DRAFT

Panhandle Watershed Case Study

TMDL BASIN 01

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08/30/2020

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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 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 TMDL 02 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 TMDL 05 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 Perdido Watershed (Florida TMDL Basin 01). The watershed borders the Pensacola Metropolitan Area. The basin is coastal, so flood risks from rainfall, wet season thunderstorms and tropical storm activity are considered potential hazards by the local officials and the people who live in the watershed. Figure 1 shows the location of the Perdido Watershed (TMDL 01) within the Florida 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.

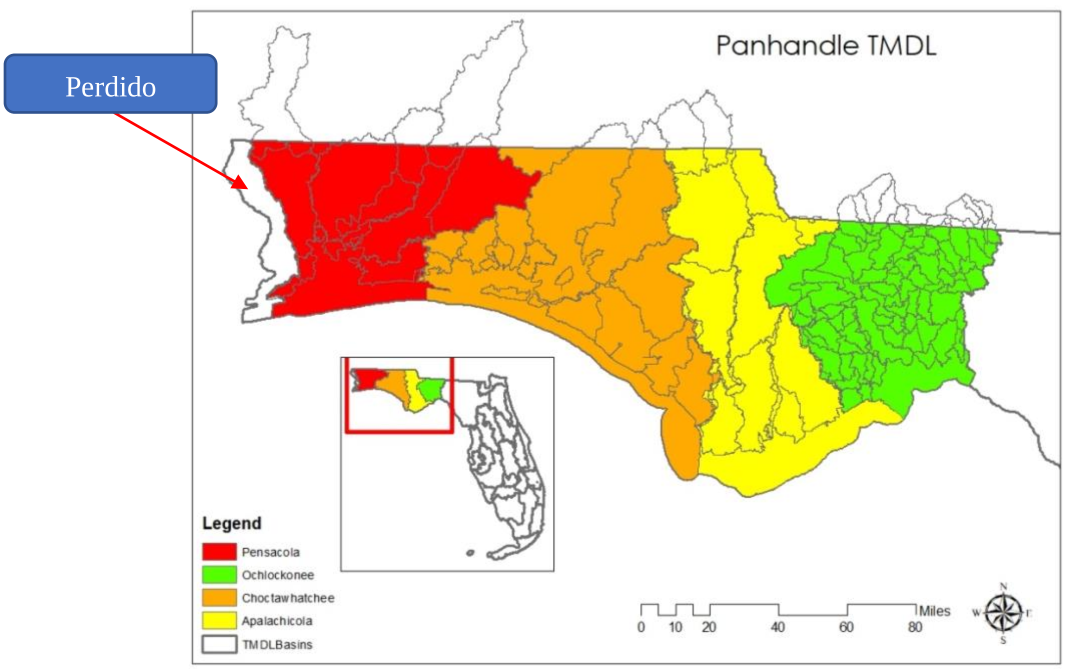

Figure 16. Location of Perdido TMDL Basin

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, 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 (smilingglobe.com, 2020). The key elements of the watershed include Perdido which is in close proximity to Pensacola Bay and Choctawhatchee Bay. Perdido River which drains into Perdido Bay is an Outstanding Florida Waters River. Figure 2 depicts the TMDL 01 subdivided into 2 HUCs that will later be analyzed individually through the use of the CASCADE software.

Figure 17. HUC Basins

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 2018, the watershed had a population of 156,332 people. The average household size for the TMDL 02 was 3 people per household. The population consists of roughly 22% under the age of 18, 16.3% who were 65 years of age or older. The racial makeup of the county was 79% White, 7.5% Black or African American, 6.30% Hispanic or Latino, 1.7% Asian, 4.80% Native American, 0.20% Pacific Islander. As of the 2010, the median income for a household in the county was $44,145, and roughly 16.10% 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 $175,000.

2.2.3. Economic Activity/Industry

As of 2018, the total number of jobs within the TMDL 02 area is 14,295, with roughly 1,145 establishments. 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 nearly 90 feet above sea level. and the lowest points are along the coast of the panhandle.

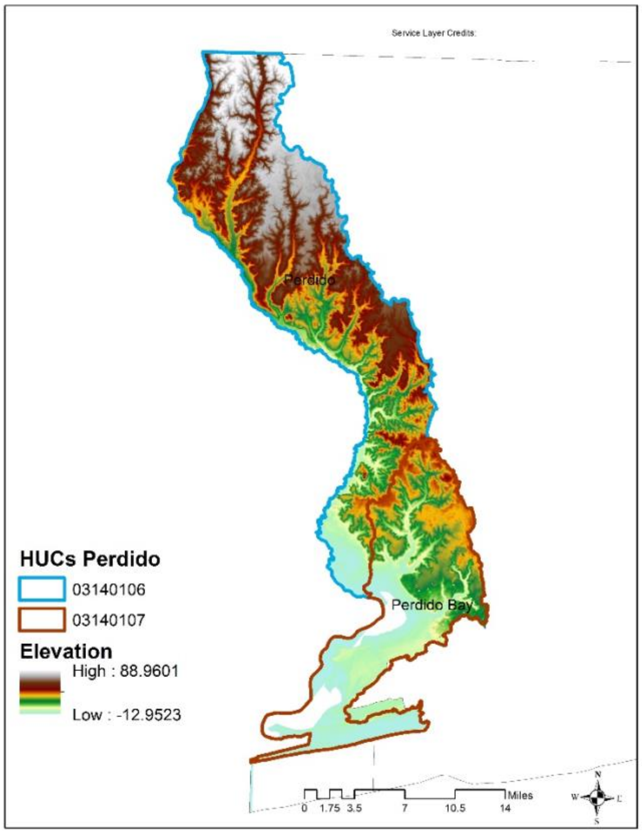

Figure 18. Topography of Perdido watershed (TMDL Basin 01) based on LiDAR DEM

3.1.2. Groundwater

Figure 4 depicts the groundwater levels within the Perdido Wayershed. The highest point reaches 101 feet in the northern part of the watershed, and the lowest point is at -5 feet along the coastline.

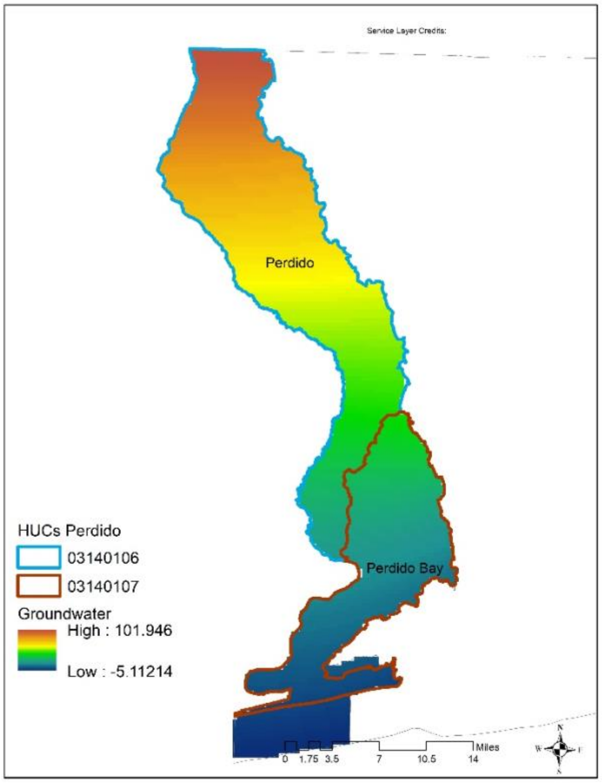

Figure 19. TMDL 01 Basin (Perdidio) Groundwater elevations

3.1.1. Impervious Areas

Figure 5 represents the impervious areas, primarily roads in the Perdido Watershed. These are areas where water cannot seep into the soil and as a result seep to unsaturated areas. Most of the impervious areas are found within the Pensacola Metropolitan Area.

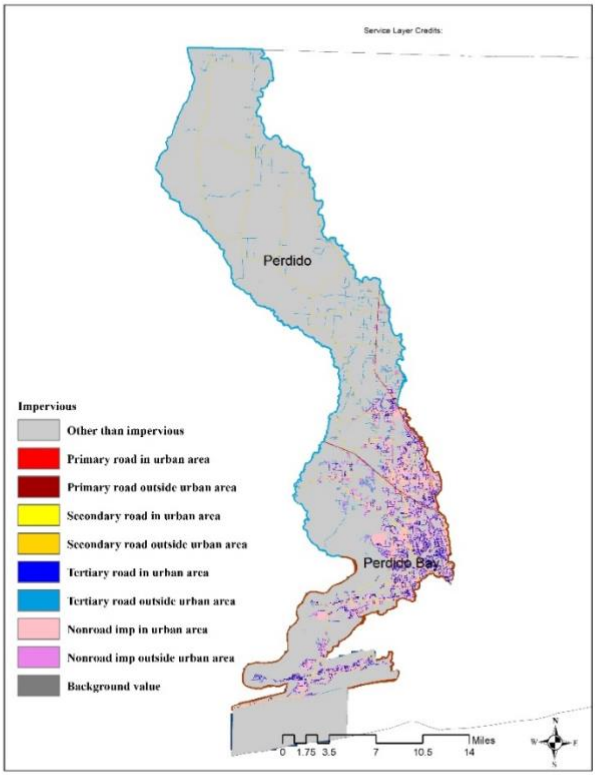

Figure 20. TMDL Basin 01 (Perdidio) Impervious Areas

3.1.2. Ground Storage

Impervious surfaces in addition to soil characteristics play an important role in determining infiltration and water holding capacity. Figure 6 is the water holding capacity. The highest capacity is at 0.46 feet and the lowest is at zero feet. Figure 7 represents the soil storage capacity in inches within the Perdido Watershed.

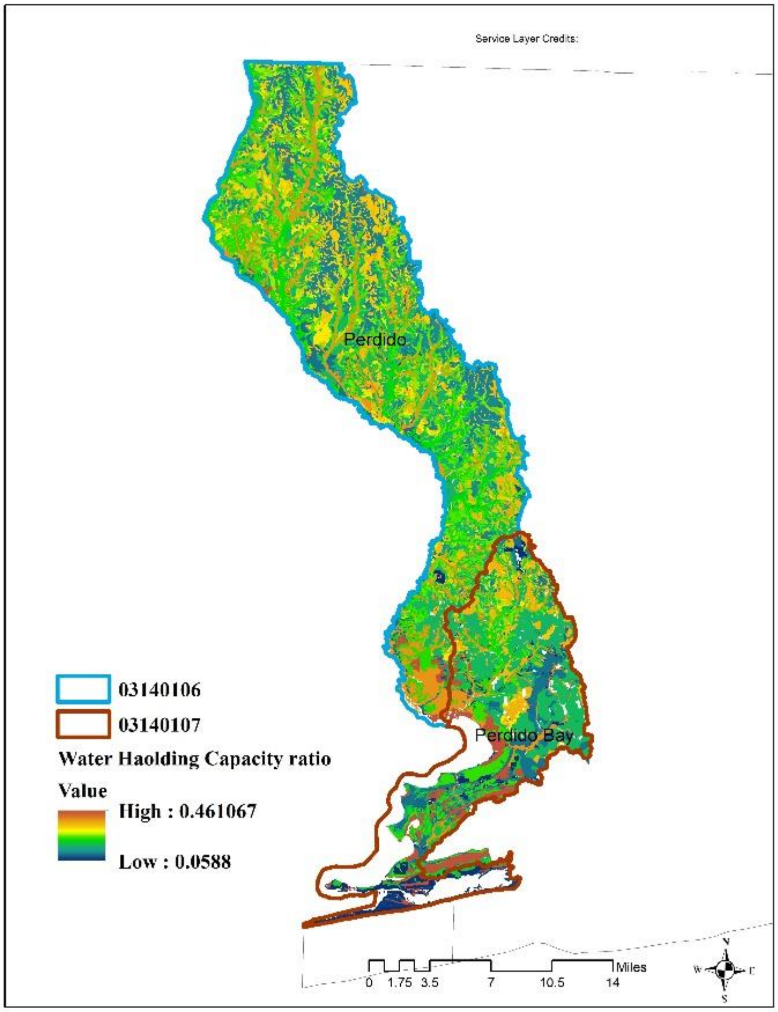

Figure 21. Perdido Watershed Water Holding Capacity Ratio

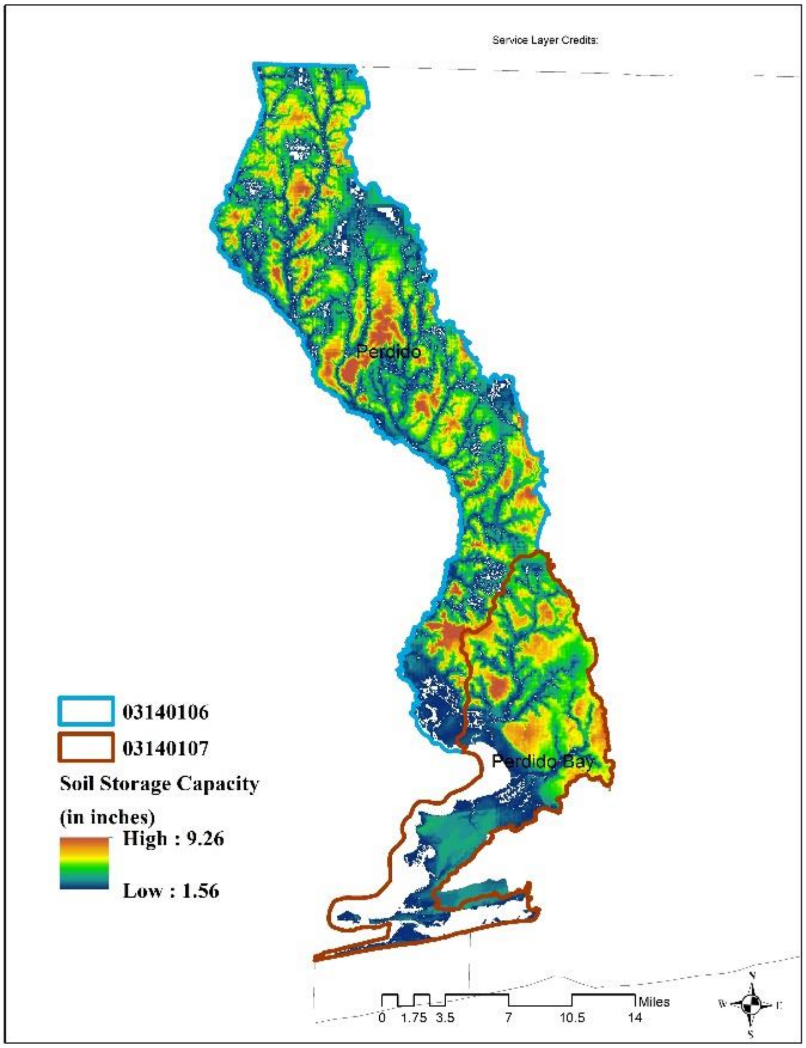

Figure 22. Soil storage capacity for TMDL 01 (Perdido)

3.1.3. Precipitation

Figure 8 depicts the precipitation values within TMDL Basin 01. The areas along the coast experience slightly higher precipitation rates than the northern part of the watershed but the difference is not significant. Most of the area is low to medium rainfall.

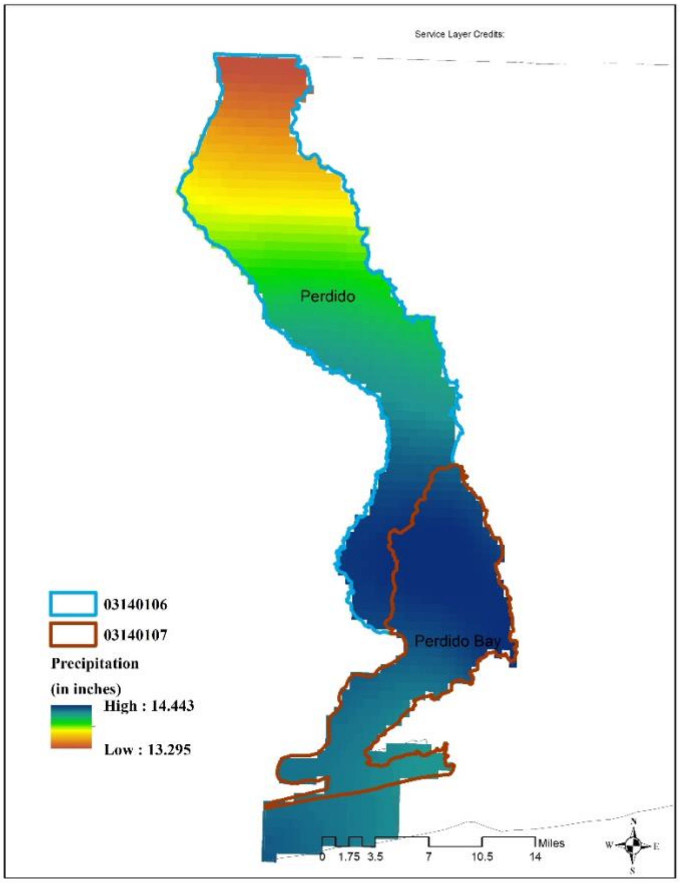

Figure 23. Perdido Precipitation

3.1.4. 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 was used to calibrate the model.

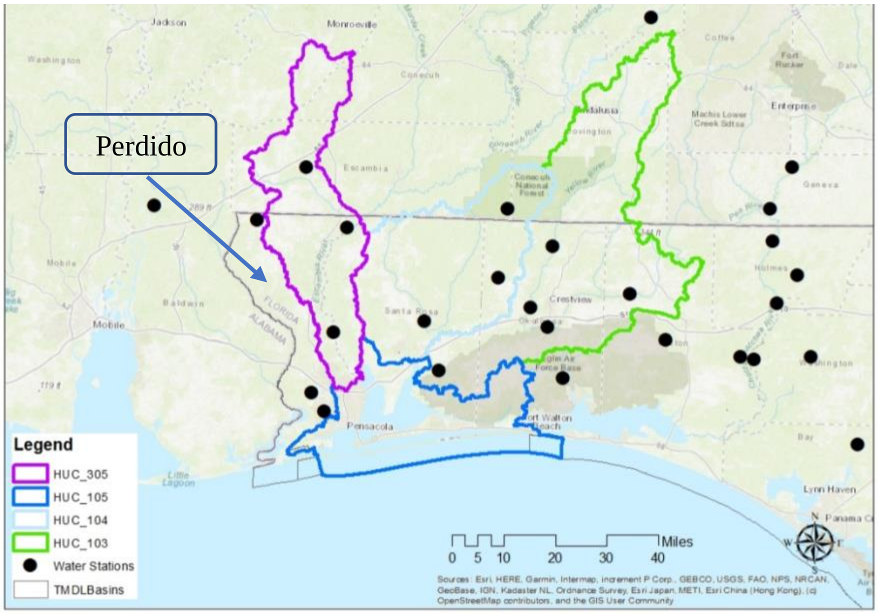

Figure 24. TMDL Basin 01 – Surface Water Stations

3.1.5. 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. As Figure 10 indicates, the urban area adjacent to the Pensacola Metropolitan Area has significant amount of open space. Open space plays an important role in stormwater management as it allows for additional water storage capacity.

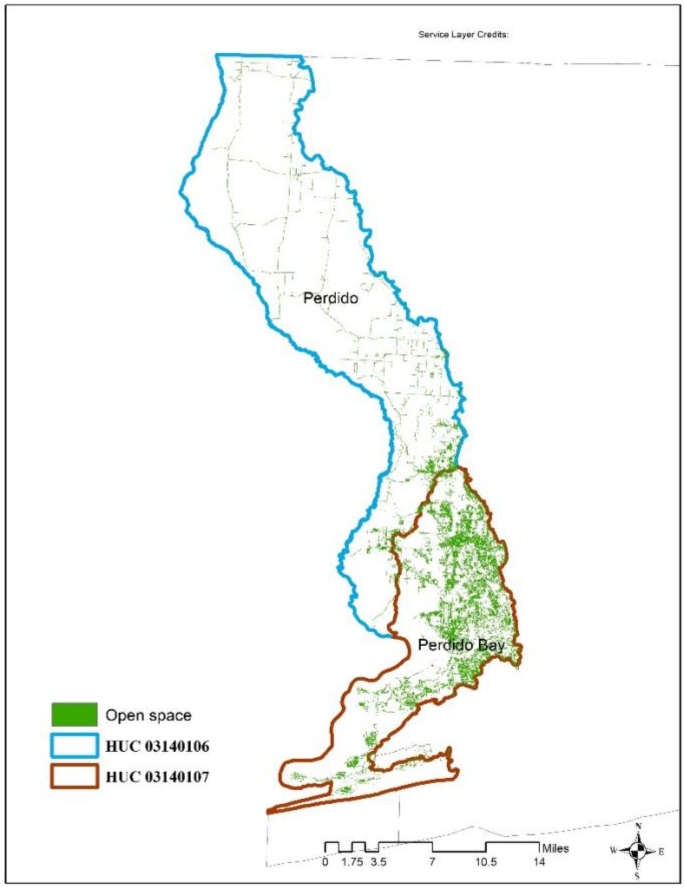

Figure 25. TMDL Basin 01 Open Space

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.

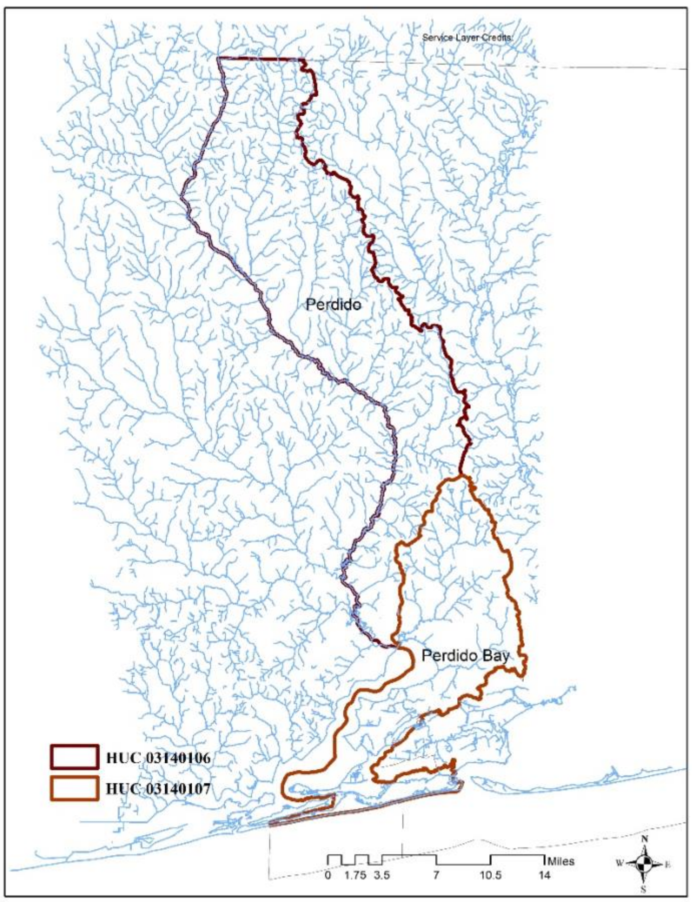

Figure 26. TMDL Basin 01 Flow Paths

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

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 12 and 13 present examples of the data inputs for the hydrologic simulation using Cascade.

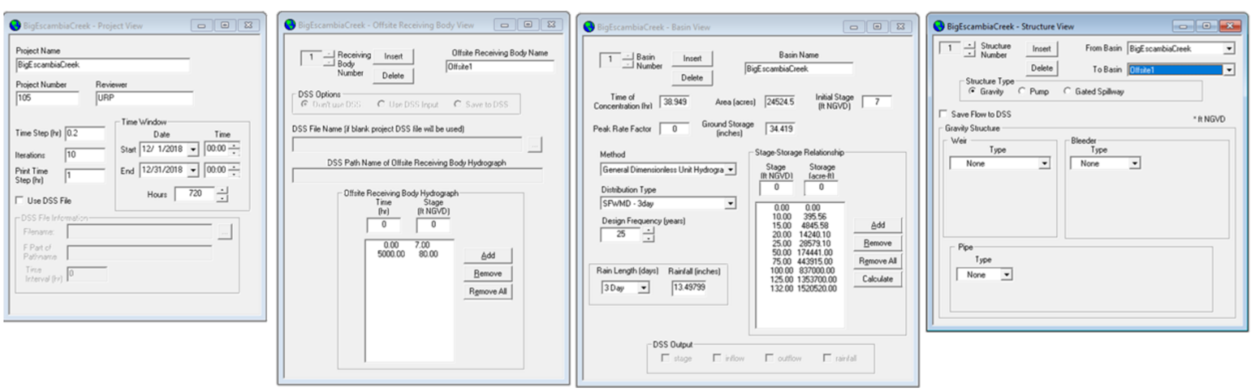

Figure 12. HUC 03140106 Cascade inputs

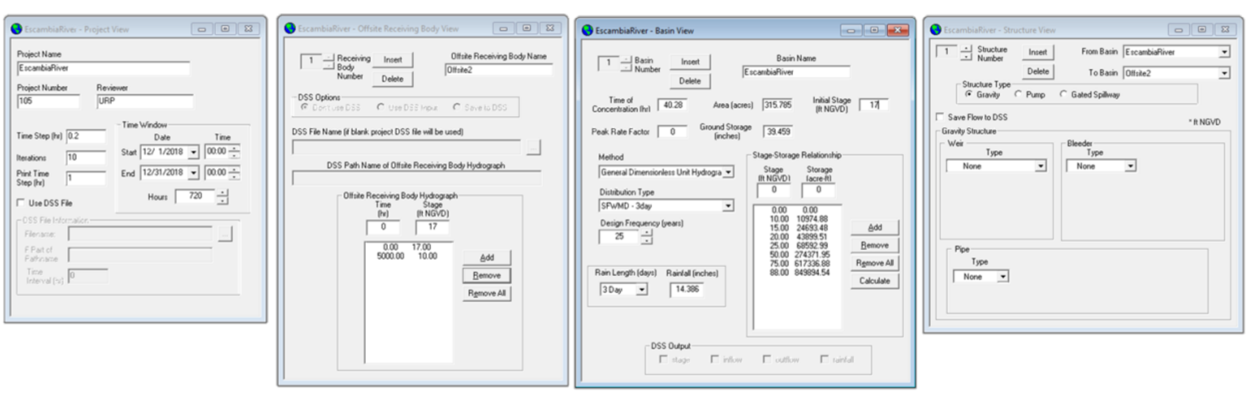

Figure 13. HUC 03140107 Cascade inputs

3.3. Modeling Results

3.3.1. Vulnerability to Flooding

Figure 14 displays the estimated flood risk for Perdido Bay and the surrounding areas (TMDL Basin #1) based on a 3-day, 25-year rainfall. The highest risk is found along the coast and at the mouth of Perdido River. The area is not densely populated but includes an urban cluster along the coast and near the Pensacola Metropolitan Area.

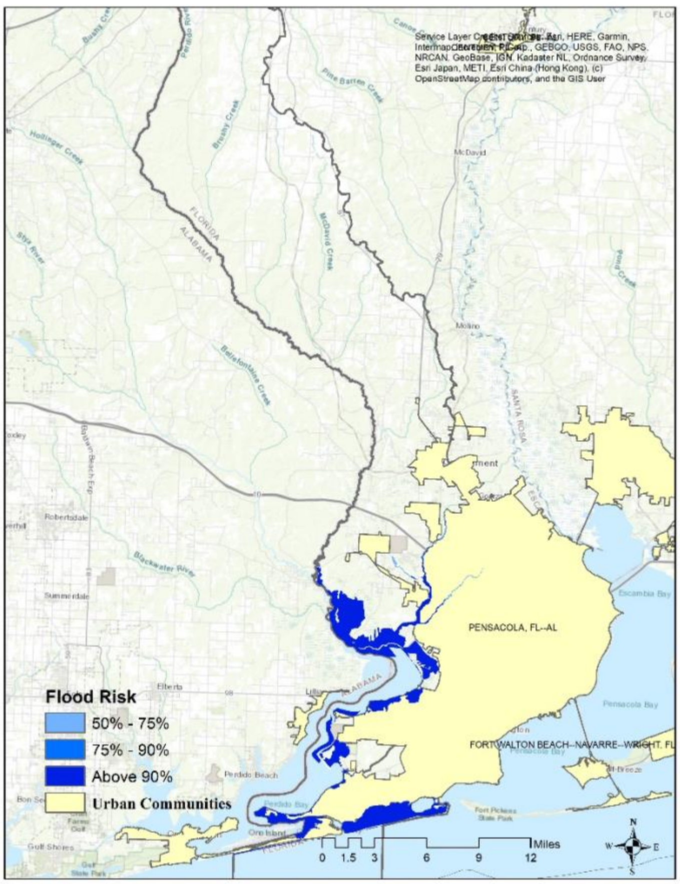

Figure 14. Flood Risk Map

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 base flood or 100-year flood. SFHAs are labeled as Zone A, Zone AE, and Zone VE. Figure 24 compares the flood risk zones based on the CASCADE results with the maps provided from FEMA. Figure 15 shows a comparison of the estimated flood risk map and FEMA’s 100-year floodplain. Table 5 provides a summary of the overlay statistics.

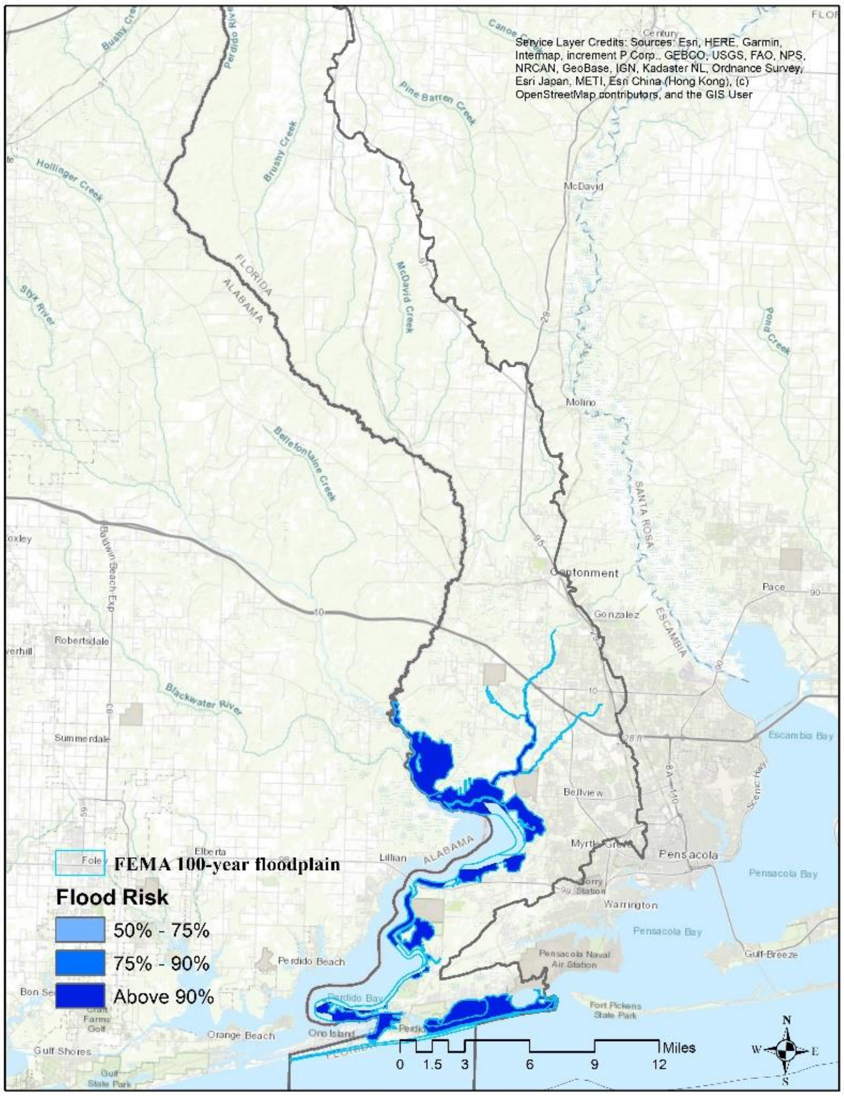

Figure 15. FEMA Flood Map Comparison

Table 1 Comparison between FEMA identified 100-year flood event and the CRT modeled flood region with a high probability for inundation in TMDL Basin #.

Category	**Results**
FEMA 1% flooding (total area: km^2)	149.3
Modeled flood risk (total area: km^2)	125.3
Overlapping area (total area: km^2)	112.7
Percent of overlap (FEMA flood zone, in percent)	83.92%
Percent of overlap (estimated flood risk, in percent)	89.94%

3.3.3. Vulnerability to Flooding

Perdido Bay is a coastal lagoon located at the border between Florida and Alabama. Perdido Bay is part of the Perdido River estuarine system which is a designated Outstanding Florida Waters river. Perdido Bay is part of the Pensacola Metropolitan Area, which incorporates the City of Pensacola (with a population of 52,975, as of 2019) and Perdido Key which is an unincorporated census-designated places. The total population of the Pensacola metropolitan area as of 2019 was 502,629. The area is highly vulnerable to flooding, especially the areas near the Perdido Bay coastal lagoon.

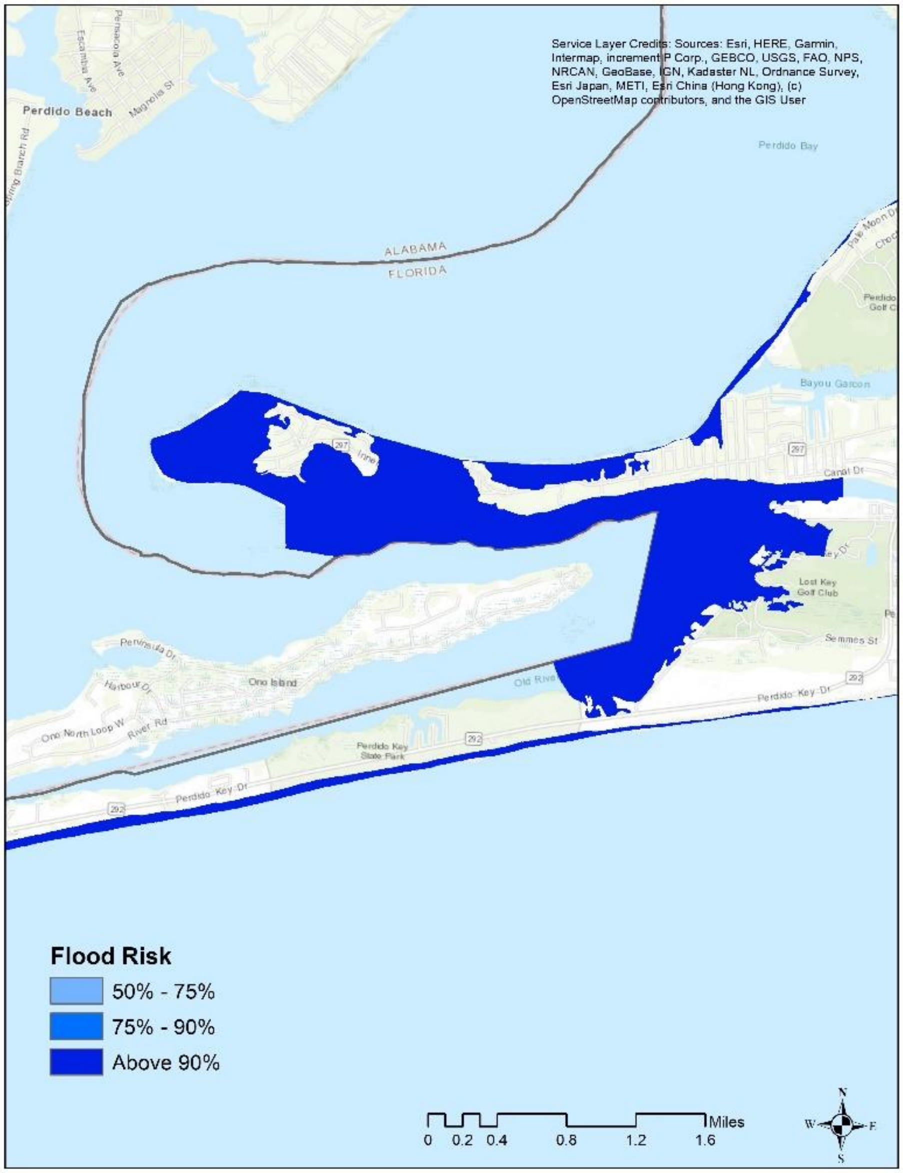

Figure 16. Perdido Key Flood Risk

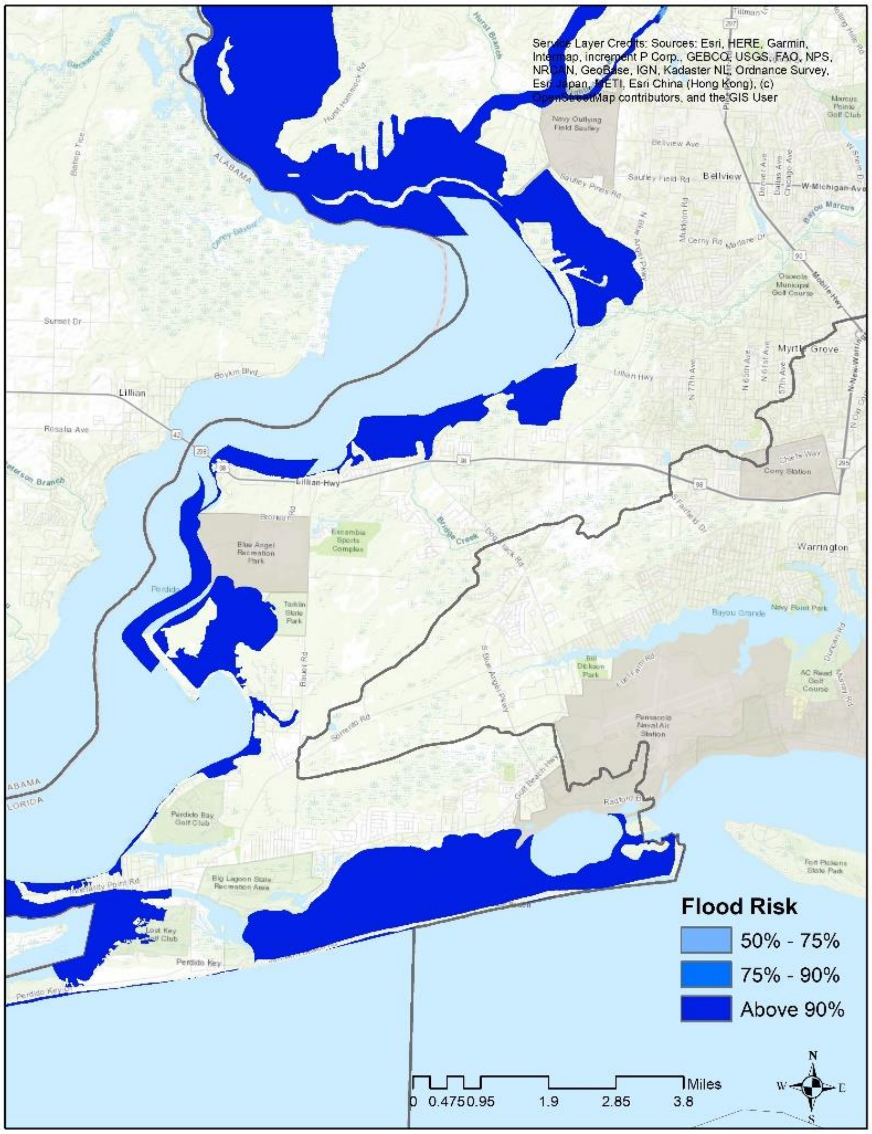

Figure 17. Perdido Bay Flood Risk

3.3.4. Repetitive Loss Comparison

Figure 18 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.

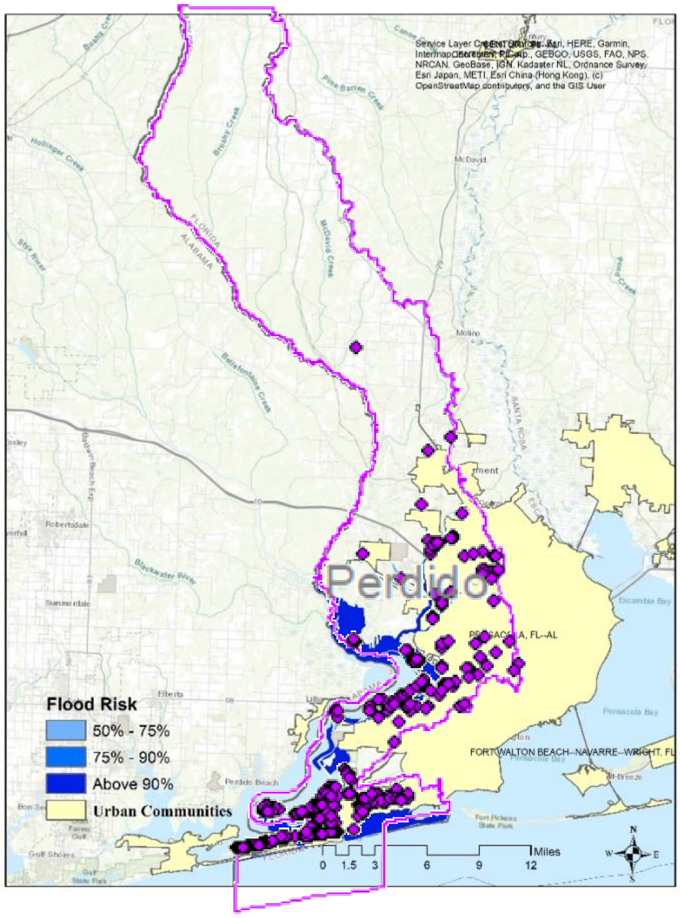

Figure18. Repetitive loss areas from 2004 -2014 superimposed on the flood risk map created by FAU

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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