DRAFT

Panhandle Watershed Case Study

TMDL BASINS 04

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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; therefore, producing 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 focuses on the development procedures for a screening tool to assess risk in the Panhandle area of Florida. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the Panhandle Basin. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties.

1.0 Introduction

In 1972, the Florida Legislature created the Northwest Florida Water Management District (NWFWMD) within the passage of the Water Resources Act (Pratt et al., 1996). The NWFWMD encompasses an area of about 11,200 square miles. The Panhandle Basin borders the Suwannee River Water Management District. The Panhandle consists of 5 TMDLs, and this report will focus on the second eastern basin, TMDL 04. The basin is coastal, so flood risks from rainfall, wet season thunderstorms and tropical storm activity are concerns for local officials and the nearly 127,000 people who live in the watershed. Figure 1 depicts the Apalachicola, TMDL 04, shown in yellow, within the Panhandle region.

The Panhandle is the least populated and most lightly visited portion of Florida and is closer in appearance to its Deep South neighbors than the tropical backdrop that characterizes the rest of the state.

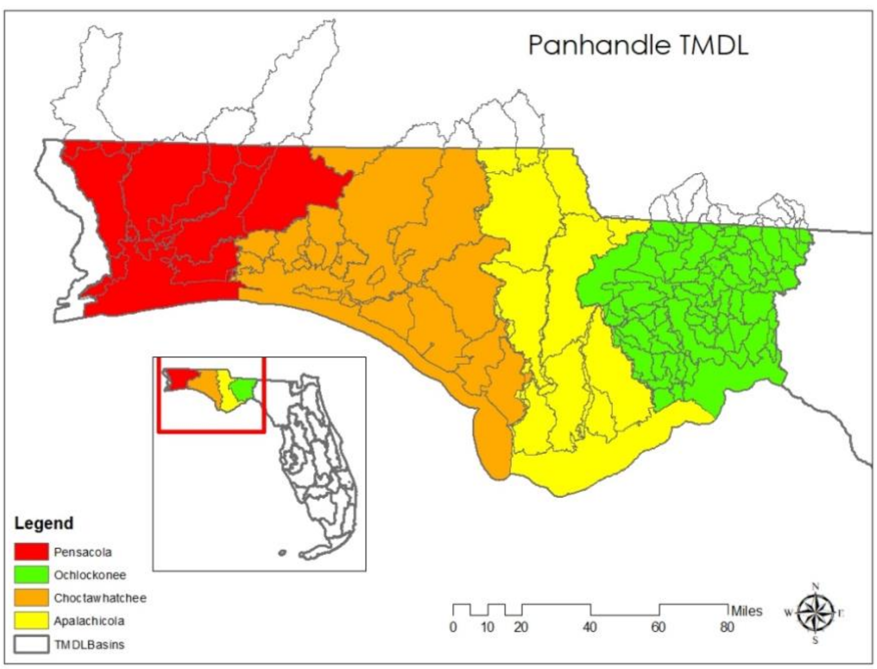

Figure 25. Location of Panhandle

2.0 Summary of Watershed

2.1. General Description of Watershed

2.1.1. Climate/Ecology

Nature reigns supreme in North Florida; forests, preserves and parks remain home to wildlife such as black bears, bald eagles and the rare Florida panther (smilingglobe.com, 2020). Cool freshwater springs can be seen throughout the panhandle area allowing for some recreational opportunities such as tubing, cave diving, etc. Normal annual rainfall ranges from about 55 to 67 inches per year; the average annual rainfall is generally highest in the western portion of the NWFWMD and lowest in the eastern portion (Pratt et al., 1996). There are two distinct rainy seasons each year, the first resulting from frontal storm systems during the winter and early spring, and the second occurring during the summer as a result of afternoon and evening thunderstorms.

2.1.2. Topography and Soils

The regions rolling, hilly terrain more closely resembles areas within Alabama or Georgia than peninsula Florida. Elevations in the highlands area range from 50 to 345 feet above sea level. The highest point in Florida, at 345 feet, is located near the town of Lakewood, which is almost on the Alabama border (smilingglobe.com, 2020). The major physiographic features include the Northern Highlands, the Marianna Lowlands, and the Coastal Lowlands (Pratt et al., 1996). Panhandle beaches are famous for their white 'sugar sand', composed of quartz washed down from the Appalachian Mountains by ancient rivers. Elevations are low, ranging from sea level to about 100 feet above sea level. The native soil and topography create an environment that is highly permeable and can absorb a significant amount of water into the soil: however, the change in the land use has resulted in the flow of water leading to impermeable land where the water collects in pools or runs off rapidly where development has taken place, in direct contrast to the natural condition. The land in many areas is poorly drained due to a flat topography and associated high water table.

2.1.3. Boundaries/Surface Waters

Drained by several large rivers, the region has extensive pine and hardwood forests, springs and swamps. Barrier islands, beaches, and tidal marshes border most of the Gulf Coast. East of the town of Apalachicola, the beaches and barrier islands give way to vast salt marshes and the coastline is accessible only by boat (smilingglobe.com, 2020). The key elements of the watershed include the bays (Apalachicola Bay), a few lakes (Lake Seminole and Dead Lake), the rivers (Chipola River and Apalachicola River), the canal system and the rainfall over the area. Figure 2 depicts the Panhandle Basin subdivided into 3 HUCs that will later be analyzed individually through the use of CASCADE.

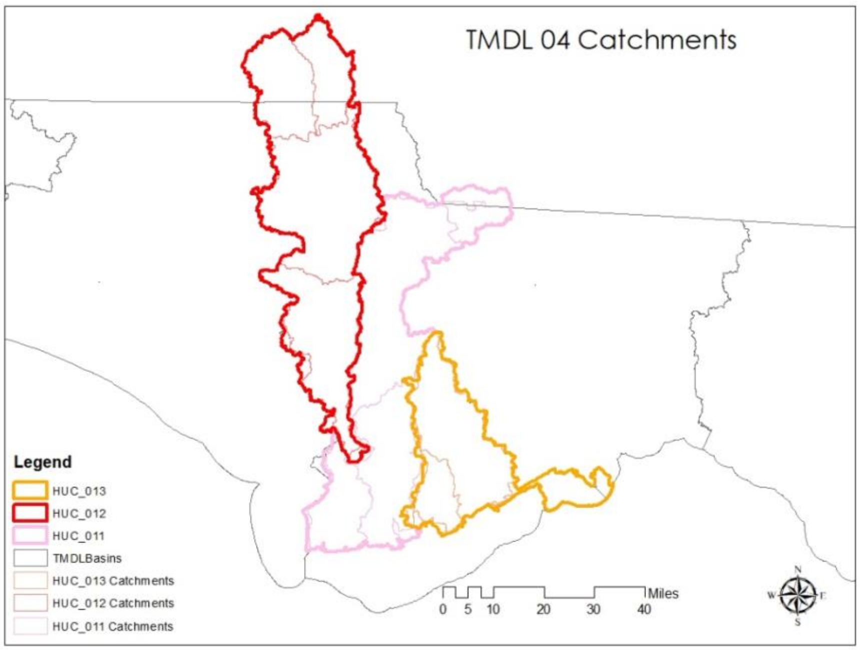

Figure 26. TMDL 04 Catchments

2.1.4. Hydrogeological Considerations

In northwest Florida, the hydrogeologic framework is divided into four groups of sediments that constitute distinct hydrogeologic systems, and each system is a compilation of lithologic beds that have similar hydrogeologic characteristics. (Pratt et al., 1996). Systems are defined by their ability to accelerate or hinder the flow of water and, thus, are not constrained by lithologic or stratigraphic boundaries. In descending order from land surface, the four systems are: Surficial Aquifer System, which includes the Sand-and-Gravel Aquifer; Intermediate System; Floridan Aquifer System; and Sub-Floridan System. In northwest Florida, the Ad Hoc Committee recognized three aquifer systems, which includes the surficial aquifer system, the intermediate aquifer system and the Floridan aquifer system, and two confining units, which includes the intermediate confining unit and the sub-Floridan confining unit. The subsurface characteristics of each system vary both laterally and with depth. The nature of the variability determines ground water availability or the degree of detention for the respective system at any given location.

2.2. Socio-economic Conditions of the Watershed

2.2.1. Demographics (US Census, 2010)

As of the 2010, the 5 counties that make up the TMDL 04 Basin had a total population of 126,658 people and 45,208 households. The average household size for the TMDL 04 was 3 people per household. The population consists of roughly 18.64% under the age of 18, 19.46% who were 65 years of age or older. The racial makeup of the county was 70.86% White, 25.46% Black or African American, 1.00% Asian, 0.62% Native American, 0.15% Pacific Islander. As of the 2010, the median income for a household in the county was $39,750, and roughly 23% of the population were below the poverty line.

2.2.2. Property

According the US Census, the median property valuation, as of 2018, is roughly near $100,000.

2.2.3. Economic Activity/Industry

As of 2018, the total number of employments within the TMDL 04 area is 4,461, with roughly 406 establishments. The total retail sales are roughly $1 million (US Census, 2018). Cool freshwater springs bubble up everywhere, affording recreational opportunities such as tubing, swimming, snorkeling, cave diving and sightseeing on glass-bottom boats (smilingglobe.com, 2020). Outdoor enthusiasts can canoe wild and scenic rivers, camp on an open prairie, cycle along the Gulf of Mexico, catch their own scallops, kayak past centuries-old forts and more.

3.0 Watershed Analysis

3.1. Data Sets

3.1.1. Topography

Figure 3 depicts the results of the LiDAR DEM, using 3-meter tiles, processed conducted for the Panhandle Basin. The highest points are approximately 350 feet above sea level near border of Georgia, and the lowest points are 0 feet at sea level shown along the coast of the panhandle.

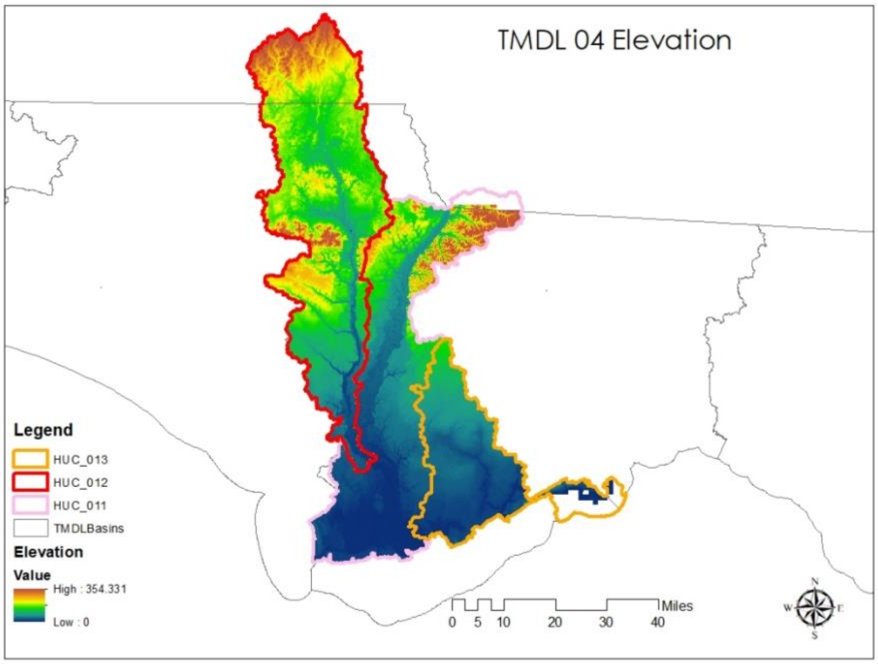

Figure 27. Topography of TMDL 04 based on Lidar DEM

The area with the highest elevation belongs to Upper Chipola River (HUC_012) at 101 feet, which are located within the State of Georgia, seen in Table 1. Upper Chipola River (HUC_012) also has the largest area at roughly 1.3 billion square feet. The catchments were separated by the bodies of water within them, as well as by the location of water stations.

Table 5. TMDL 04 Elevation

HUC_011

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	VARIETY	MAJORITY	MINORITY	MEDIAN	ACRES
1	Upper Apalachicola River	1	1396509	1256858100	1	91	90	30.2463	19.617331	42239230	91	14	91	26	28853.491736
2	Mosquito Creek	2	189713	170741700	20	96	76	71.407958	17.091212	13547018	77	87	96	77	3919.690083
3	Lower Apalachicola River	3	804715	724243500	0	22	22	5.373681	4.872172	4324282	23	1	22	4	16626.342975
4	Cypress Creek	4	473501	426150900	0	13	13	2.556366	2.032982	1210442	14	0	13	2	9783.078512

HUC_012

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	VARIETY	MAJORITY	MINORITY	MEDIAN	ACRES
1	Big Creek	1	625404	562863600	25	108	83	55.157238	17.484879	34495557	84	43	25	51	12921.570248
2	Cowarts Creek	2	435635	392071500	25	107	82	53.930088	16.10539	23493834	83	46	107	49	9000.72314
3	Upper Chipola River	3	1519247	1367322300	0	101	101	40.201364	13.872772	61075801	102	40	2	39	31389.400826
4	Lower Chipola River	4	979236	881312400	1	77	76	26.245714	15.328425	25700748	77	26	77	25	20232.14876

HUC_013

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM	VARIETY	MAJORITY	MINORITY	MEDIAN	ACRES
1	New River	1	991951	892755900	0	37	37	11.155773	7.689904	11065980	38	4	37	9	20494.855372
2	Whiskey George Creek	2	272815	245533500	0	20	20	4.43267	2.575078	1209299	19	3	18	4	5636.673554

3.1.2. Groundwater

Figure 4 depicts the ground water levels within the TMDL 04 region. The highest point reaches 240 feet near the Alabama and Georgia borders, and the lowest point is nearly at 0 feet along the coastline.

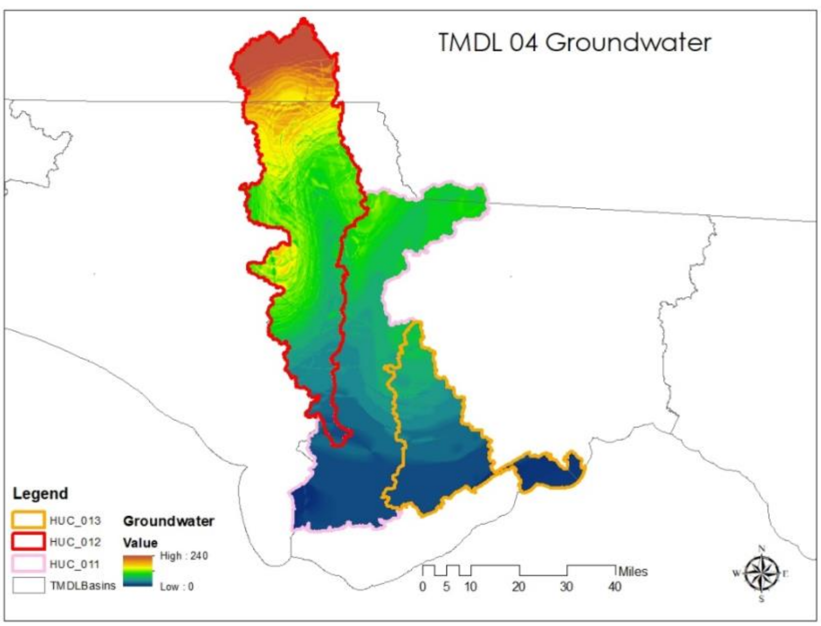

Figure 28. TMDL 04 Groundwater

The area with the highest groundwater level occurs within the Cowarts Creek (HUC_012) at 240 feet, which are located within the State of Georgia, seen in Table 2.

Table 6. TMDL 04 Groundwater

HUC_011

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Upper Apalachicola River	1	1396437	1256793300	20	100	80	57.217072	15.857167	79900036.766178
2	Mosquito Creek	2	189710	170739000	59.465881	79.999939	20.534058	70.777879	3.685887	13427271.441292
3	Lower Apalachicola River	3	804715	724243500	6.429664	50	43.570336	19.522492	10.777845	15710041.916451
4	Cypress Creek	4	473499	426149100	0	20	20	9.010713	4.413451	4266563.419799

HUC_012

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Big Creek	1	625357	562821300	88.720833	222.883209	134.162376	160.623137	30.308771	100446803.074821
2	Cowarts Creek	2	435538	391984200	90.017708	240	149.982292	170.5037	39.174034	74260840.391808
3	Upper Chipola River	3	1519189	1367270100	48.321575	140	91.678425	88.613752	16.774289	134621037.140404
4	Lower Chipola River	4	979207	881286300	10	139.998108	129.998108	57.373162	26.473973	56180202.228456

HUC_013

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	New River	1	991947	892752300	0	70	70	29.281005	15.763716	29045204.578593
2	Whiskey George Creek	2	272815	245533500	6.16772	29.999115	23.831395	12.363714	4.485608	3373006.590551

3.1.3. Impervious Areas

Figure 5 represents the impervious areas, primarily roads in the TMDL 04 region. These are areas where water cannot seep into the soil and as a result seep to unsaturated areas. Most of the impervious areas are located in some parts in the north.

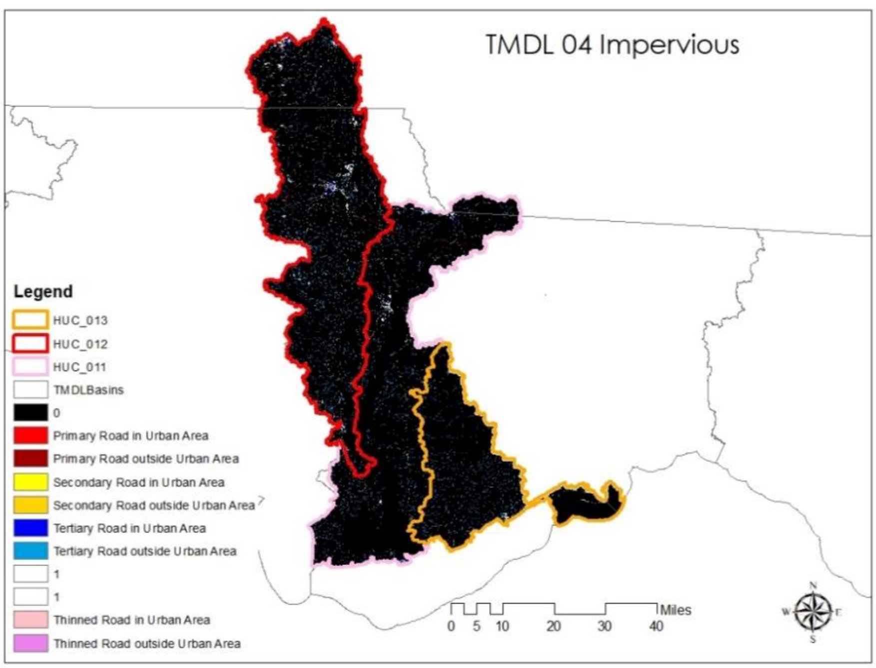

Figure 29. Panhandle Impervious Areas

Figure 6 is the water holding capacity. The highest capacity is at 0.68 feet and the lowest is at zero feet.

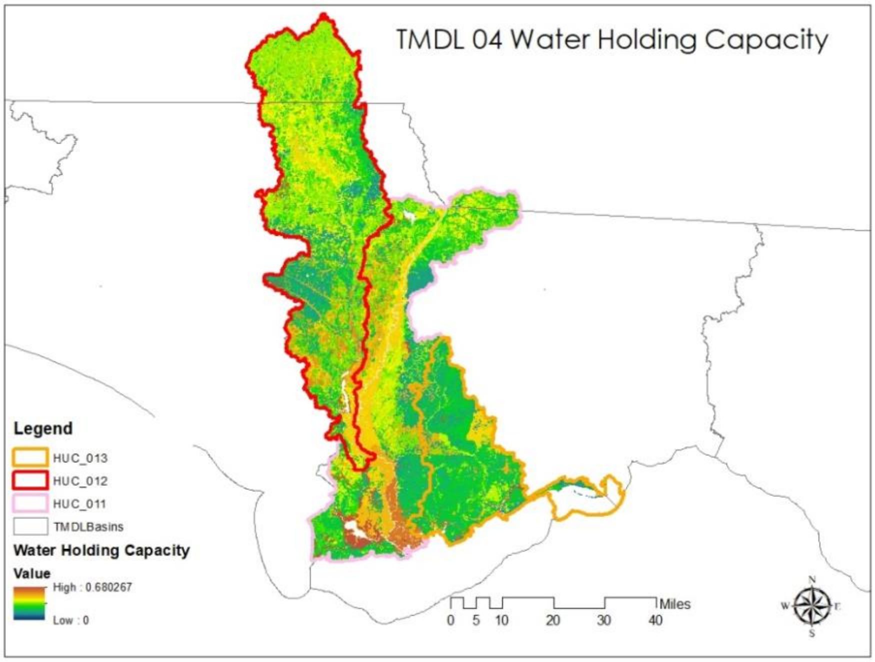

Figure 30. Panhandle Water Holding Capacity

3.1.4. Ground Storage

Figure 7 represents the ground storage within the TMDL 04 region. The highest levels of ground storage are located in the northern portion and stretches south within HUC_012. The lowest levels are concentrated near the coast.

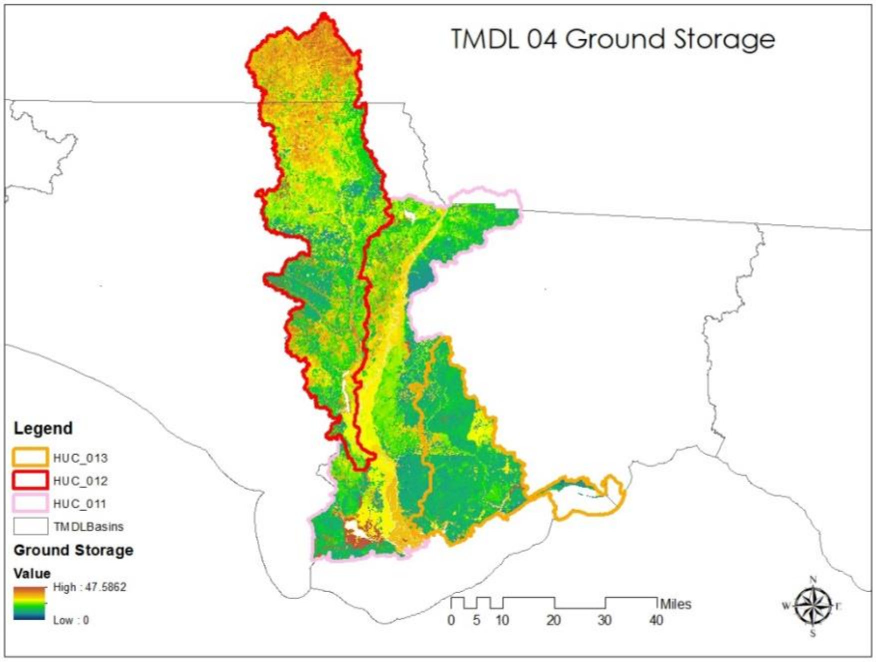

Figure 31. TMDL 04 Ground Storage

The area with the highest ground storage level occurs within the Big Creek and Cowarts Creek (HUC_031) at roughly 47 feet each, seen in Table 3.

Table 7. TMDL 04 Ground Storage

HUC_011

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Upper Apalachicola River	1	1220434	1220434800	0.536	36.41	35.8831	16.974914	5.908954	20716776
2	Mosquito Creek	2	1698676	169867600	4.964	24.16	19.1966	12.873055	3.272112	21867150.
3	Lower Apalachicola River	3	7048826	704882600	0.576	43.53	42.9604	16.788848	7.266121	11834166
4	Cypress Creek	4	4076911	407691100	0.511	43.53	43.0257	17.149995	9.53151	69919003.

HUC_012

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Big Creek	1	5609553	560955300	0	47.58	47.5862	24.40483	4.216117	13690018
2	Cowarts Creek	2	3908274	390827400	0	47.41	47.4156	24.809793	5.536979	96963467.
3	Upper Chipola River	3	1353899	1353899700	4.224	42.47	38.2520	17.046682	5.843458	23079497
4	Lower Chipola River	4	8631979	863197900	0.551	41.77	41.2188	17.119373	6.828777	14777406

HUC_013

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	New River	1	8875138	887513800	2.727	43.53	40.8098	12.246286	4.750782	10868747
2	Whiskey George Creek	2	2417444	241744400	3.783	43.53	39.7537	11.23821	4.579411	27167744.

3.1.5. Precipitation

Figure 8 depicts the precipitation values within the TMDL 04 region. Precipitation flows from the north experiencing less rainfall with roughly 10 inches of rainfall, and the south portion experiencing higher levels of rainfall with approximately 13 inches of rainfall.

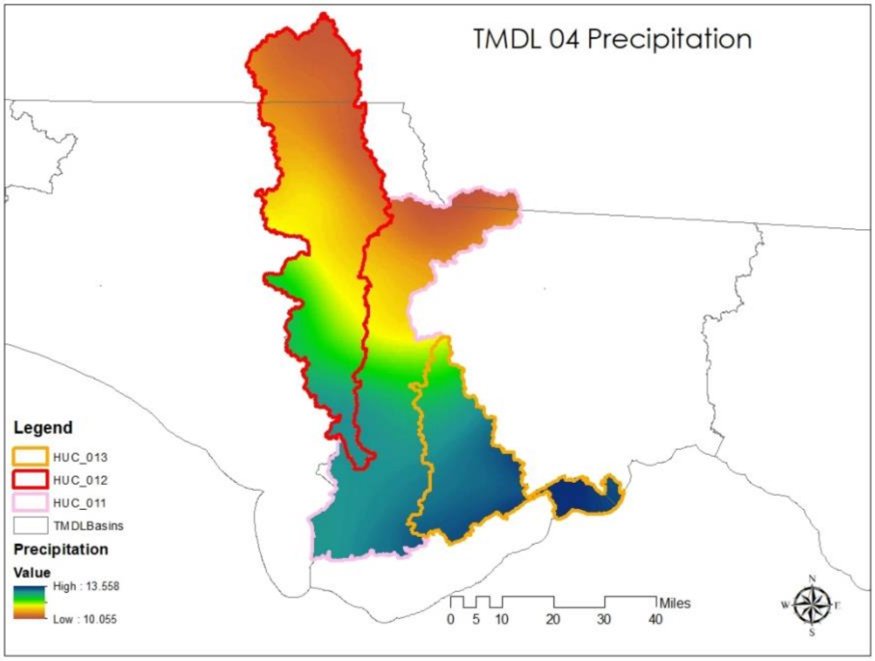

Figure 32. Panhandle Water Stations

New River and Whiskey George Creek (HUC_013) experiences the largest amount of rainfall with roughly 13.4 inches of rainfall, seen in Table 3. Both New River and Whiskey George Creek are located in the southwest portion of the TMDL. The area with the lowest rainfall, nearly 10 inches, is located near Mosquito Creek (HUC_011).

Table 8. TMDL 04 Precipitation

HUC_011

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Upper Apalachicola River	1	1684	1268322886.776565	10.107	12.941	2.834	11.221365	0.723416	18896.777995
2	Mosquito Creek	2	223	167954871.586208	10.098	10.712	0.614	10.425404	0.148551	2324.864999
3	Lower Apalachicola River	3	955	719268620.470083	12.315	13.269	0.954	12.942918	0.165717	12360.486983
4	Cypress Creek	4	559	421016920.254216	12.865	13.074	0.209001	12.93847	0.040698	7232.605005

HUC_012

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	Big Creek	1	731	557755119.071491	10.229	10.805	0.576	10.510122	0.149184	7682.898999
2	Cowarts Creek	2	519	395998504.51177	10.149	10.55	0.401	10.266071	0.083355	5328.091
3	Upper Chipola River	3	1792	1367301194.768963	10.177	11.928	1.751	10.967723	0.385693	19654.159011
4	Lower Chipola River	4	1156	882031351.0898	11.248	12.961	1.713	12.15133	0.462997	14046.938006

HUC_013

Rowid	NAME	ZONE-CODE	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	New River	1	1195	896181266.366625	11.513	13.47	1.957001	12.921249	0.422459	15440.891994
2	Whiskey George Creek	2	330	247481019.164005	12.974	13.366	0.392	13.190833	0.087369	4352.975003

3.1.6. Surface Waters

Figure 9 shows the location of existing water stations. The data provided from each water station will justify the results obtained from CASCADE. Some HUCs did not contain any existing water stations, however due to the flow of the rivers, the data collected from the basin upstream will be used to prove the validity of the results.

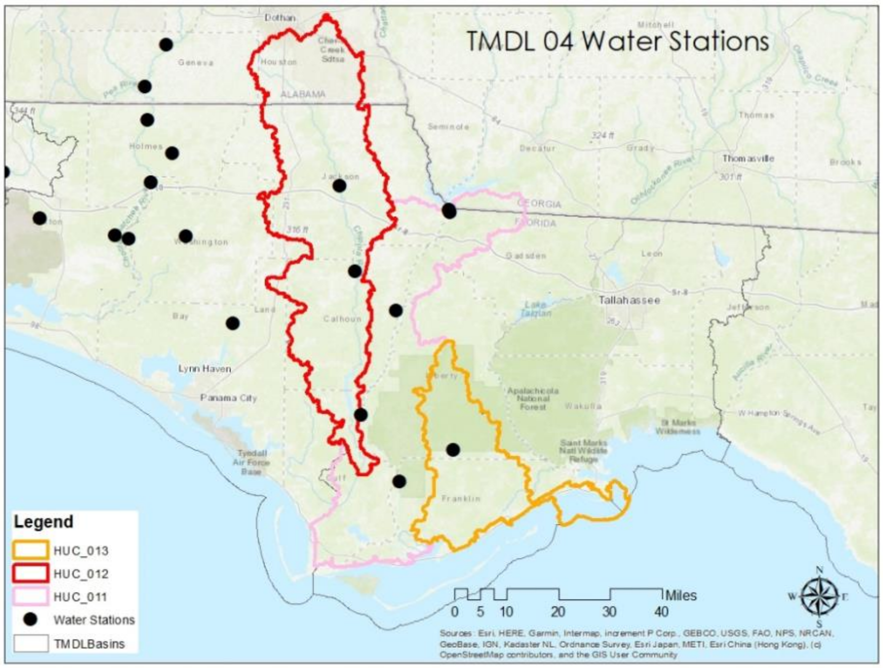

Figure 33. TMDL 04 Water Stations

3.1.7. Open Space

While the soil may have the capacity to store water, the type of land cover will either allow or prevent soil infiltration. If an area is covered by impervious surfaces, the rainfall will not infiltrate the soil causing surface runoff and increased flooding. Only those areas classified as open space, or pervious land, will minimize surface runoff, promoting soil infiltration and storage in the unsaturated zone. Therefore, incorporating impervious surfaces into the calculation of soil storage capacity is important. The National Land Cover Database was used to classify land as either pervious or impervious. Then, impervious surfaces were assigned a value of zero to designate all impervious areas as having no soil storage capacity since rainfall will simply runoff along the surface without any soil infiltration, preventing storage in the unsaturated zone. Figure 10 depicts the open spaces using a binary system. The open spaces are scattered across the TMDL.

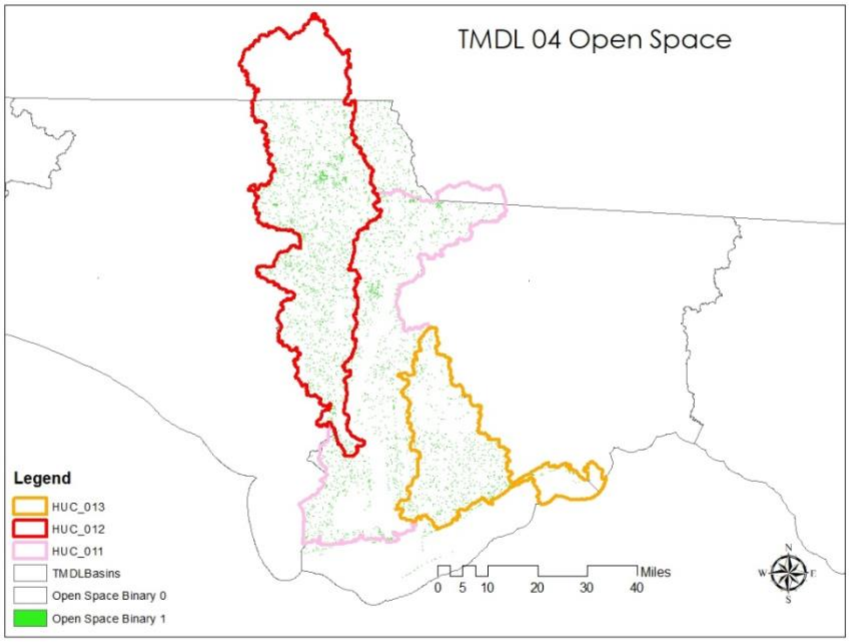

Figure 34. Panhandle Open Space

3.2. Modeling Protocol

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 waterway flow paths from ArcHydro as in Figure 11.

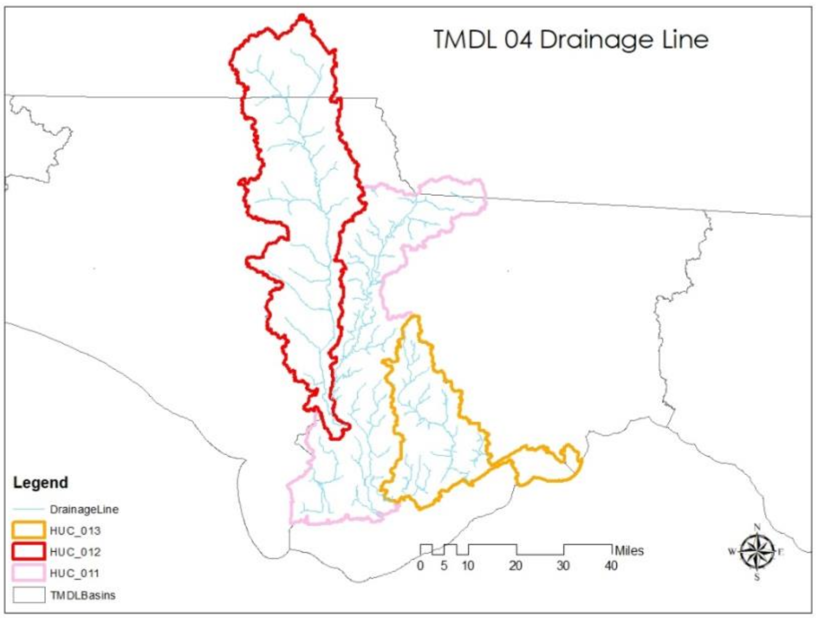

Figure 35. Panhandle Flow Paths

The inputs required by the model were prepared based on datasets of DEM, water table, soil storage, and rainfall. The steps are as follows.

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.

Figures 12-21 are examples interface of the simulation for one catchment in Cascade 2001.

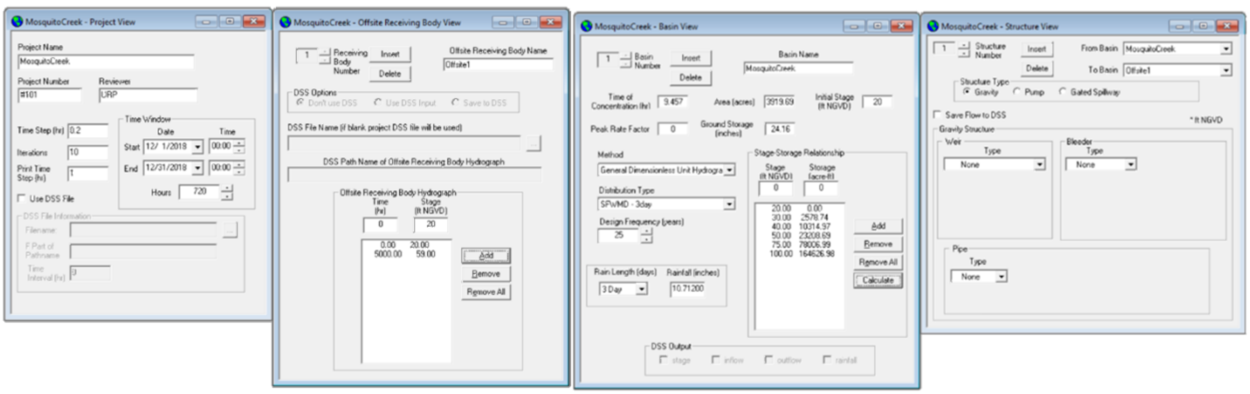

Figure 36. Mosquito Creek Cascade (HUC_011)

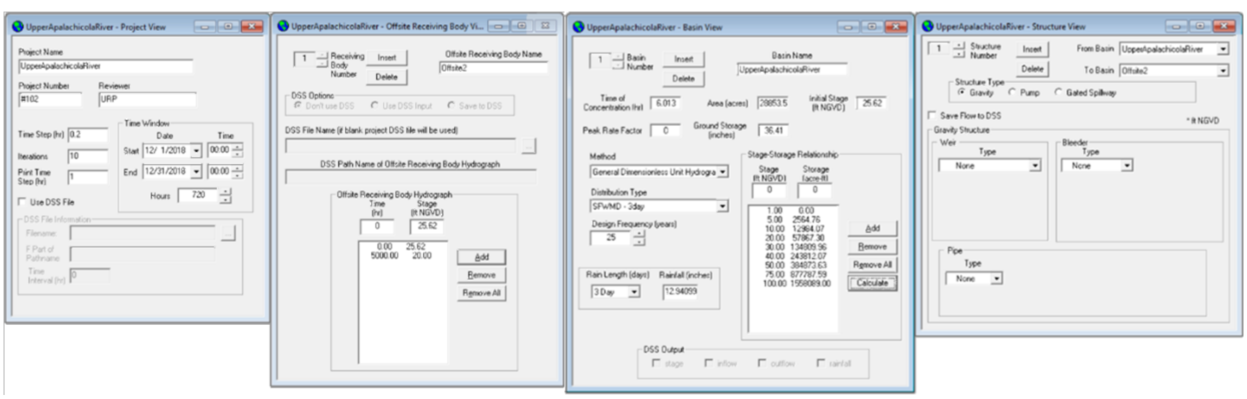

Figure 37. Upper Apalachicola River Cascade (HUC_011)

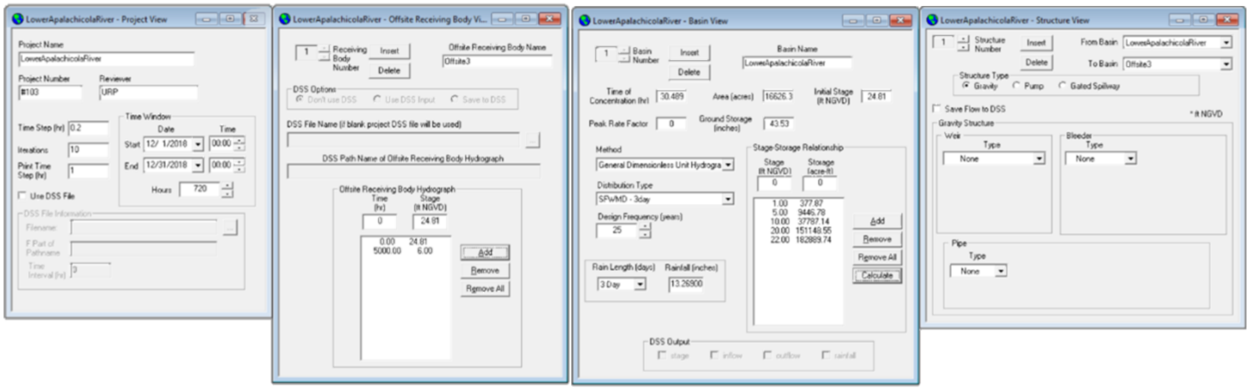

Figure 38. Lower Apalachicola River Cascade (HUC_011)

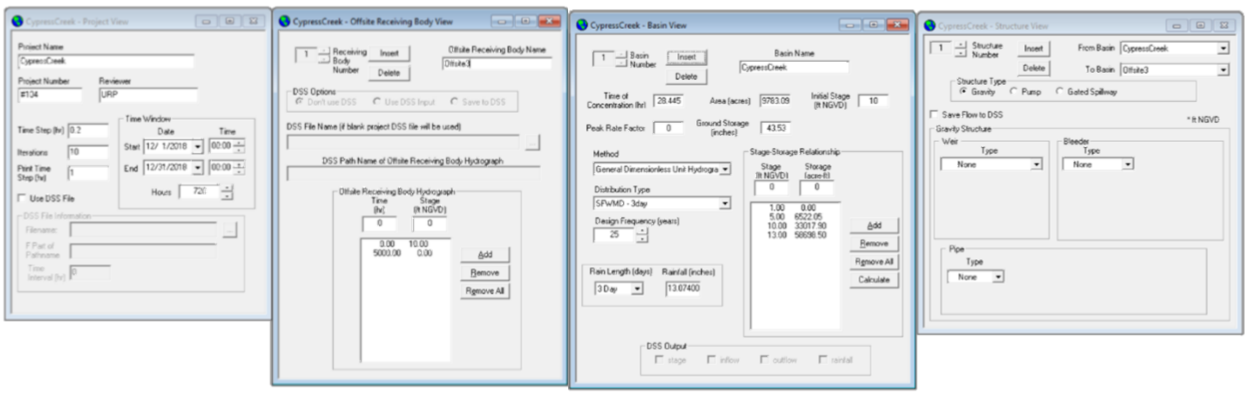

Figure 39. Cypress Creek Cascade (HUC_011)

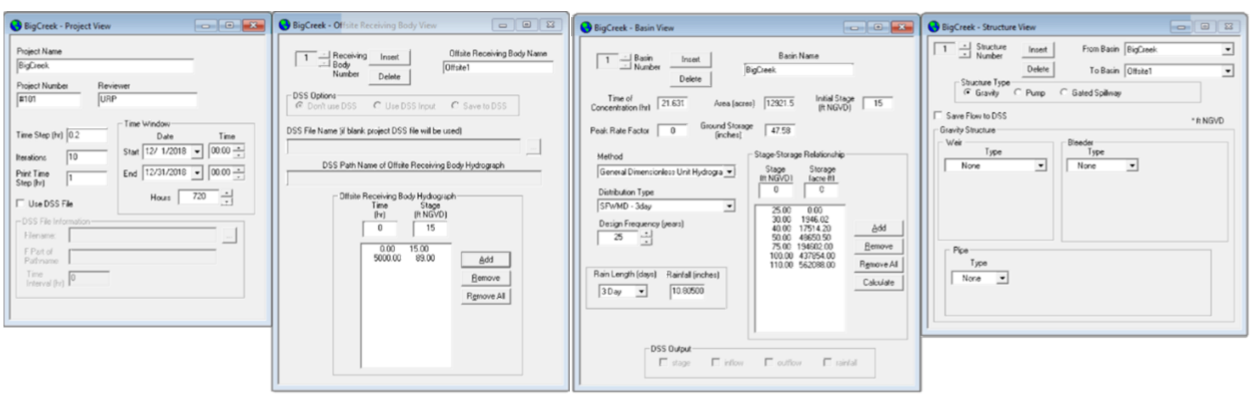

Figure 40. Big Creek Cascade (HUC_012)

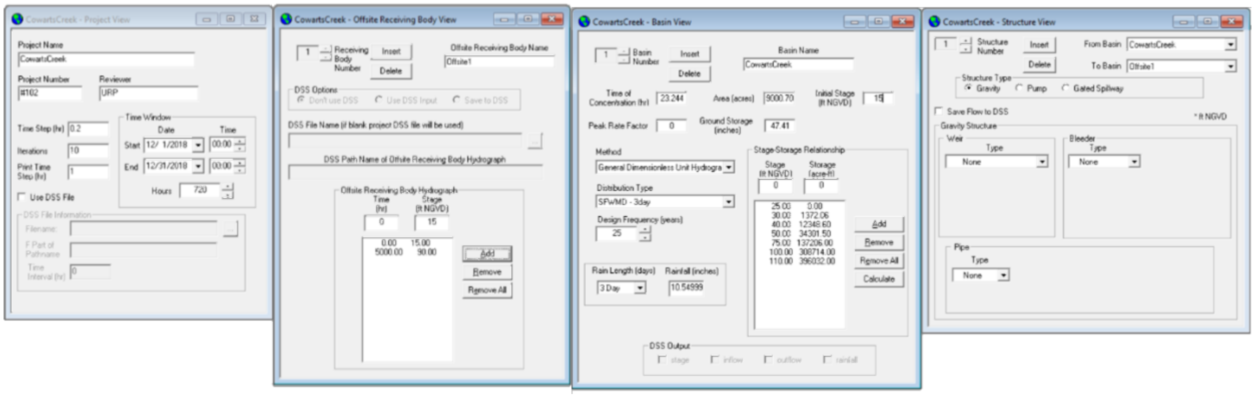

Figure 41. Cowarts Creek Cascade (HUC_012)

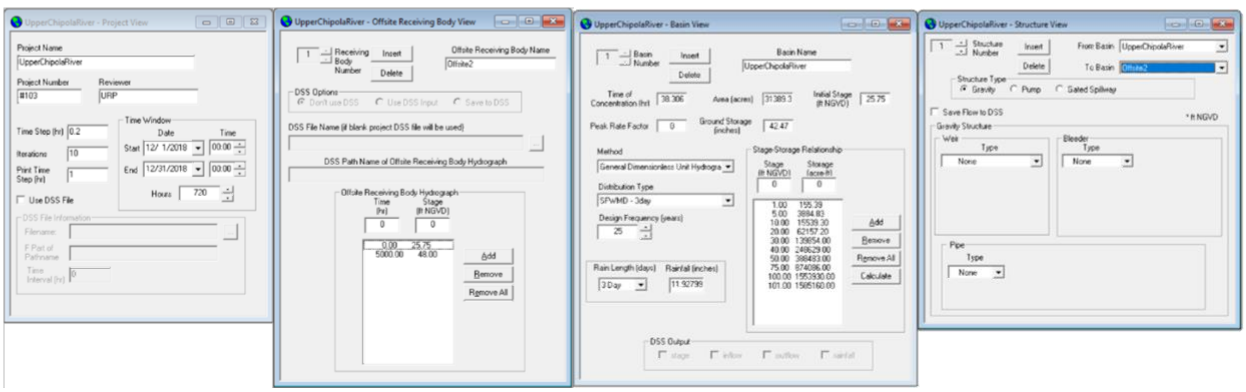

Figure 42. Upper Chipola River Cascade (HUC_012)

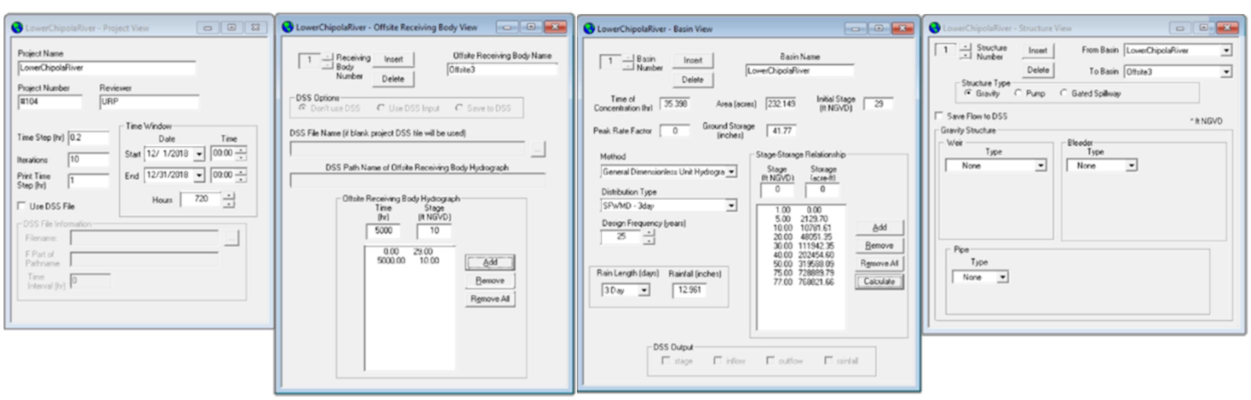

Figure 43. Lower Chipola River Cascade (HUC_012)

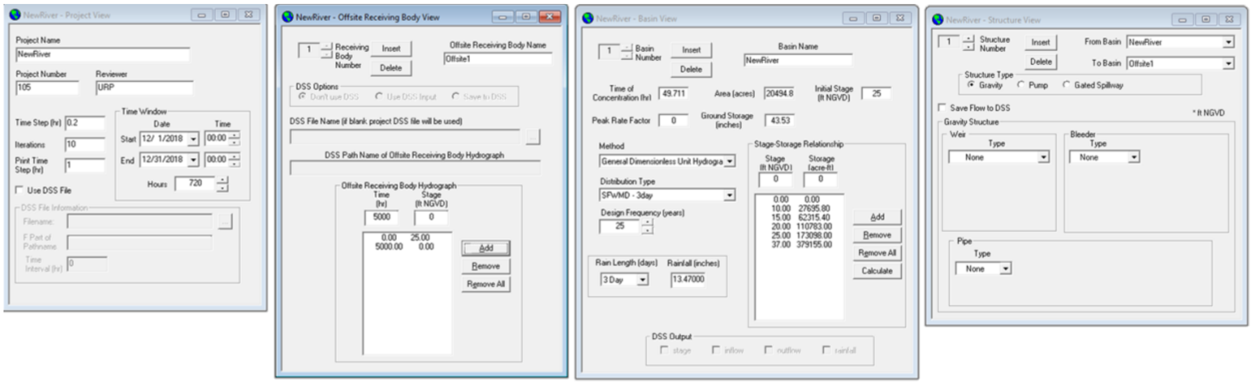

Figure 44. New River Cascade (HUC_013)

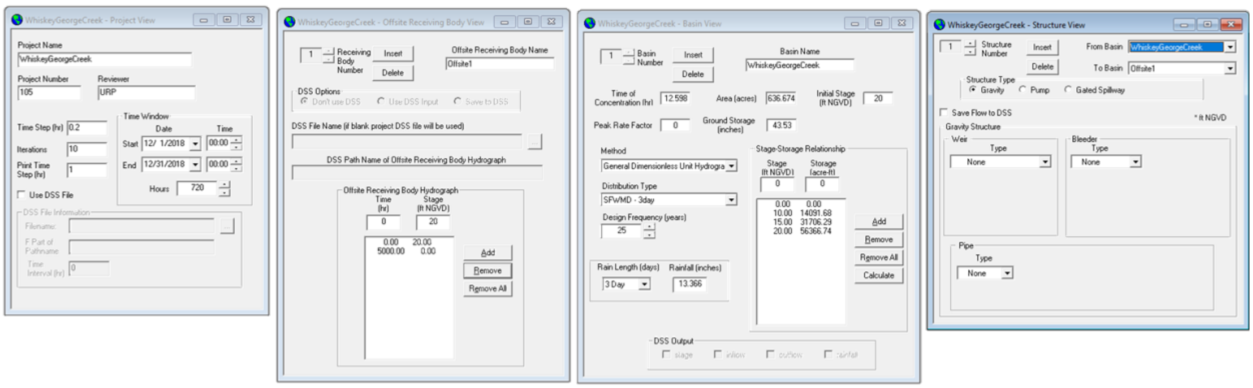

Figure 45. Whiskey George Creek Cascade (HUC_013)

3.3. Modeling Results

3.3.1. Vulnerability to Flooding

Figure 22 displays flood risk for TMDL Basin #4 based on a 3-day, 25-year, rainfall which are consistent with the requirements for stormwater permitting in Florida. The urbanized areas include the Apalachicola urban cluster, Blountstown, Chattahoochee, Marianna, and Port St. Joe. Among the urban communities, the most vulnerable are the coastal communities along the Apalachicola Bay as well as Port St. Joe.

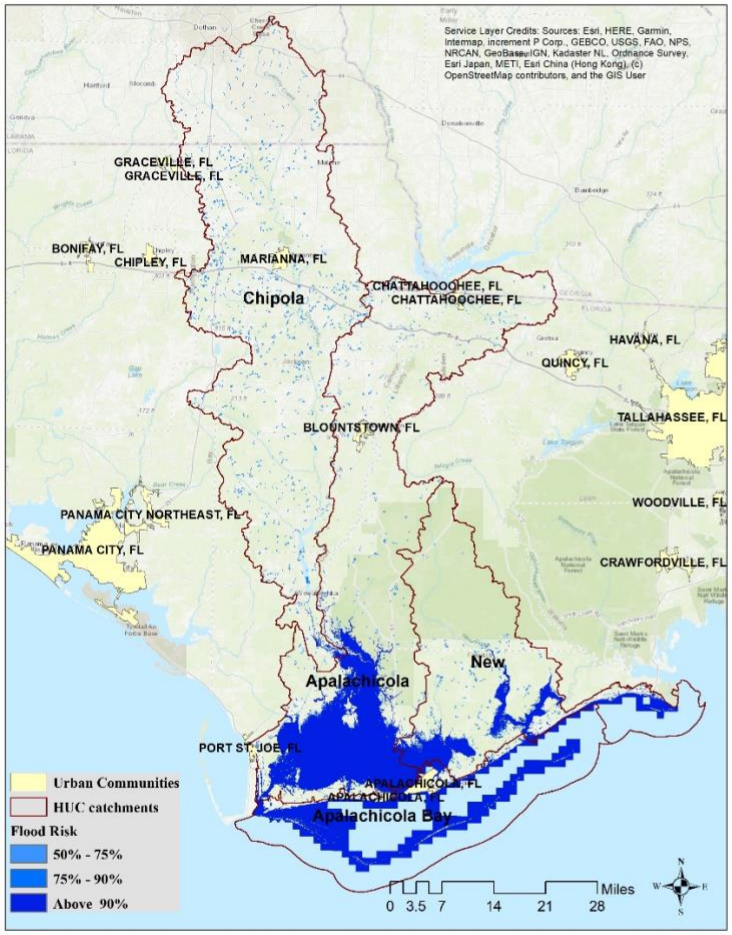

Figure 46. Flood Risk Map

3.3.2. FEMA Flood Map Comparison

For comparison, FEMA flood hazard areas identified on the Flood Insurance Rate Map are identified as a Special Flood Hazard Area (SFHA). SFHA are defined as the area that will be inundated by the flood event having a “1-percent chance” of being equaled or exceeded in any given year. The 1-percent annual chance flood is also referred to as the 100-year flood. SFHAs are labeled as Zone A, Zone AE, and Zone VE. Figure 23 compares the flood risk zones based on the CASCADE results with the maps provided from FEMA. The percent area of overlap indicates agreement between the two flood layers. Table 5 shows the results of the area cross-tabulations.

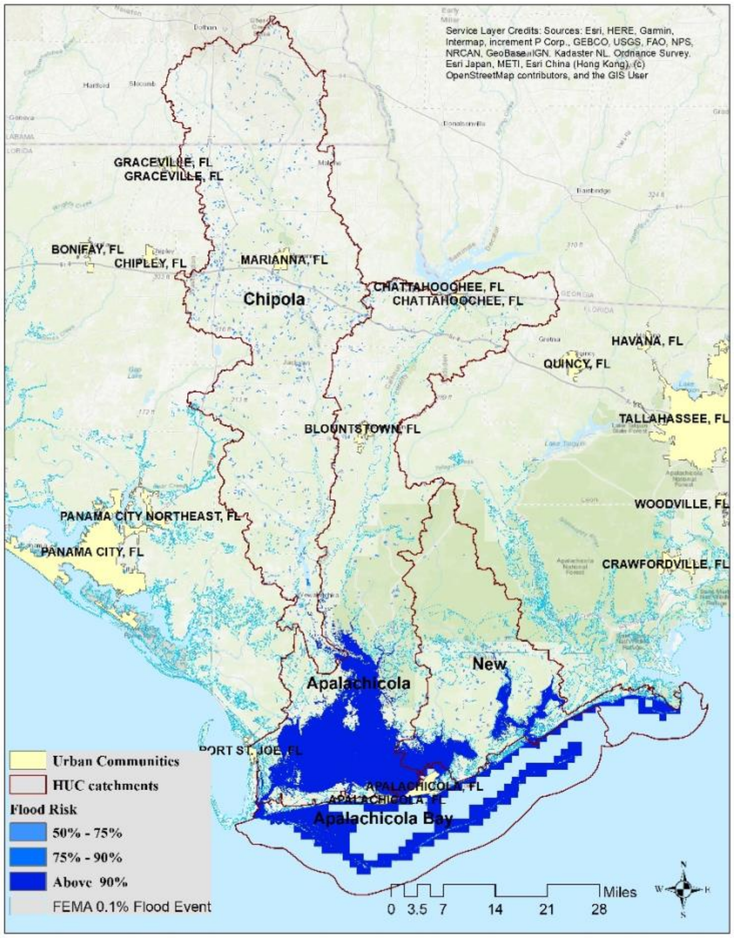

Figure 47. FEMA Flood Map Comparison

Table 5. Comparison between FEMA identified 100-year flood event and the CRT modeled flood region with a high probability for inundation in TMDL Basin #4.

Category	Results
FEMA 1% flooding (total area: km^2)	349.4
Modeled flood risk (total area: km^2)	214.5
Overlapping area (total area: km^2)	187.6
Percent of overlap (FEMA flood zone, in percent)	58.5%
Percent of overlap (estimated flood risk, in percent)	81.3%

3.3.3. Vulnerability to Flooding

The Apalachicola TMDL Basin drains includes the Apalachicola Bay, which incorporates the City of Apalachicola (with a population of 2,360, as of 2020). The area is highly vulnerable to flooding as it drains four rivers (Escambia, Blackwater, Yellow, and East Rivers). The Bay has been designated as a National Estuarine Research Reserve and the Apalachicola River is the largest source of freshwater to the estuary. The maps below (Figure 24) highlight locations vulnerable to flooding in the Apalachicola Bay.

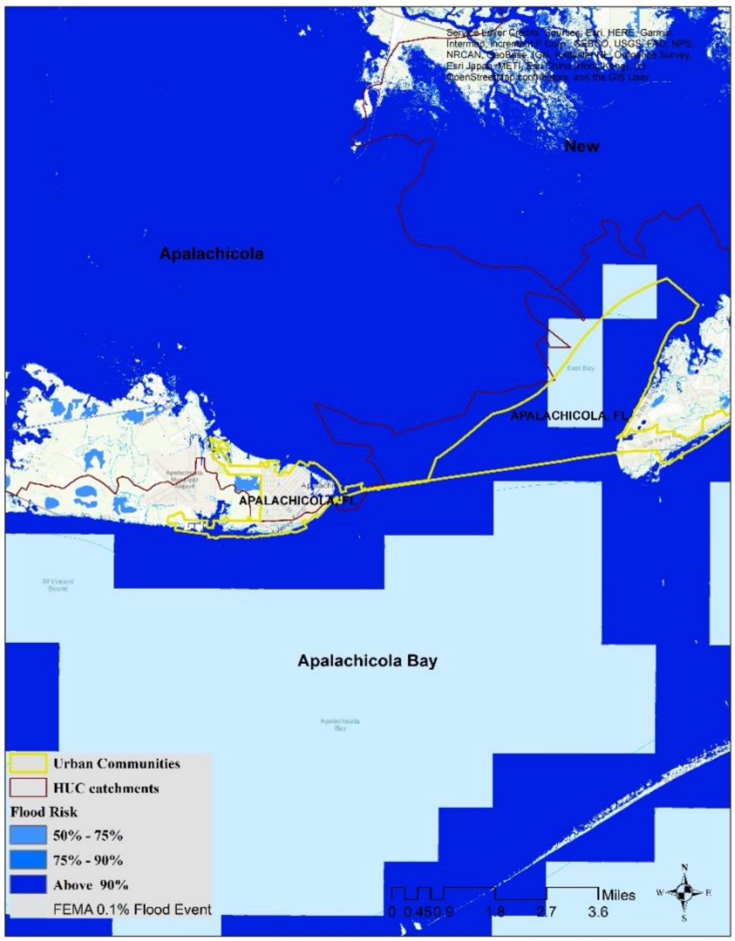

Figure 48. FEMA Flood Map Comparison – Apalachicola Bay

3.3.4. Repetitive Loss Comparison

Figure 25 shows a comparison of the flood map and repetitive loss property locations for the basin. The loss areas coincide with the areas predicted by the FAU model as being at risk for flooding.

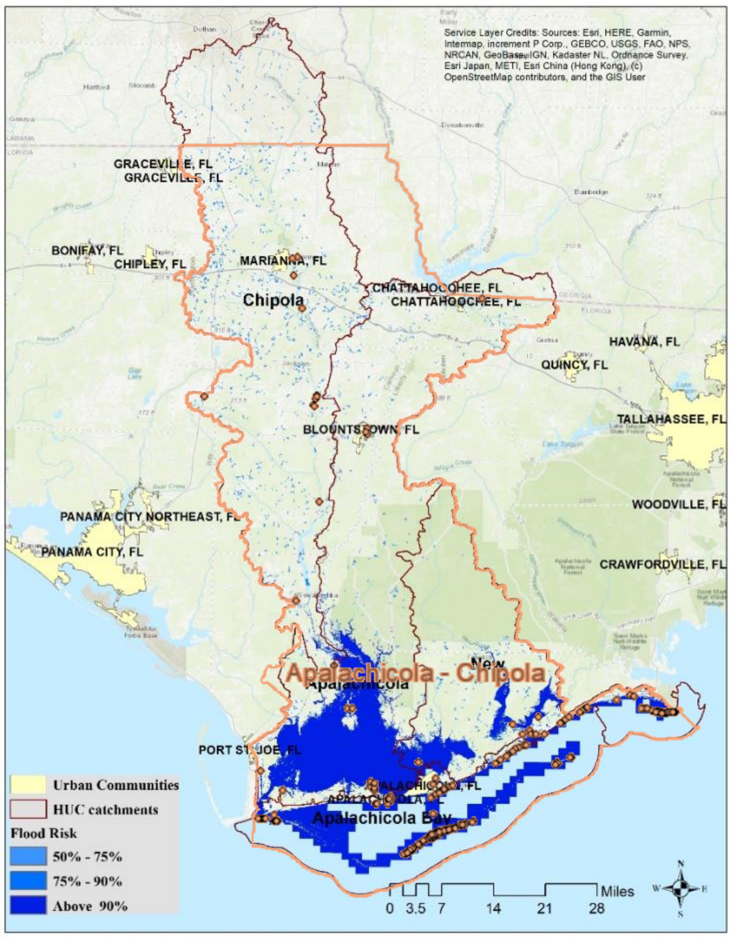

Figure 25. Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU

4.0 Conclusion

FDEM contracted with FAU to develop a screening tool of flood risk areas for 29 watershed basins. The effort discussed herein focuses on the development procedures for a screening tool to assess risk in the Panhandle area of Florida. The effort discussed herein focusses on the development procedures for a screening tool to assess risk in the Apalachicola watershed basin. The watershed located in Northwest Florida combines readily available data on topography, ground and surface water elevations, tidal data for coastal communities, open space and rainfall to permit an assessment of the risk of inundation of property within the Panhandle Basin.

The basin shows widespread flooding along the beach 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 community showed it was are flood prone. The repetitive loss maps confirmed FAU’s modeling. Such knowledge permits the development of tools to permit local agencies to develop means to address high risk properties. Solutions to improve flood resiliency in the is basin will yield long term benefits.

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