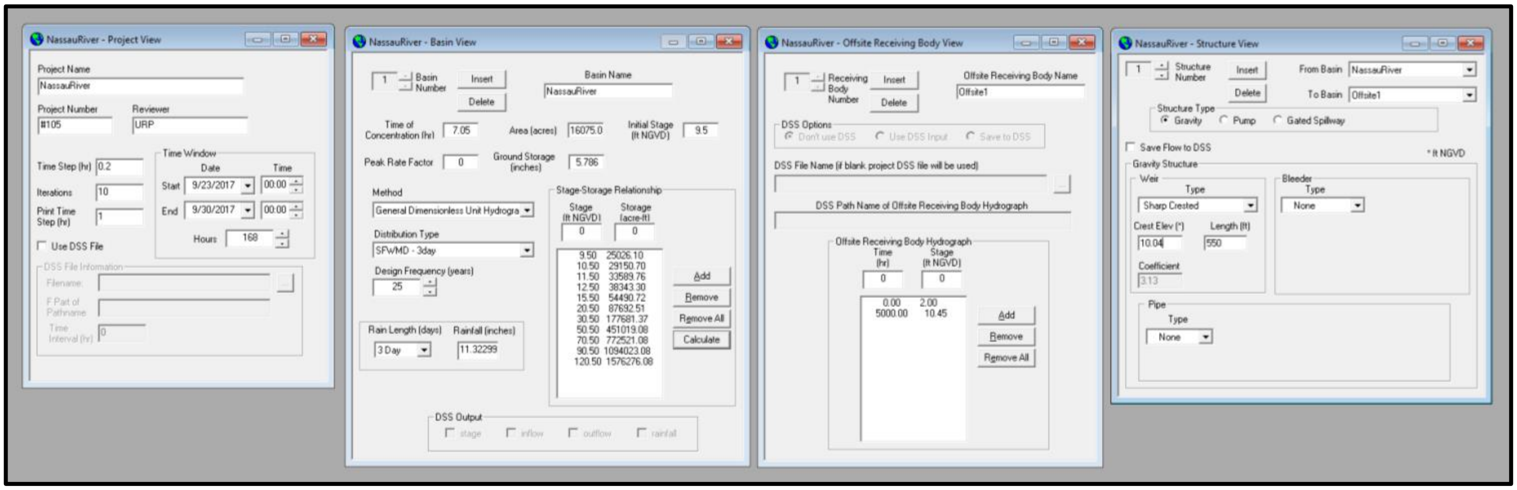

Figure 17. Cascade run for Nassau River in Nassau

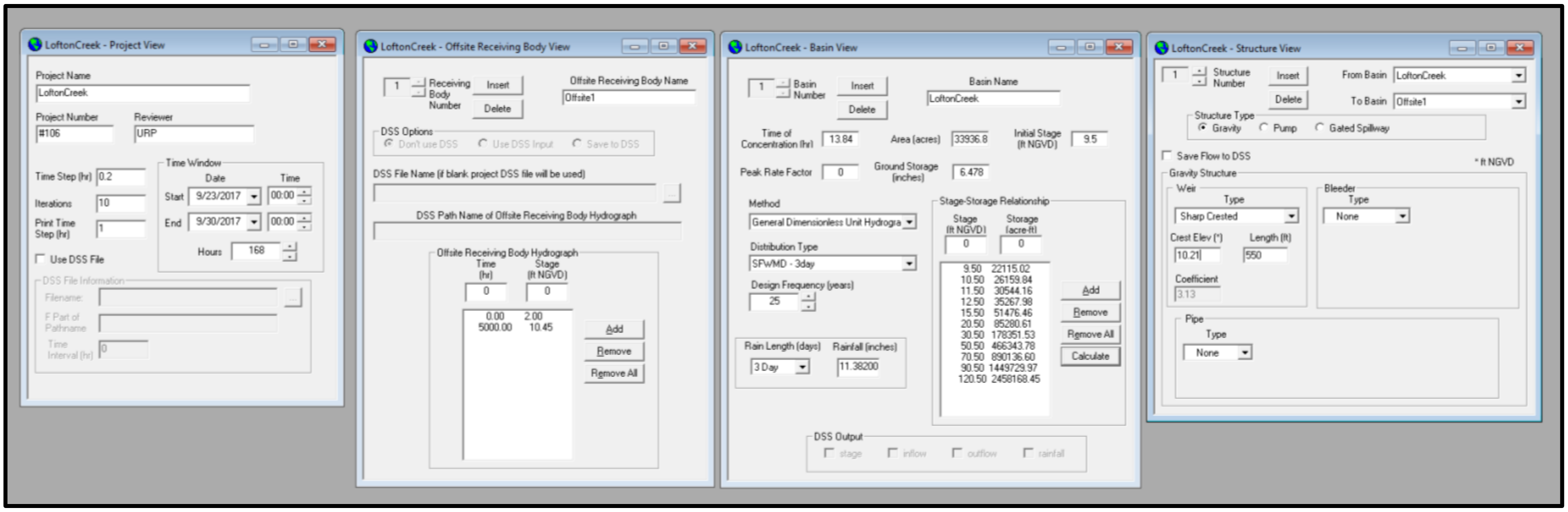

Figure 18. Cascade run for Lofton Creek in Nassau

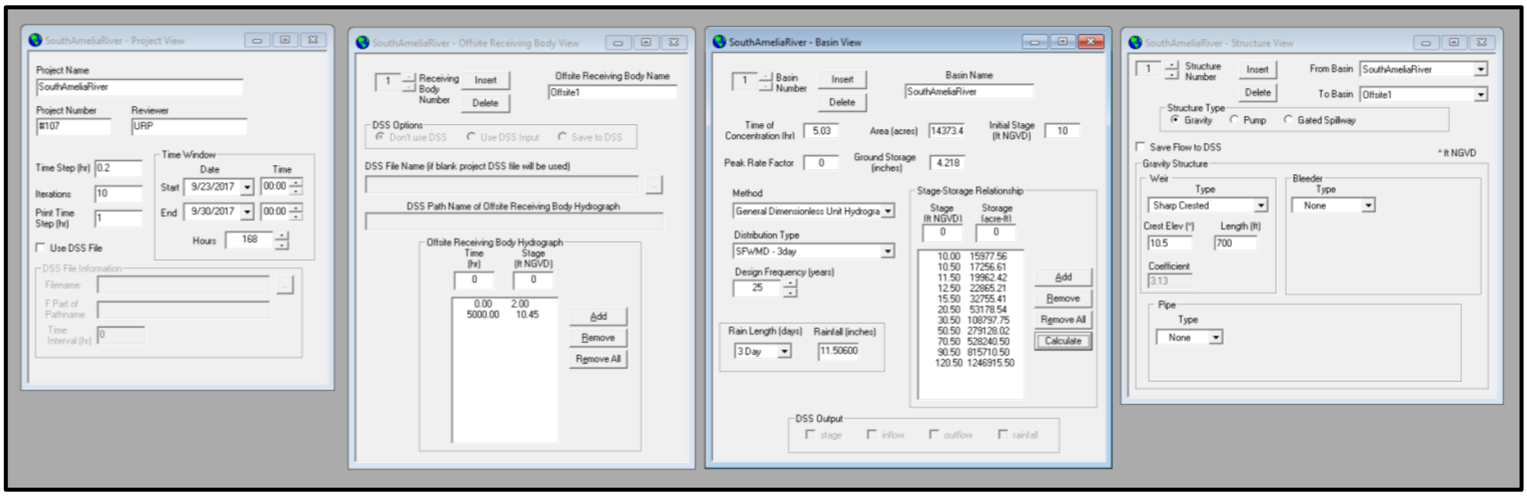

Figure 19. Cascade run for South Amelia River in Nassau

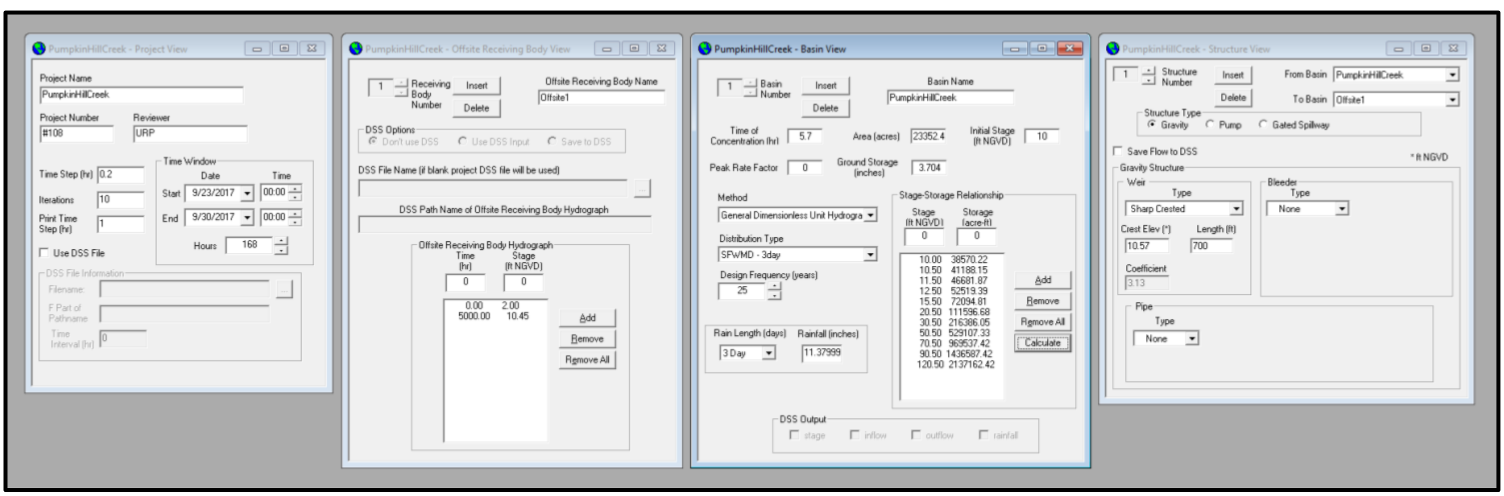

Figure 20. Cascade run for Pumpkin Hill creek in Nassau

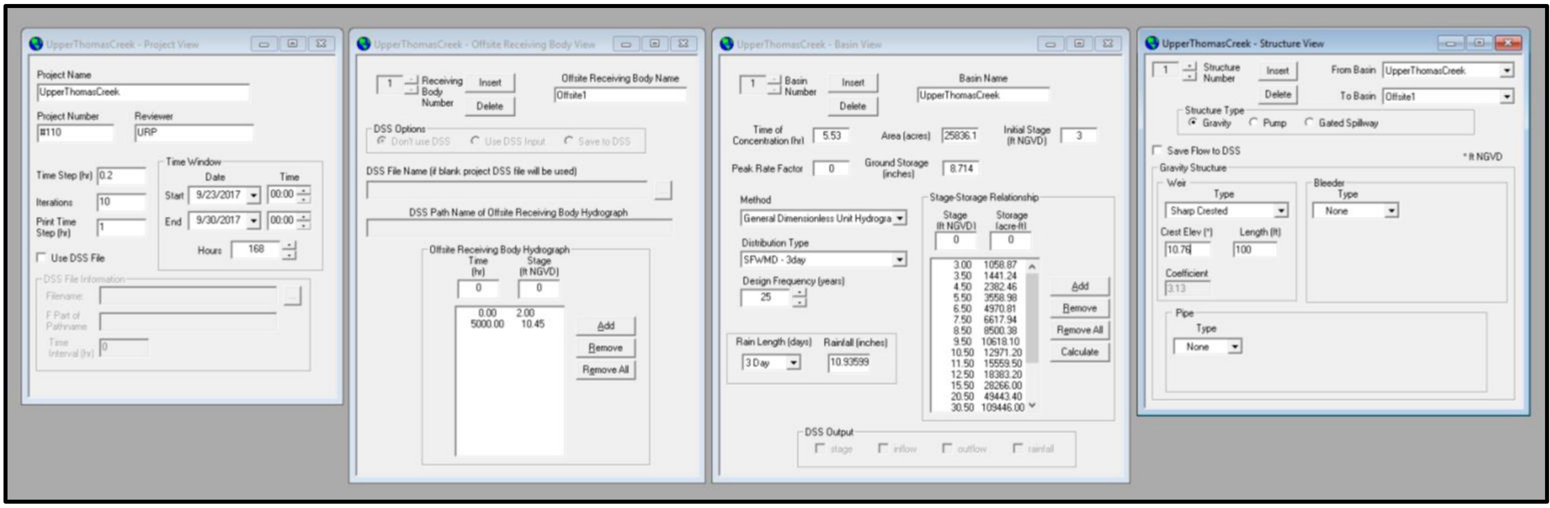

Figure 21. Cascade run for Upper Thomas Creek in Nassau

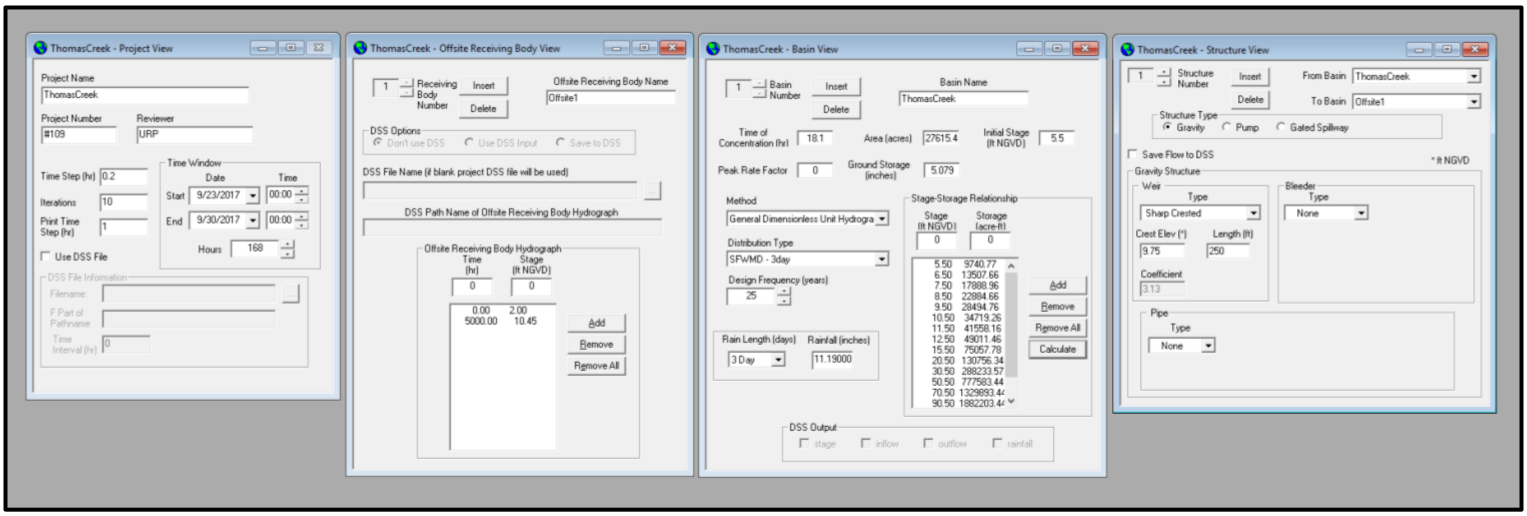

Figure 22. Cascade run for Thomas Creek in Nassau

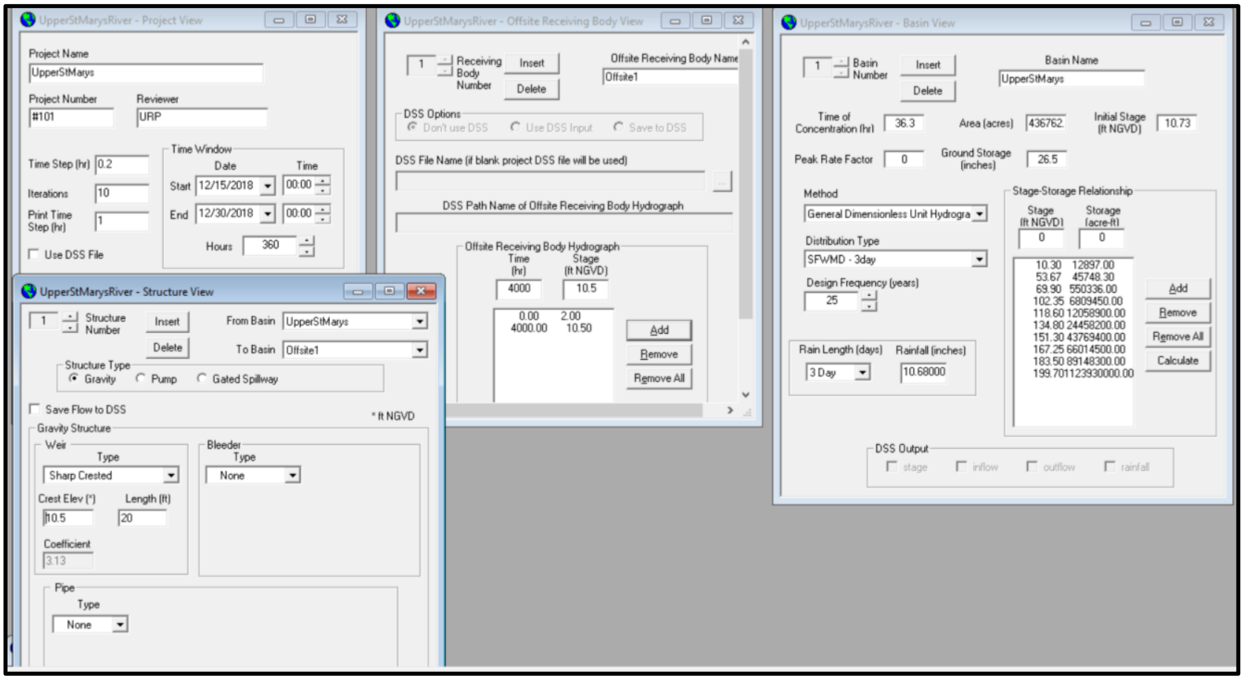

Figure 22. Cascade run for Upper St. Mary's River watershed

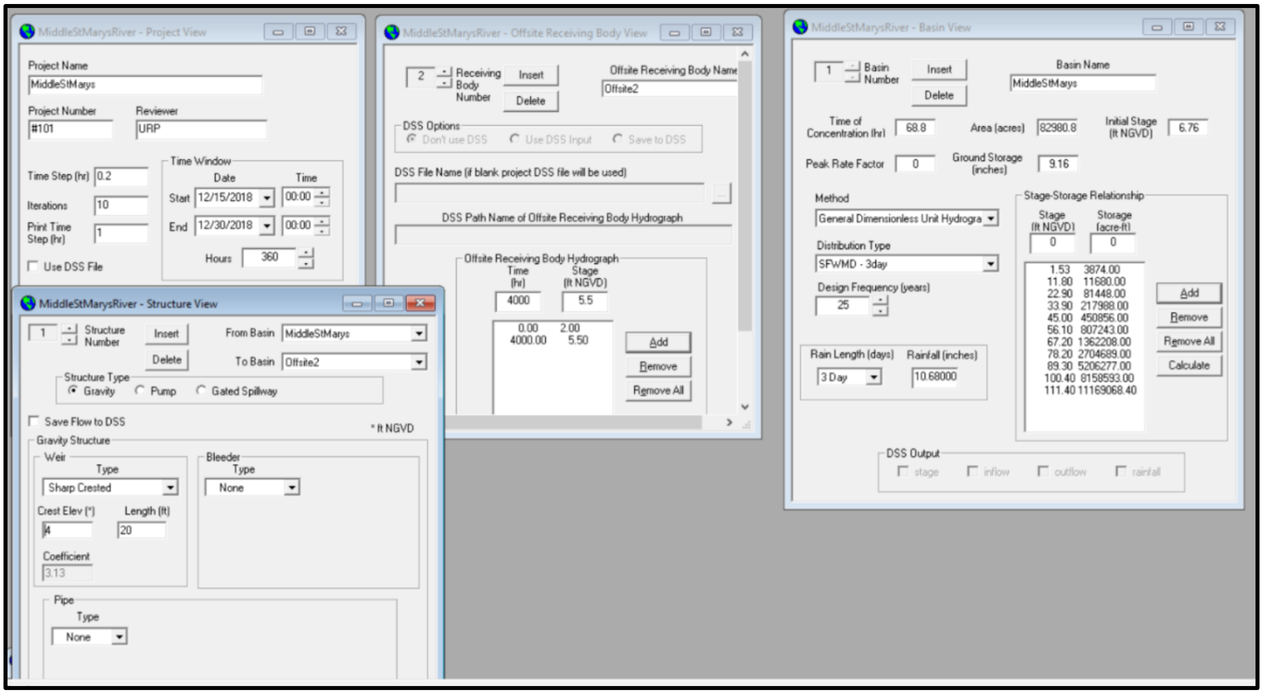

Figure 23 Cascade run for Middle St. Mary's in St. Mary's

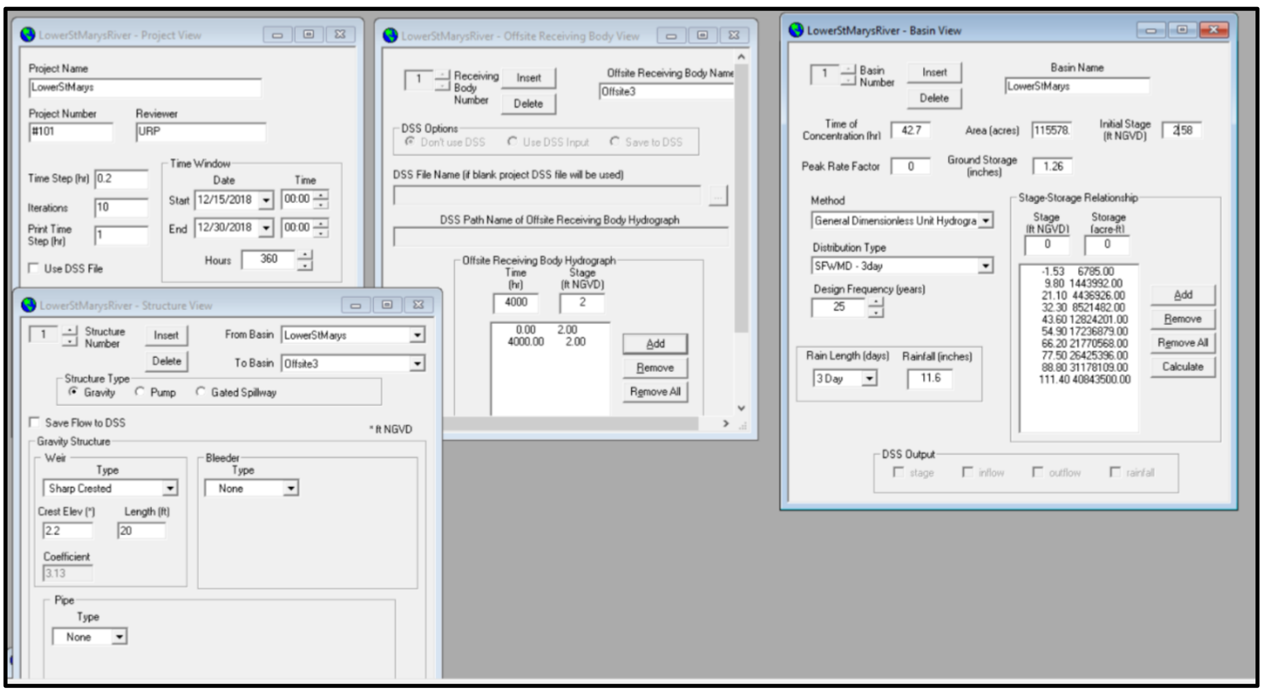

Figure 24. Cascade run for Lower St. Mary's River watershed

3.3.3 Vulnerability to Flooding

Figure 25 contains the predicted likelihood of flooding in the Nassau/St. Mary's watershed. The probability of inundation was determined based on the Z-score for each of the pixels within the watershed, which was used to represent the confidence interval. Z-score values that were below 0 were considered having less than of 50% likelihood of flooding, between 0 and 0.675 having 50% - 75% likelihood of flooding, between 0.675 and 1.282 having 75% - 90% likelihood of flooding, and above 1.282 having over 90% of flooding. In addition, known bodies of water (ex. lakes, canals, rivers, etc.) were also displayed so to only show land-based flooding.

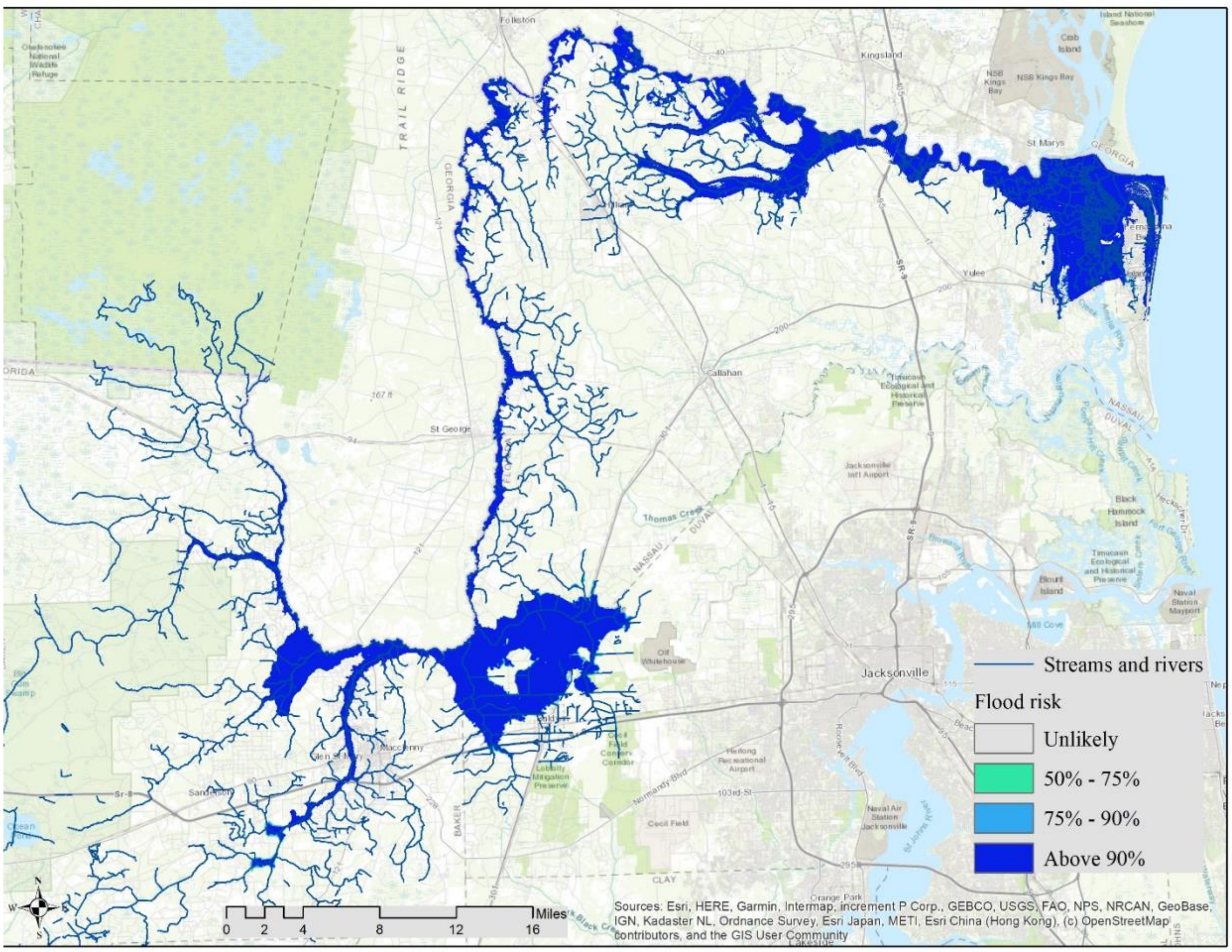

Figure 25. Results from the flood risk analysis in the St. Mary's River watershed (Florida)

3.3.4 FEMA Flood map comparison

Figure 26 contains the risk of flooding for the watershed based on FEMA estimations of flood risk. The 1-percent annual chance flood is also referred to as the base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AO, Zone AH, Zones A1-A30, Zone AE, Zone A99, Zone AR, Zone AR/AE, Zone AR/AO, Zone AR/A1-A30, Zone AR/A, Zone V, Zone VE, and Zones V1-V30. Moderate flood hazard areas, labeled Zone B or Zone X (shaded) are also shown on the FIRM, and are the areas between the limits of the base flood and the 0.2-percent-annual-chance (or 500-year) flood. The areas of minimal flood hazard, which are the areas outside the SFHA and higher than the elevation of the 0.2-percent-annual-chance flood, are labeled Zone C or Zone X (unshaded) ("Definitions of FEMA Flood Zone Designations," n.d.). Figure 27 compares the FEMA flood zones and the FAU vulnerability areas.

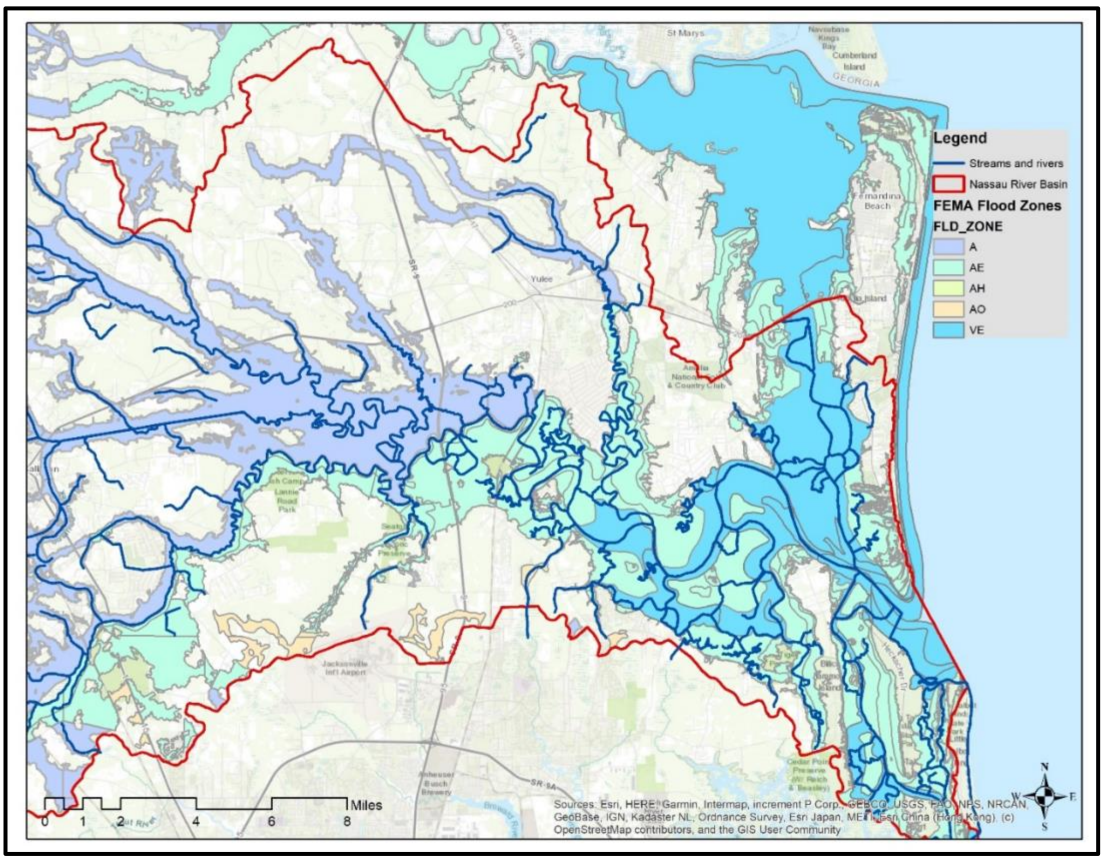

Figure 26. FEMA flood zones in the Nassau River watershed

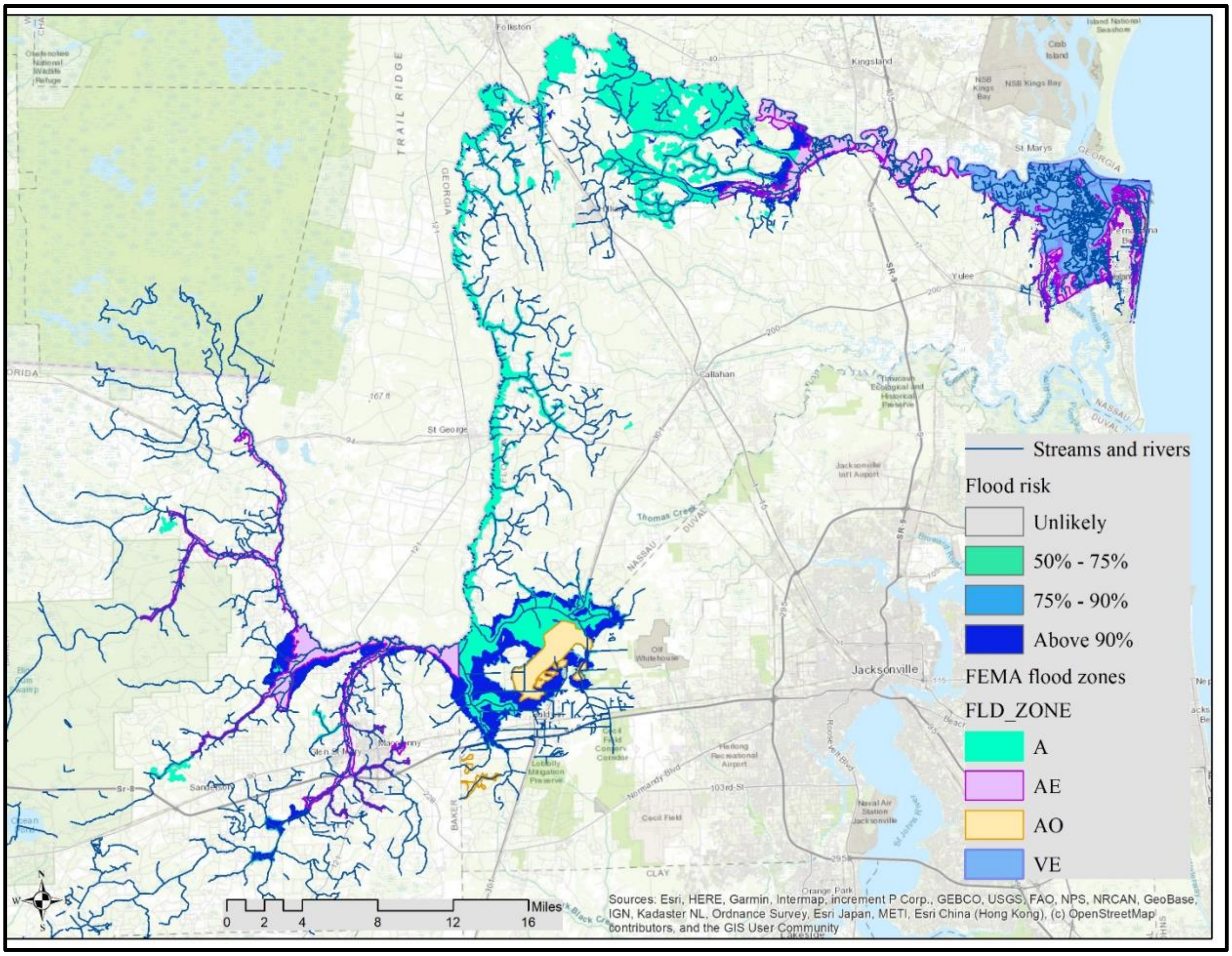

Figure 27. Overlay of the flood risk maps and FEMA flood zones in the St. Mary's River watershed

3.4 Repetitive Loss

A comparison of the flood map and repetitive loss property locations for the basin indicates that the major loss area is along the river and the coast. The loss areas coincide with the areas predicted by the FAU model as being at risk for flooding.

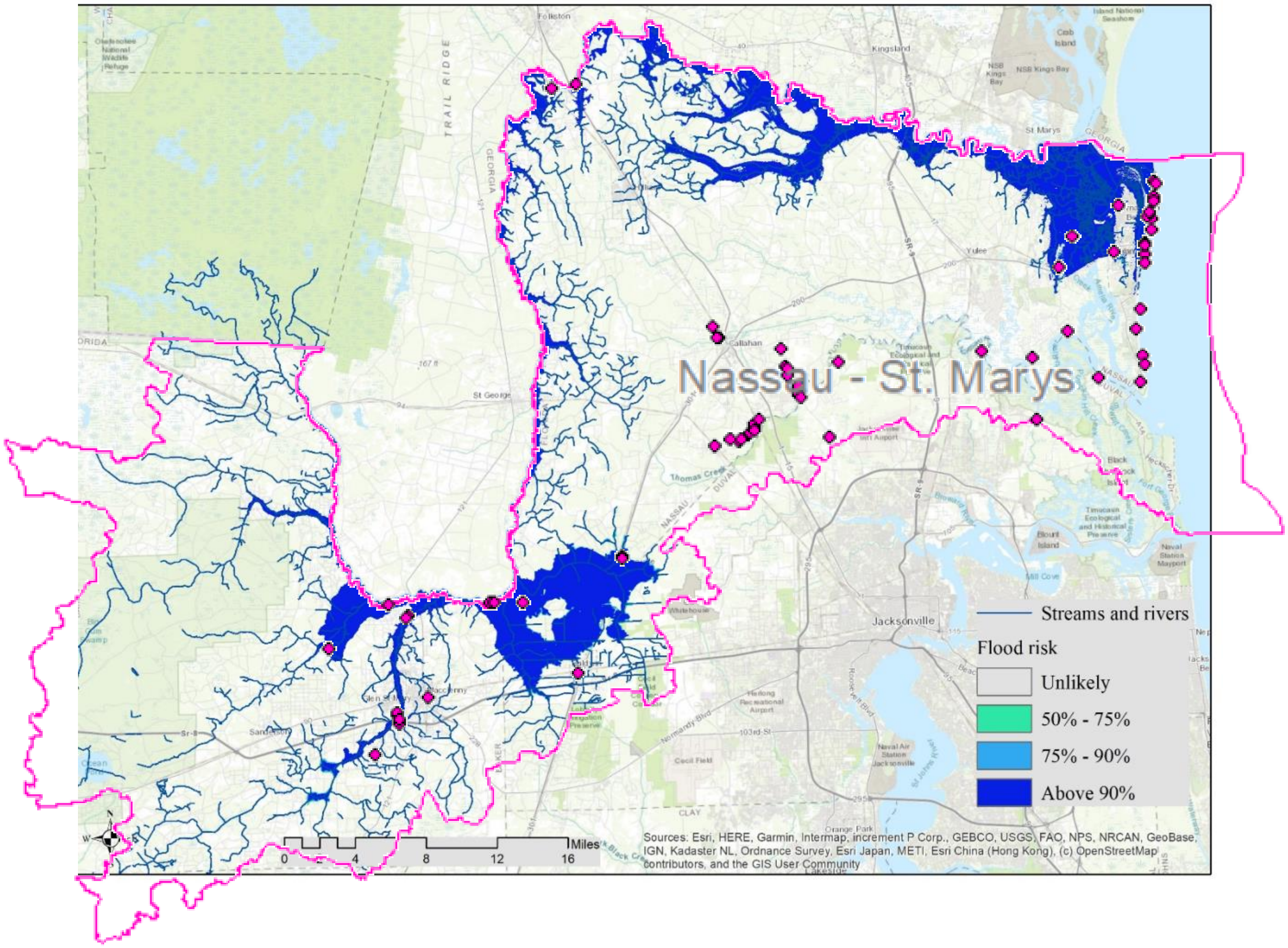

Figure 28 Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU

3.5 Drill down in Developed Areas Loss

The Nassau River Basin borders Jacksonville Metropolitan area and is considerable urbanized. It incorporates the cities of Fernandina Beach, Callahan, Yulee, Hillard, and Nassau Village-Ratliff, along with others. Figure 29 shows the drilldown areas. Figure 30 indicates the location of the urbanized areas in proximity to the Nassau River floodplain. Figures 31 through 35 provide a closer look at the estimated vulnerability to floods within and around Fernandina Beach (population of 12,588 as of 2018), Yulee (population of 28,798 as of 2018), and the census-designated place Nassau Village – Ratliff (population of 5,337 as of 2010). The maps below highlight locations vulnerable to flooding in the western and eastern parts of the Nassau – St. Mary's Rivers riverine and estuarine systems.

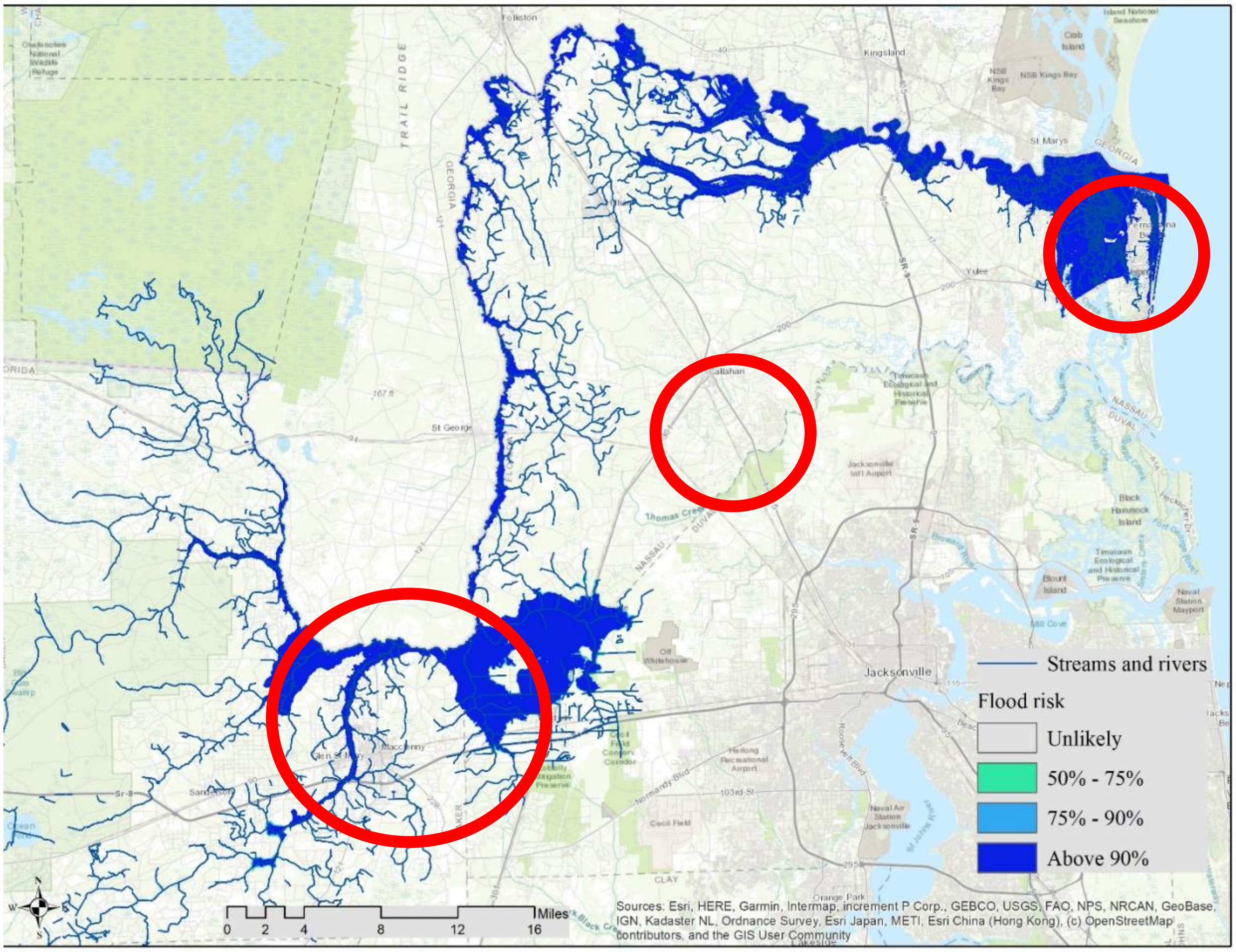

Figure 29 Location of drilldown areas.

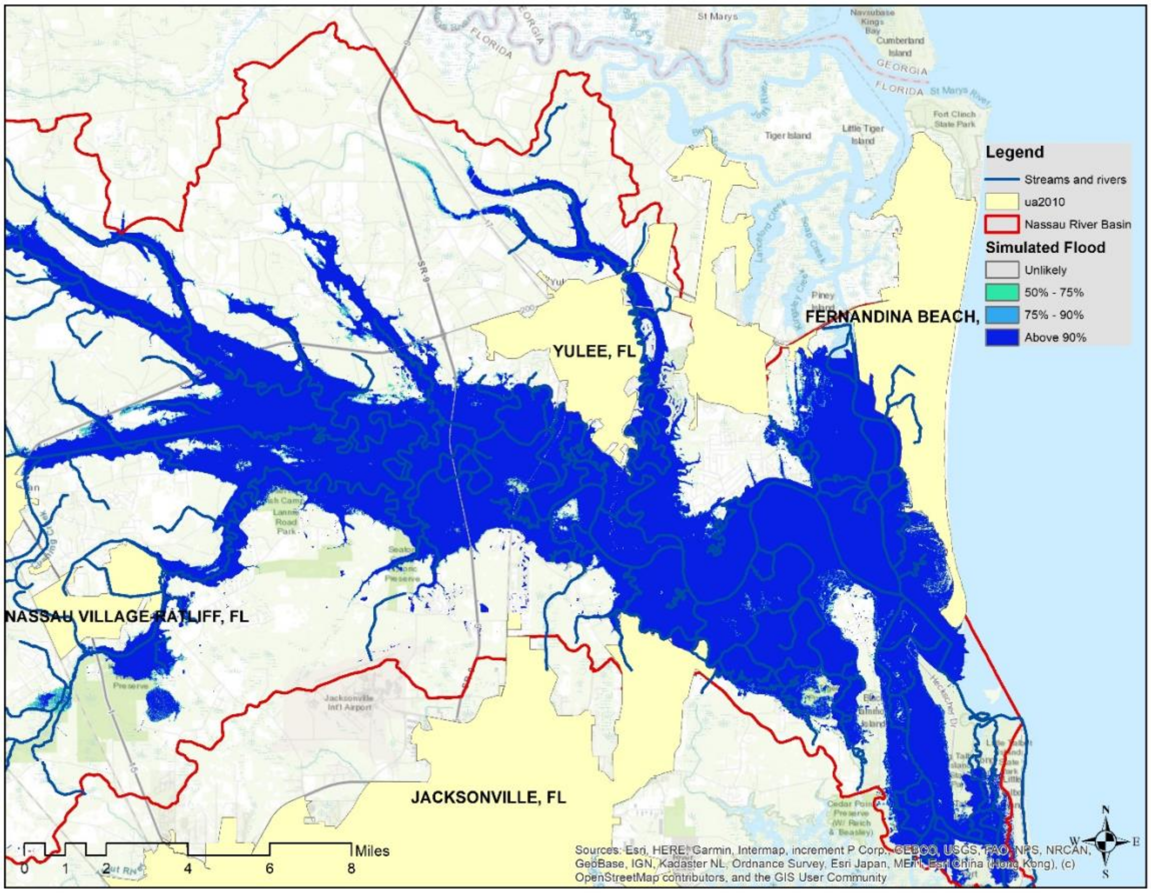

Figure 30. Urbanized areas in close proximity to the Nassau River floodplain

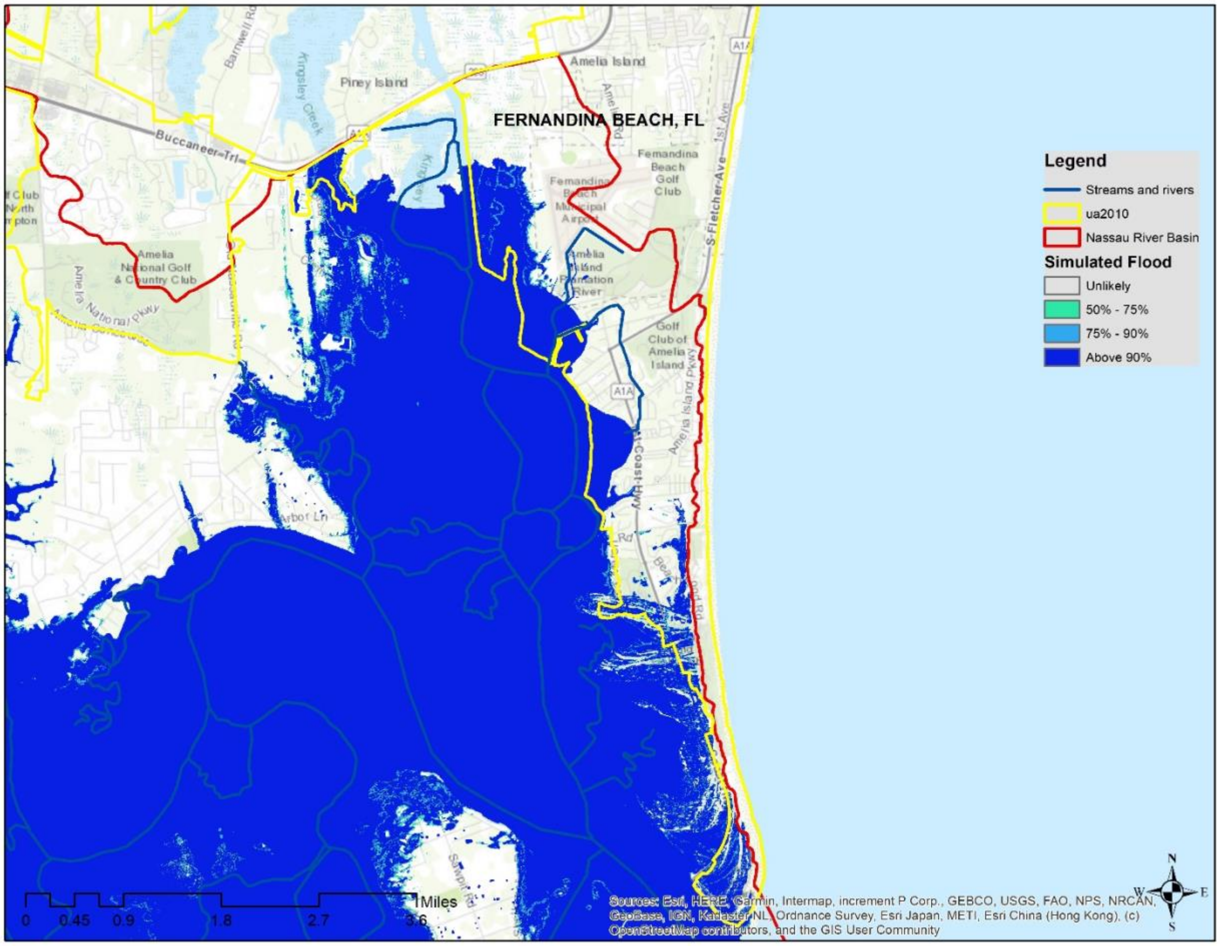

Figure 31. Flood risk vulnerability near Fernandina Beach – Nassau River

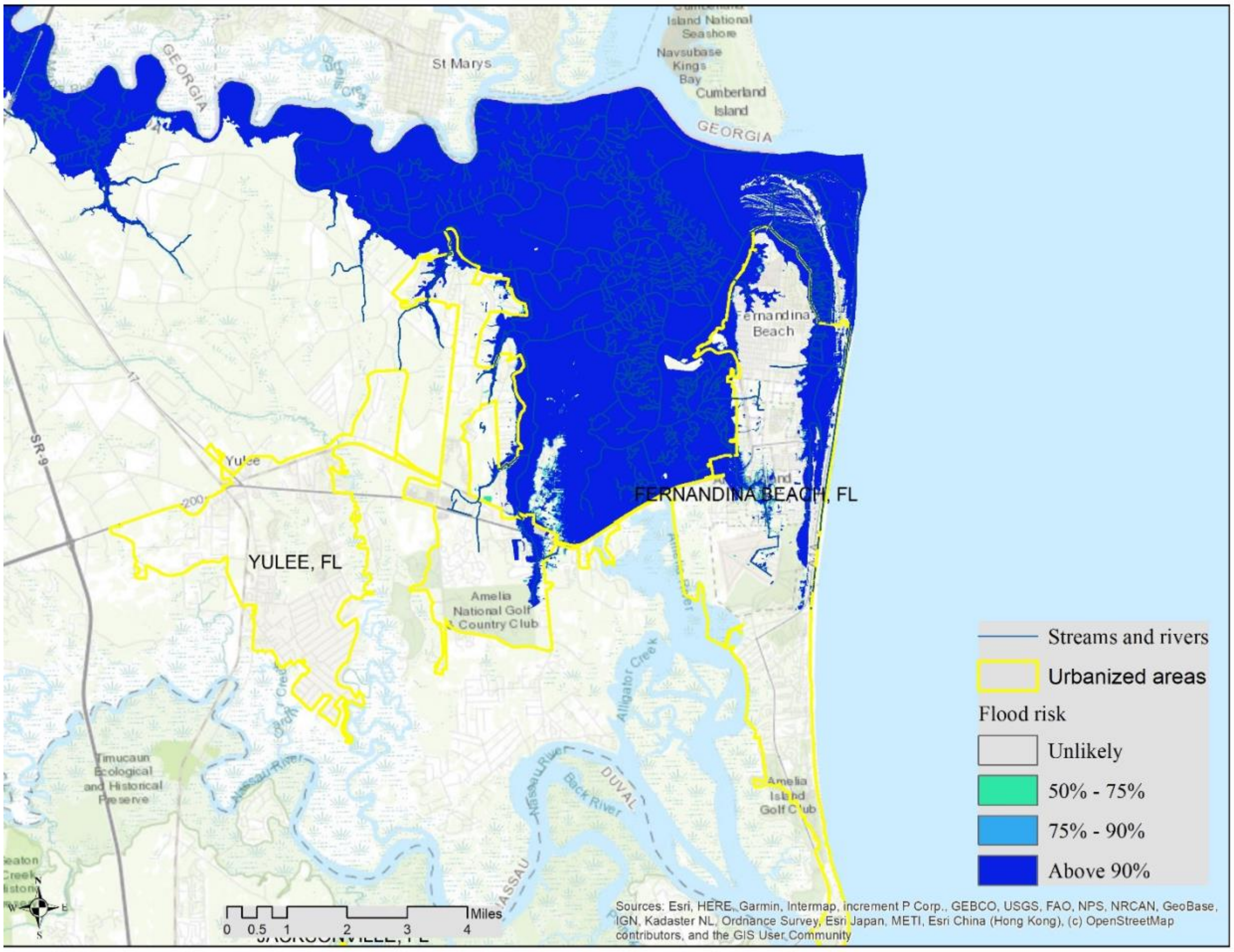

Figure 32. Flood risk vulnerability near Fernandina Beach – St. Mary’s River

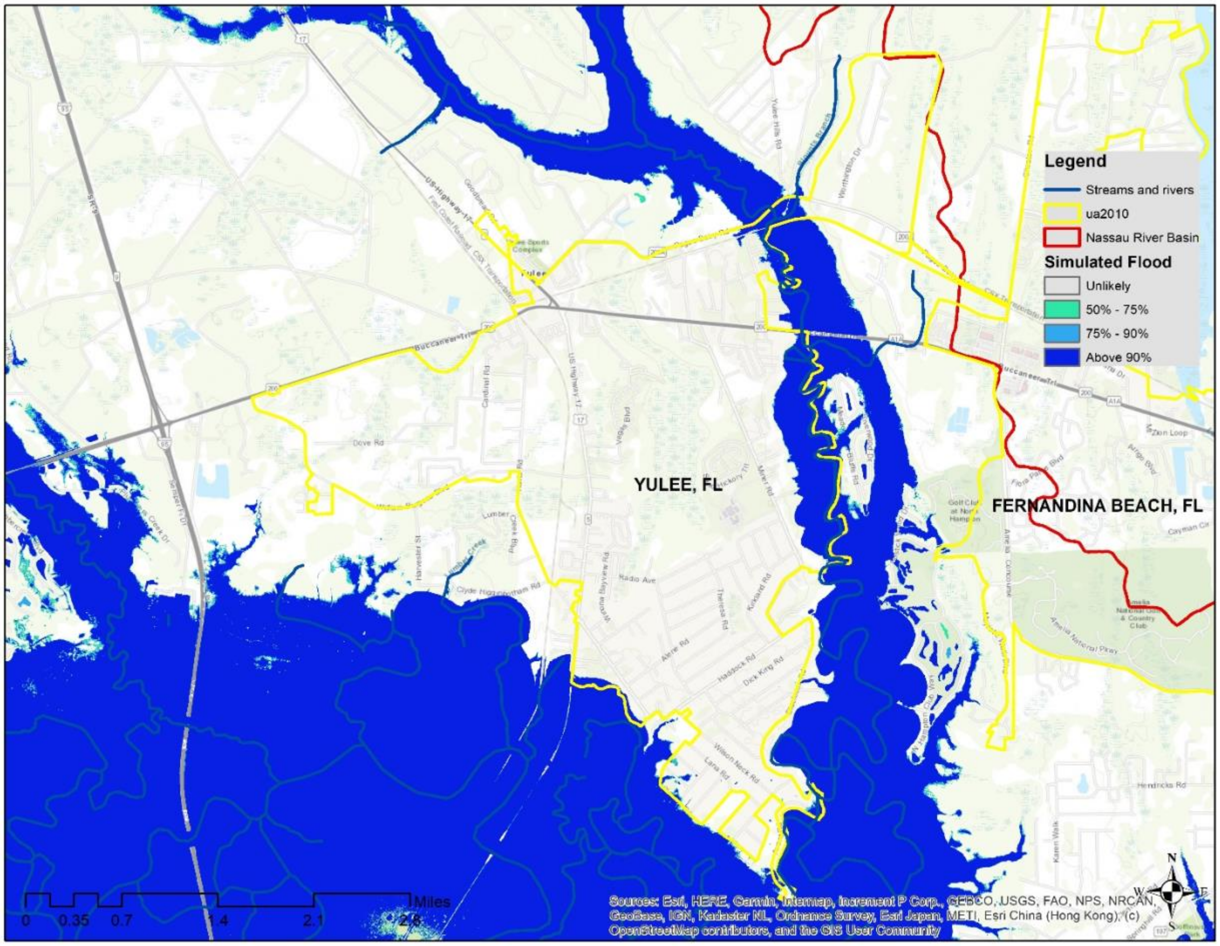

Figure 33. Flood risk vulnerability near Yulee, Florida

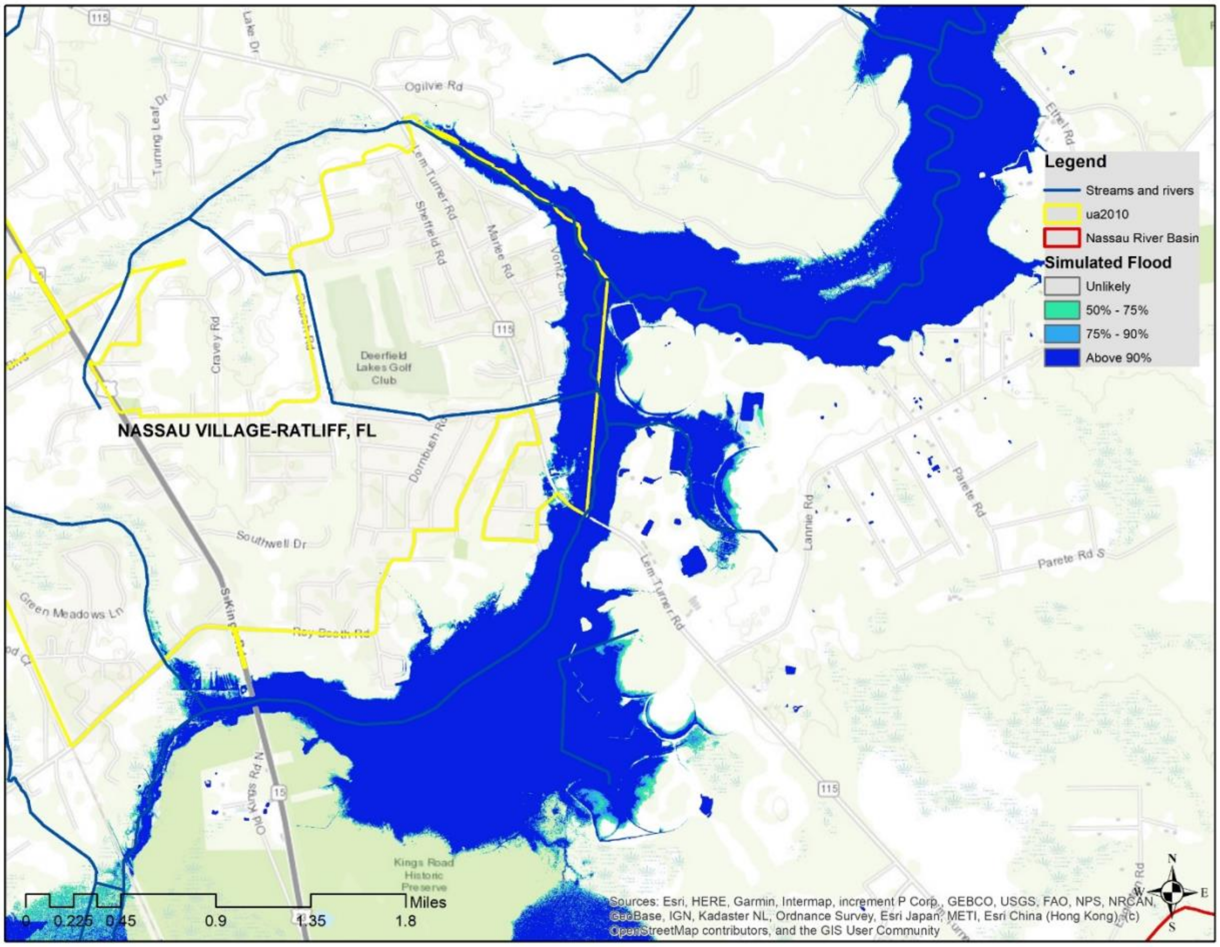

Figure 34. Flood risk vulnerability near Nassau Village - Ratliff, Florida

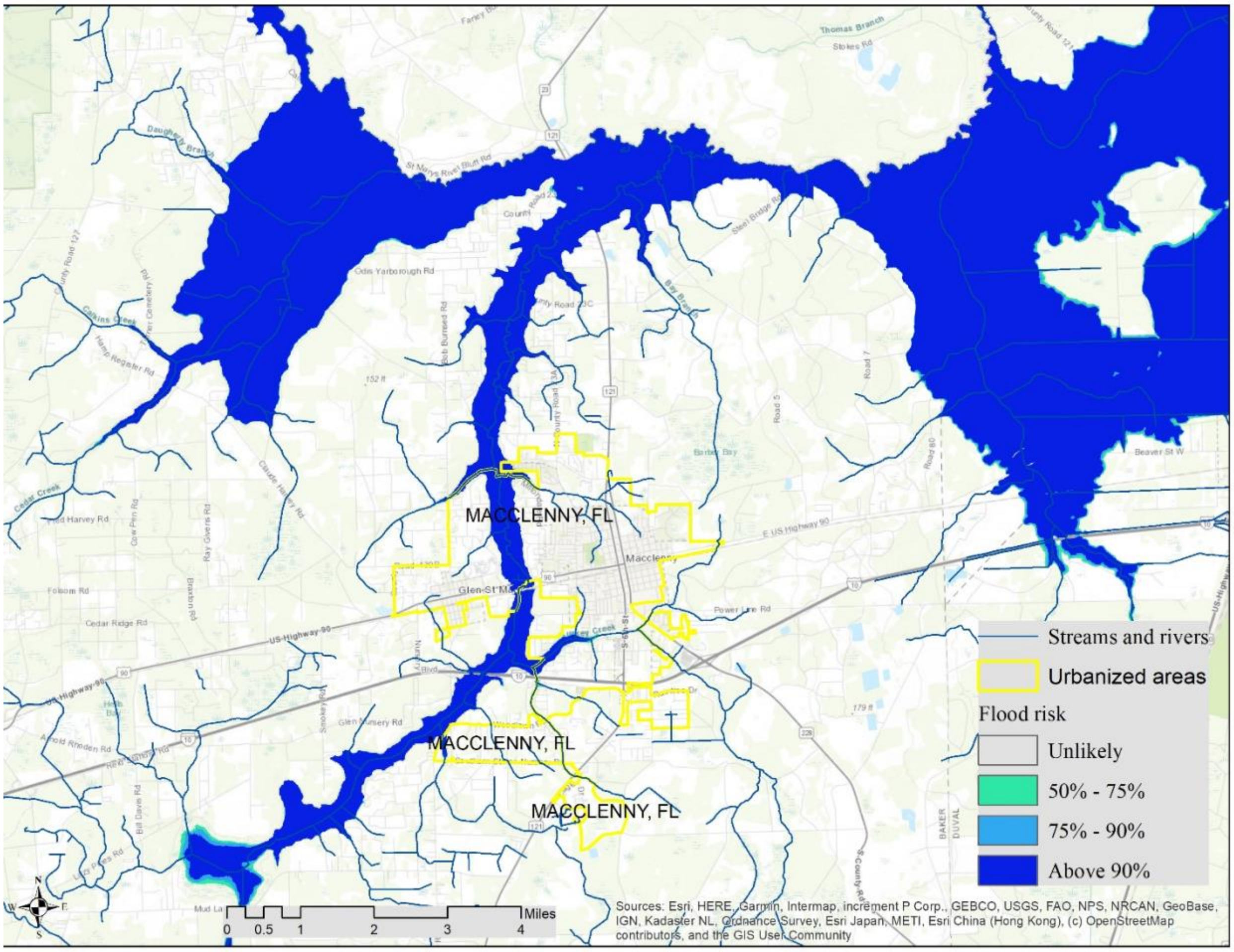

Figure 35. Flood risk vulnerability near MacClenny – St. Mary's River, Florida

4.0 Conclusions

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 Nassau/St. Mary's Basin (#14) 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 Atlantic Ocean coast and extensive sensitive areas that currently received extensive environmental protection. A drilldown to the local communities indicates that the major developments are flood prone. Solutions to improve flood resiliency in this basin will yield long term benefits. The developed kriging approach produced a reasonable groundwater table pattern for this watershed, which is critical for further Cascade modeling. Application of the developed protocol for inundation mapping works well for this watershed.

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