4 Flood Risk Assessment

Requirement §201.6(c)(2): [The plan shall include] A risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards.

This section describes the Risk Assessment process for the development of the Collier County Floodplain Management Plan. It describes how the County met the following requirements from the 10-step planning process:

- Planning Step 4: Assess the Hazard
- Planning Step 5: Assess the Problem

As defined by FEMA, risk is a combination of hazard, vulnerability, and exposure. "It is the impact that a hazard would have on people, services, facilities, and structures in a community and refers to the likelihood of a hazard event resulting in an adverse condition that causes injury or damage."

This flood risk assessment covers the entire geographical area of Collier County, FL. The risk assessment process identifies and profiles relevant hazards and assesses the exposure of lives, property, and infrastructure to these hazards. The process allows for a better understanding of a jurisdiction's potential risk to natural hazards and provides a framework for developing and prioritizing mitigation actions to reduce risk from future hazard events. This risk assessment followed the methodology described in the FEMA publication Understanding Your Risks—Identifying Hazards and Estimating Losses (FEMA 386-2, 2002), which breaks the assessment down to a four-step process:

1) Identify Hazards;

2) Profile Hazard Events;

3) Inventory Assets; and

4) Estimate Losses.

Data collected through this process has been incorporated into the following sections of this chapter:

Section 4.1: **Hazard Identification** identifies the natural flood hazards that threaten the planning area.

Section 4.2: **Hazard Profiles** discusses the threat to the planning area and describes previous occurrences of flood hazard events and the likelihood of future occurrences.

Section 4.3: Vulnerability Assessment assesses the planning area's exposure to natural flood hazards; considering assets at risk, critical facilities, and future development trends.

Section 4.4: Capability Assessment inventories existing mitigation activities and policies, regulations, and plans that pertain to mitigation and can affect net vulnerability.

4.1 Hazard Identification

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the type…of all natural hazards that can affect the jurisdiction.

Collier County's FMPC conducted a hazard identification study to determine the natural flood hazards that threaten the planning area.

4.1.1 Results and Methodology

Using existing flood hazard data and input gained through planning meetings, the FMPC agreed upon a list of natural flood hazards that could affect Collier County. Flood hazard data from the Collier County Local Mitigation Strategy (LMS), FEMA, the Florida Division of Emergency Management (FDEM), the National Oceanic and Atmospheric Administration (NOAA), the National Hurricane Center (NHC), National Climatic Data Center (NCDC), the Spatial Hazards Events and Losses Database for the United States (SHELDUS^{TM}) and many other sources were examined to assess the significance of these hazards to the planning area. Significance was measured in general terms and focused on key criteria such as frequency and resulting damage, which includes deaths and injuries, as well as property and economic damage.

The flood hazards identified in Table 4.1 were evaluated as part of this plan. Only the more significant hazards with the potential to cause significant human and/or monetary losses in the future have a more detailed hazard profile and are analyzed further in Section 4.3 Vulnerability Assessment.

Table 4.1 Flood Hazard Summary

Hazard	Frequency of Occurrence	Spatial Extent	Potential Magnitude	Significance
Climate Change and Sea Level Rise	Highly Likely	Significant	Critical	Medium
Coastal/Canal Bank Erosion	Highly Likely	Limited	Negligible	Low
Dam/Levee Failure	Unlikely	Limited	Negligible	Low
Flood: 100-/500-year	Occasional	Extensive	Catastrophic	High
Flood: Stormwater/Localized Flooding	Highly Likely	Limited	Negligible	Medium
Hurricane and Tropical Storms (including Storm Surge)	Likely	Extensive	Catastrophic	High

Guidelines:
Frequency of Occurrence:
Highly Likely: Nearly 100% probability within the next year.
Likely: Between 10 and 100% probability within the next year.
Occasional: Between 1 and 10% probability within the next year.
Unlikely: Less than 1% probability within the next year.

Potential Magnitude:
Catastrophic: More than 50% of the area affected.
Critical: 25 to 50% of the area affected.
Limited: 10 to 25% of the area affected.
Negligible: Less than 10% of the area affected.

Spatial Extent:
Limited: Less than 10% of planning area.
Significant: 10-50% of planning area.
Extensive: 50-100% of planning area.

Significance:
Low
Medium
High

Source: AMEC Data Collection Guide

The following hazard was evaluated by the FMPC and determined to be a non-prevalent hazard that should not be included in the plan. Following is a brief description of the hazard and the reason for its exclusion:

- **Tsunamis** - Defined as a long-term (generally 15 to 60 minutes) wave caused by a large scale movement of the sea floor due to volcanic eruption, marine earthquake or landslide. Barely noticeable at sea, the wave velocity may be as high as 400 knots so that it travels great distances and in shoal water reaches heights up to 15 meters. NOAA indicates that the risk of a tsunami in the area is relatively low due to the relatively shallow depth of the Gulf of Mexico and the absence of geologic formation and activity on the sea floor.

4.1.2 Disaster Declaration History

The FMPC researched past events that resulted in a federal and/or state emergency or disaster declaration in the planning area for Collier County in order to identify known flood hazards. Federal and/or state disaster declarations may be granted when the Governor certifies that the combined local, county and state resources are insufficient and that the situation is beyond their recovery capabilities. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be so severe that both the local and state government capacities are exceeded, a federal emergency or disaster declaration may be issued allowing for the provision of federal assistance.

Details on federal and state disaster declarations were obtained by the FMPC from FEMA and FDEM, and compiled chronologically in Tables 4.2 and 4.3. Table 4.2 displays flood related major disaster declarations that Florida has received from FEMA since 2002. This table reflects the vulnerability and historic patterns of flood hazards for Florida.

Table 4.2 FEMA Major Disaster Declarations for Florida, 2002-2014

Hazard Type	Disaster #	Date
Severe Storms, Flooding, Tornadoes and Straight-line Winds	DR-4177	05/06/2014
Severe Storms and Flooding	DR-4138	08/02/2013
Hurricane Isaac	DR-4084	10/18/2012
Tropical Storm Debby	DR-4068	07/03/2012
Severe Storms, Flooding, Tornadoes and Straight-line Winds	DR-1840	05/27/2009
Severe Storms, Flooding, Tornadoes and Straight-line Winds	DR-1831	04/21/2009
Hurricane Gustav	DR-1806	10/27/2008
Tropical Storm Fay	DR-1785	08/24/2008
Severe Storms, Tornadoes and Flooding	DR-1680	02/08/2007
Severe Storms and Tornadoes	DR-1679	02/03/2007
Hurricane Wilma	DR-1609	10/24/2005
Hurricane Katrina	DR-1602	08/28/2005
Hurricane Dennis	DR-1595	07/10/2005
Hurricane Jeanne	DR-1561	09/26/2004
Hurricane Ivan	DR-1551	09/16/2004
Hurricane Frances	DR-1545	09/04/2004
Hurricane Charley and Tropical Storm Bonnie	DR-1539	08/13/2004
Severe Storms and Flooding	DR-1481	07/29/2003

Source: Florida State Hazard Mitigation Plan (August 2013), FEMA

A review of state and federal declared disasters indicates that Collier County received 15 flood related federal disaster declarations between 1960 and 2014. The disaster-related damage to people and property resulted from wind and flood damage associated with hurricanes and tropical storms.

Table 4.3 FEMA Major Disaster Declarations for Collier County, 1960 - 2014

Hazard Type	Disaster #	Date	IA Dollars Obligated[1]	PA Dollars Obligated[1]
Hurricane Betsy	DR-209	09/14/1965	N/A	N/A
Hurricane Andrew	DR-955	08/24/1992	N/A	N/A
Tornadoes, Flooding, High Winds, Tides, Freezing	DR-982	03/13/1993	N/A	N/A
Hurricane Opal	DR-1069	10/04/1995	N/A	N/A
Hurricane Irene	DR-1306	10/20/1999	$0.00	$106,731,098.99
Tropical Storm Gabrielle	DR-1393	09/28/2001	$0.00	$23,166,642.94
Hurricane Charley and Tropical Storm Bonnie	DR-1539	08/13/2004	$208,970,753.97	$0.00
Hurricane Frances	DR-1545	09/04/2004	$411,862,738.49	$0.00
Hurricane Ivan	DR-1551	09/16/2004	$164,517,307.53	$0.00
Hurricane Jeanne	DR-1561	09/26/2004	$398,624,417.44	$0.00
Hurricane Katrina	DR-1602	08/28/2005	$0.00	$194,516,321.23
Hurricane Wilma	DR-1609	10/24/2005	$342,257,844.09	$0.00
Tropical Storm Fay	DR-1785	08/24/2008	$19,216,129.55	$0.00
Tropical Storm Debby	DR-4068	07/03/2012	$27,800,267.48	$0.00
Hurricane Isaac	DR-4084	10/18/2012	$0.00	$10,161,439.44
		Total:	**$1,573,249,458.55**	**$334,575,502.60**

Source: FEMA, FDEM
[1]Dollar damage values are for all Counties included in the disaster declaration.
N/A = no data available

4.2 Hazard Profiles

Requirement §201.6(c)(2)(i): [The risk assessment shall include a] description of the…location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

The hazards identified in Section 4.1 Hazard Identification, are profiled individually in this section. Information provided by members of the FMPC has been integrated into this section with information from other data sources.

Each hazard is profiled in the following format:

Hazard/Problem Description

This section provides a description of the hazard followed by details specific to the Collier County planning area. Where available, this section also includes information on the hazard extent, seasonal patterns, speed of onset/duration, magnitude and any secondary effects.

Past Occurrences

This section contains information on historical events, including the extent or location of the hazard within or near the Collier County planning area.

Frequency/Likelihood of Future Occurrence

This section gauges the likelihood of future occurrences based on past events and existing data. The frequency is determined by dividing the number of events observed by the number of years on record and multiplying by 100. This provides the percent chance of the event happening in any given year (e.g. 10 hurricanes or tropical storms over a 30-year period equates to a 33 percent chance of experiencing a hurricane or tropical storm in any given year). The likelihood of future occurrences is categorized into one of the classifications as follows:

- ***Highly Likely*** – Near 100 percent chance of occurrence within the next year
- ***Likely*** – Between 10 and 100 percent chance of occurrence within the next year (recurrence interval of 10 years or less)
- ***Occasional*** – Between 1 and 10 percent chance of occurrence within the next year (recurrence interval of 11 to 100 years)
- ***Unlikely*** – Less than 1 percent chance or occurrence within the next 100 years (recurrence interval of greater than every 100 years).

Those hazards determined to be of high or medium significance were characterized as priority hazards that required further evaluation in Section 4.3 Vulnerability Assessment. Significance was determined by frequency of the hazard and resulting damage, including deaths/injuries and property, crop and economic damage. Hazards occurring infrequently or having little to no impact on the Collier County planning area were determined to be of low significance and not considered a priority hazard. These criteria allowed the FMPC to prioritize hazards of greatest significance and focus resources where they are most needed.

The National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC) has been tracking severe weather since 1950. Their Storm Events Database contains an archive of destructive storm or weather data and information which includes local, intense and damaging events. This database contains 67 flood related severe weather events that occurred in Collier County between January 1950 and May 2014. Table 4.4 summarizes these events.

Table 4.4 NCDC Severe Weather Reports for Collier County, 1950-2014

Type	# of Events	Property Loss	Deaths	Injuries
Flash Flood	6	$460,000.00	0	0
Flood	4	$0.00	0	0
Coastal Flood	1	$70,000.00	0	0
Heavy Rain	6	$60,000.00	0	0
Hurricane/Typhoon	6	$2,500,000.00	1	0
Storm Surge/Tide	3	$6,060,000.00	0	0
Tropical Depression	0	$0.00	0	0
Tropical Storm	11	$395,000.00	0	0
Waterspout	30	0.00	0	0
Total:	**67**	**$9,545,000.00**	**1**	**0**

Source: National Climatic Data Center Storm Events Database
Note: Losses reflect totals for all impacted areas within Collier County.

The FMPC supplemented NCDC data with data from SHELDUS™ (Spatial Hazard Events and Losses Database for the United States). SHELDUS™ is a county-level data set for the United States that tracks 18 types of natural hazard events along with associated property and crop losses, injuries, and fatalities for the period 1960-present. Produced by the Hazards Research Lab at the University of South Carolina, this database combines information from several sources (including the NCDC). With the release of SHELDUS 13.1, the database includes every loss causing and/or deadly event between 1960 through present. For events that covered multiple counties, the dollar losses, deaths, and injuries were equally divided among the affected counties (e.g., if four counties were affected, then a quarter of the dollar losses, injuries, and deaths were attributed to each county).

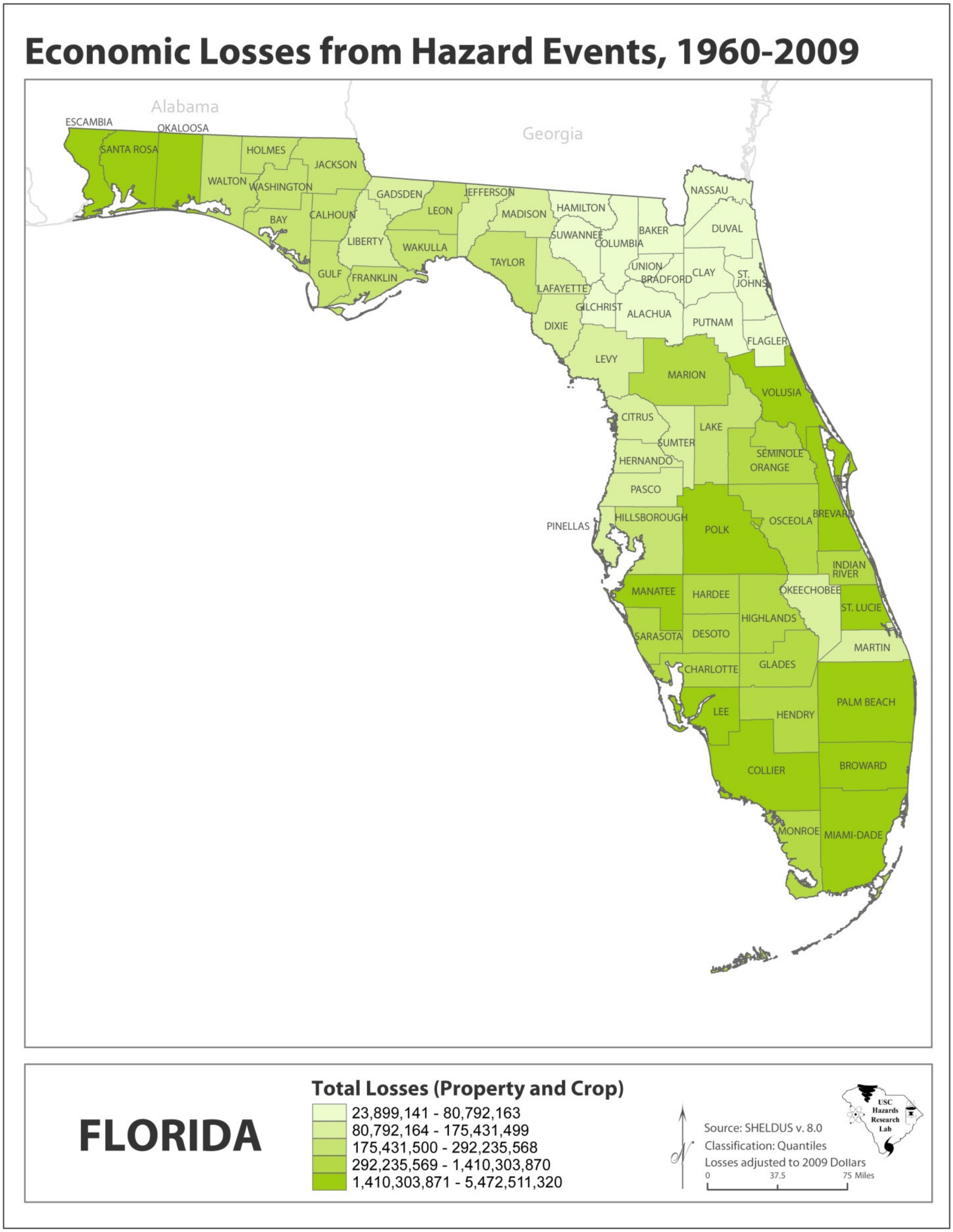
SHELDUS™ contains information on 46 severe weather events that occurred in Collier County between 1960 and 2013. Table 4.5 summarizes these events.

Table 4.5 SHELDUS Severe Weather Reports for Collier County, 1960-2013

Type	# of Events	Property Loss	Crop Loss	Deaths	Injuries
Coastal	4	$64,919.00	$0.00	4	1
Flooding	10	$7,671,554.00	$56,566,005.00	0	0
Hurricane/Tropical Storm	25	$13,527,475,180.00	$443,030,549.00	4	56
Severe Storm/Thunder Storm	7	$111,628.00	$0.00	0	4
Total:	**46**	**$13,535,323,281.00**	**$499,596,554.00**	**8**	**61**

Source: Hazards & Vulnerability Research Institute (2014). The Spatial Hazard Events and Losses Database for the United States, Version 13.1 [Online Database]. Columbia, SC: University of South Carolina. Available from http://www.sheldus.org
Note: Losses have been adjusted for inflation to 2013 dollars.

The figure below reflects economic losses from hazard events contained within the SHELDUS data set for the entire State of Florida from 1960 - 2009. Collier County ranks among the highest in the State for total property and crop losses.



Source: SHELDUS v8.0

The following sections provide profiles of the natural flood hazards that the FMPC identified in Table 4.1 Flood Hazard Summary.

4.2.1 Climate Change and Sea Level Rise

Hazard/Problem Description

Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use (IPCC, 2014). Climate change is a natural occurrence in which the earth has warmed and cooled periodically over geologic time. The recent and rapid warming of the earth over the past century has been cause for concern, as this warming is very likely due to the accumulation of human-caused green house gases, such as CO_2, in the atmosphere (IPCC, 2007). This warming is occurring almost everywhere in the world which suggests a global cause rather than changes in localized weather patterns.

Due to sea-level rise projected throughout the 21st century and beyond, coastal systems and low-lying areas will increasingly experience adverse impacts such as submergence, coastal flooding, and coastal erosion. The population and assets projected to be exposed to coastal risks as well as human pressures on coastal ecosystems will increase significantly in the coming decades due to population growth, economic development, and urbanization (IPCC, 2014). Southwest Florida is particularly vulnerable to the effects of climate change and sea level rise, due to its populous coastal counties, subtropical environment, porous geology and low topography. Seawalls cannot block seawater from infiltrating the porous limestone underground, and saltwater has already contaminated freshwater aquifers.

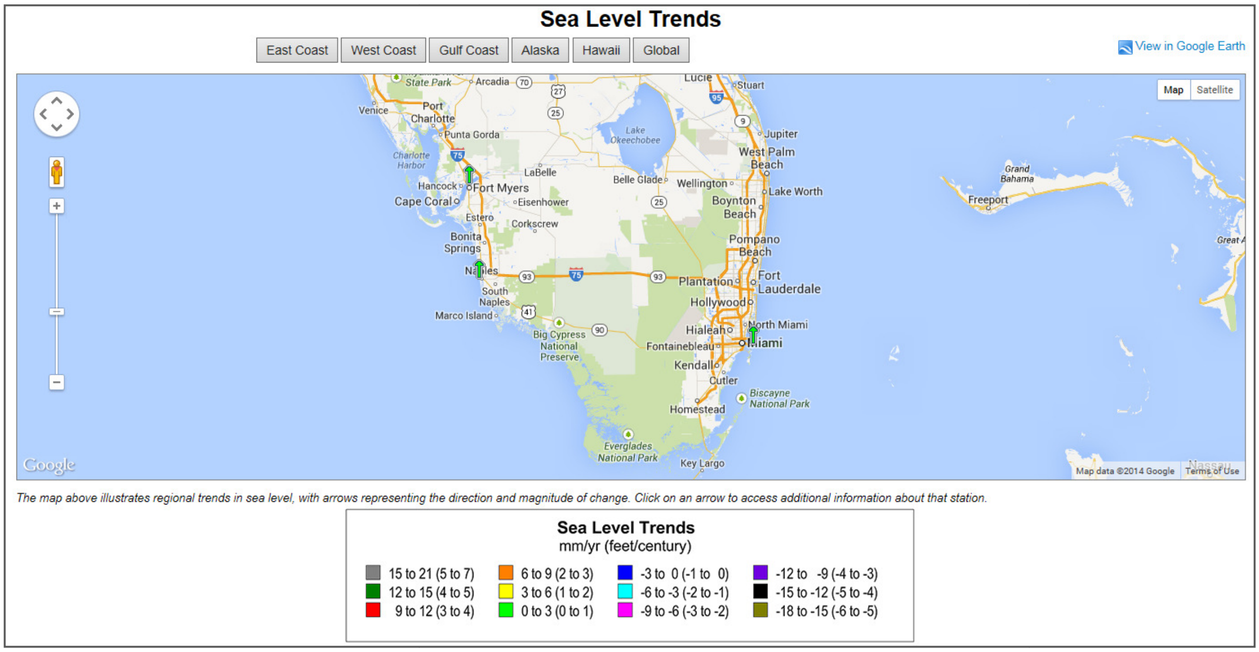
Climate change has the potential to alter the nature and frequency of flood hazards that the County already experiences such as hurricane storm surge, coastal erosion, and stormwater drainage. Sea level rise may also place additional stress on aquifers (saltwater intrusion) and gravity flow stormwater and septic systems to a rising groundwater table. An elevated storm surge due to sea level rise could produce a cascade of consequences affecting things such as land use, infrastructure, facilities, waterway navigation, the local economy, public health and safety, drinking water supplies, and ecosystems.

The potential for climate change influences on each flood hazard summarized in this plan is noted within each of the hazard's "Frequency/Likelihood of Future Occurrence" discussion section.

Past Occurrences

There are generally two separate mechanics involved in global sea level rise. The first is directly attributed to global temperature increases, which warm the oceans waters and cause them to expand. The second is attributed to the melting of ice over land which simply adds water to the oceans. Global sea level rise is likely caused by a combination of these two mechanics and can be exasperated on the local level by factors such as erosion and subsidence. The rate of sea level rise has varied throughout geologic history, and studies have shown that global temperature and sea level are strongly correlated.

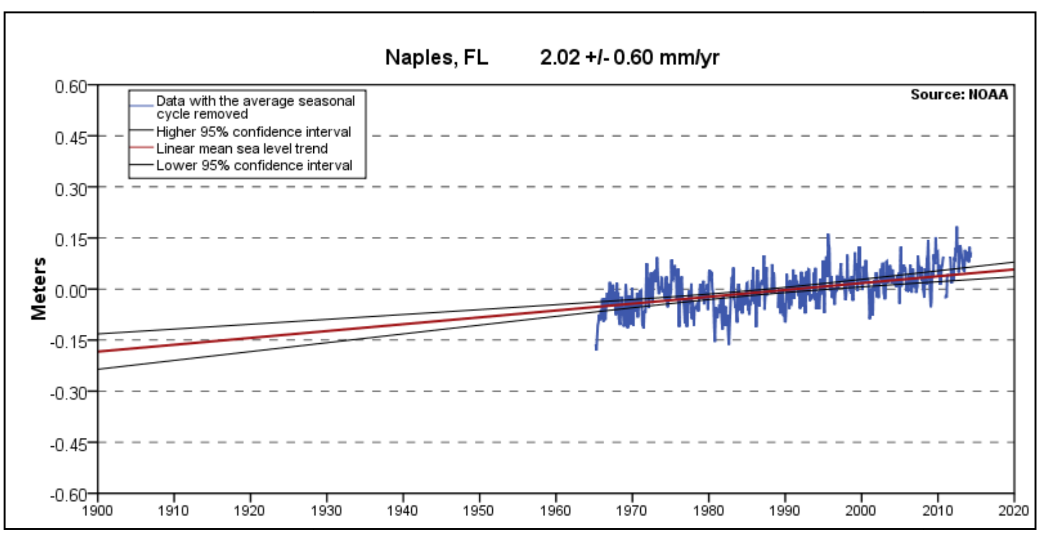
The Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with tide stations operating on all U.S. coasts. Changes in Mean Sea Level (MSL), either a sea level rise or sea level fall, have been computed at 128 long-term water level stations using a minimum span of 30 years of observations at each location. These measurements have been averaged by month to remove the effect of higher frequency phenomena (e.g. storm surge) in order to compute an accurate linear sea level trend. Figure 4.1 illustrates regional trends in sea level from NOAA.



Source: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

Figure 4.1 – Gulf/Atlantic Coast Sea Level Trends

Figure 4.2 shows the monthly mean sea level at NOAA's Naples, FL station without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The mean sea level trend is 2.02 millimeters/year with a 95% confidence interval of +/- 0.60 mm/yr based on monthly mean sea level data from 1965 to 2006 which is equivalent to a change of 0.66 feet in 100 years.



Source: http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml

Figure 4.2 - Mean Sea Level Trend for Naples, Florida

Since 1901, the average surface temperature across the contiguous 48 states has risen at an average rate of 0.14°F per decade (1.4°F per century). Average temperatures have risen more quickly since the late 1970s (0.36 to 0.55°F per decade). Seven of the top 10 warmest years on record for the contiguous 48 states have occurred since 1998, and 2012 was the warmest year on record. Figure 4.3 below, based on data from NOAA and prepared by the EPA, shows how annual average air temperatures have changed in different parts of the United States since 1901. Current science is projecting that the southeastern United States could experience a general increase in average temperatures anywhere from 4.5°F to 9°F in the coming century (Karl et al, 111).

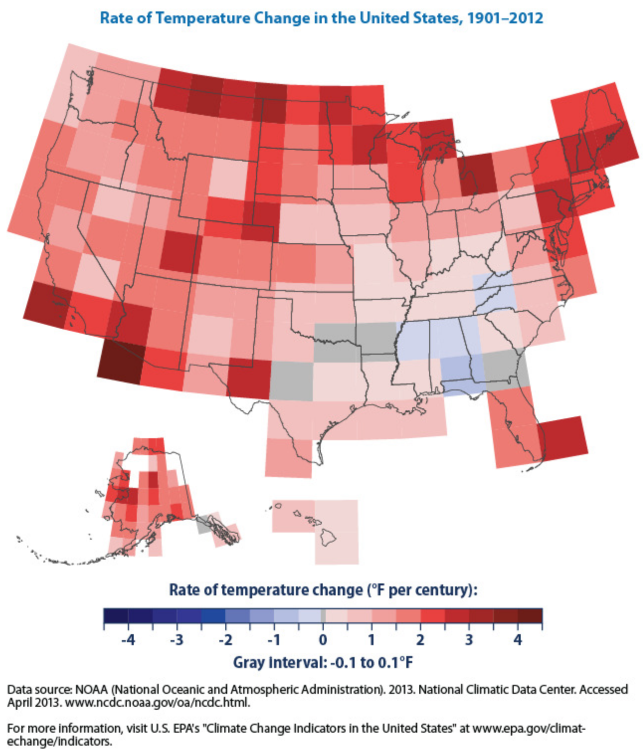


Figure 4.3- Rate of Temperature Change in the United States, 1901-2012

Frequency/Likelihood of Future Occurrence

Highly Likely - Understanding trends in sea level, as well as the relationship between global and local sea level, provides critical information about the impacts of the Earth's climate on our oceans and atmosphere. Changes in sea level are directly linked to a number of atmospheric and oceanic processes. Changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity are examples of known effects of a changing climate, all of which are directly related to, and captured in, long-term sea level records. Sea levels provide an important key to understanding the impact of climate change along our coasts. By combining local rates of relative sea level change for a specific area based on observations with projections of global sea level rise, communities can begin to analyze and plan for the impacts of sea level rise for long-range planning (NOAA, 2014).

A 2009 study performed by the Southwest Florida Regional Planning Council and Charlotte Harbor National Estuary Program considered three climate change severity scenarios: *least case* (90% probability of occurrence), *moderate case* (50% probability of occurrence), and *worst case* (5% probability of occurrence). These scenarios are based upon the USEPA Report "The Probability of Sea Level Rise." Basically, the formula multiplies the historic sea level rise (2.3 mm/yr) in southwest Florida (closest point is St. Petersburg, FL from Table 9-2 in USEPA Report) by the number of future years from 1990, plus the Normalized Sea Level Projections (Table 9-1 in USEPA Report).

Table 4.6- Sea Level Projection by Year for Southwest Florida

Probability (%)	2025		2050		2075		2100		2150		2200	
	cm	in	cm	in	cm	in	cm	in	cm	in	cm	in
90 (best)	7	2.8	13	5.0	20	7.7	26	10.4	40	15.7	53	21.0
80	9	3.6	17	6.6	26	10.1	35	13.9	53	20.8	71	28.1
70	11	4.4	20	7.8	30	11.6	41	16.3	63	24.7	85	33.6
60	12	4.7	22	8.6	34	13.2	45	17.8	72	28.3	99	39.1
50 (moderate)	13	5.1	24	9.4	37	14.4	50	19.8	80	31.4	112	44.2
40	14	5.5	27	10.6	41	16.0	55	21.8	90	35.4	126	49.7
30	16	6.3	29	11.3	44	17.1	61	24.1	102	40.1	146	57.6
20	17	6.7	32	12.5	49	19.1	69	27.3	117	46.0	173	68.2
10	20	7.9	37	14.5	57	22.3	80	31.6	143	56.2	222	87.5
5 (worst)	22	8.7	41	16.1	63	24.6	91	35.9	171	67.2	279	110.0
2.5	25	9.9	45	17.6	70	27.4	103	40.7	204	80.2	344	135.6
1	27	10.6	49	19.2	77	30.1	117	46.2	247	97.2	450	177.3
Mean	13	5.1	25	9.8	38	14.8	52	20.6	88	34.6	129	50.9

Source: IPCC 2007

The level of sea level rise discussed for Florida in the recent report entitled ―Global Climate Change Impacts in the United States‖ (Karl et al. 2009) falls between the moderate case and worst case scenarios predicted by the IPCC (2007) with a 30% probability of 24 inches of sea level rise by the year 2100.

According to the SFRCCC, scientific evidence strongly supports that sea level is rising and will continue to rise beyond 2060 even if mitigation efforts to reduce greenhouse gas emission are successful. Uncertainties in sea level rise projections do exist due to natural variability, limitations of existing computer models, and the inability to forecast human response in limiting greenhouse gas emissions. Therefore, projections will need to be reviewed and revised in the future as modeling capabilities improve and major findings in climate science data become available. Ultimately, it is important to understand that sea level rise is not an endpoint but rather a continuing trend and Collier County must consider and plan for sea level rise in future policy decisions.

4.2.2 Coastal/Canal Bank Erosion

Hazard/Problem Description

Coastal Erosion

Coastal erosion is a process whereby large storms, flooding, strong wave action, sea level rise, and human activities, such as inappropriate land use, alterations, and shore protection structures, wears away the beaches and bluffs along the coast. Erosion undermines and often destroys homes, businesses, and public infrastructure and can have long-term economic and social consequences. According to NOAA, coastal erosion is responsible for approximately $500 million per year in coastal property loss in the United States, including damage to structures and loss of land. To mitigate coastal erosion, the federal government spends an average of $150 million every year on beach nourishment and other shoreline erosion control measures.

Coastal erosion has both natural causes and causes related to human activities. Gradual coastal erosion results naturally from the very slow rise of sea-level. Severe coastal erosion can occur over a very short period of time when the state is impacted by hurricanes, tropical storms and other weather systems. Sand is moved parallel to most beaches in Florida by longshore drift and currents. Sand is continually removed by longshore currents in some areas but it is also continually replaced by sand carried in by the same type of currents. Structures such as piers or sea walls, jetties, and navigational inlets may interrupt the movement of sand. Sand can become "trapped" in one place by these types of structures. The currents will, of course, continue to flow, though depleted of sand trapped elsewhere. With significant amounts of sand trapped in the system, the continuing motion of currents (now deficient in sand) results in erosion. In this way, human construction activities that result in the unnatural trapping of sand have the potential to result in significant coastal erosion.

Erosion rates and potential impacts are highly localized. Severe storms can remove wide beaches, along with substantial dunes, in a single event. In undeveloped areas, these high recession rates are not likely to cause significant concern, but in some heavily populated locations, one or two feet of erosion may be considered catastrophic (NOAA, 2014).

Canal Bank Erosion

Streams/canals erode by a combination of direct stream processes, like down cutting and lateral erosion, and indirect processes, like mass-wasting accompanied by transportation. When the channel bends, water on the outside of the bend (the cut-bank) flows faster and water on the inside of the bend (the point) flows slower as shown in Figure 4.4. This distribution of velocity results in erosion occurring on the outside of the bend and deposition occurring on the inside of the bend.

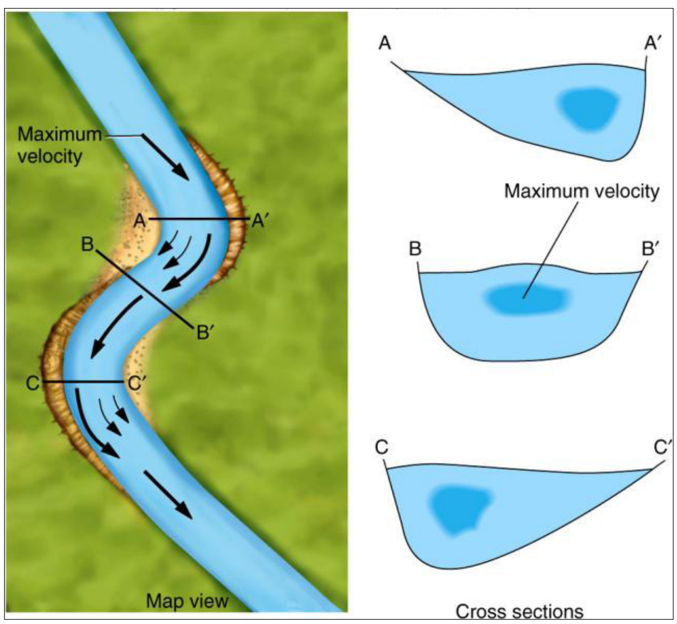


Figure 4.4- Stream Meanders

Stream bank erosion is a natural process, but acceleration of this natural process leads to a disproportionate sediment supply, stream channel instability, land loss, habitat loss and other adverse effects. Stream bank erosion processes, although complex, are driven by two major components: stream bank characteristics (erodibility) and hydraulic/gravitational forces. Many land use activities can affect both of these components and lead to accelerated bank erosion. The vegetation rooting characteristics can protect banks from fluvial entrainment and collapse, and also provide internal bank strength. When riparian vegetation is changed from woody species to annual grasses and/or forbs, the internal strength is weakened, causing acceleration of mass wasting processes. Stream bank aggradation or degradation is often a response to stream channel instability. Since bank erosion is often a symptom of a larger, more complex problem, the long-term solutions often involve much more than just bank stabilization.

Numerous studies have demonstrated that stream bank erosion contributes a large portion of the annual sediment yield.

Determining the cause of accelerated streambank erosion is the first step in solving the problem. When a stream is straightened or widened, streambank erosion increases. Accelerated streambank erosion is part of the process as the stream seeks to re-establish a stable size and pattern. Damaging or removing streamside vegetation to the point where it no longer provides for bank stability can cause a dramatic increase in bank erosion. A degrading streambed results in higher and often unstable, eroding banks. When land use changes occur in a watershed, such as clearing land for agriculture or development, runoff increases. With this increase in runoff the stream channel will adjust to accommodate the additional flow, increasing streambank erosion. Addressing the problem of streambank erosion requires an understanding of both stream dynamics and the management of streamside vegetation.

Past Occurrences

A report developed in June 2012 by the Florida Department of Environmental Protection (DEP), Division of Water Resource Management, titled "Critically Eroded Beaches in Florida" inventoried critically eroded areas along the Atlantic and Gulf coasts. The following definition was used to identify critically eroded areas:

Critically eroded area is a segment of the shoreline where natural processes or human activity have caused or contributed to erosion and recession of the beach or dune system to such a degree that upland development, recreational interests, wildlife habitat, or important cultural resources are threatened or lost. Critically eroded areas may also include peripheral segments or gaps between identified critically eroded areas which, although they may be stable or slightly erosional now, their inclusion is necessary for continuity of management of the coastal system or for the design integrity of adjacent beach management projects.

In some areas the erosion processes are not particularly significant except to the extent that adjacent public or private interests may be threatened. Whether erosion is deemed critical is determined by the existence of a threat to interests in need of protection. Lacking any threat an erosion condition is not a critical problem.

According to the Florida DEP report, there are eight critically eroded beach areas (13.7 miles), three non-critically eroded beach areas (5.1 miles), and one critically eroded inlet shoreline area (0.8 mile) in Collier County.

In northern Collier County, a 0.4-mile beach segment north of Wiggins Pass (R14-R16.3) is critically eroded threatening sea turtle and gopher tortoise habitat. A 1.6-mile beach segment (R22.3-R30.5) is critically eroded threatening development interests in Vanderbilt Beach. This area has a beach restoration project and numerous bulkheads.

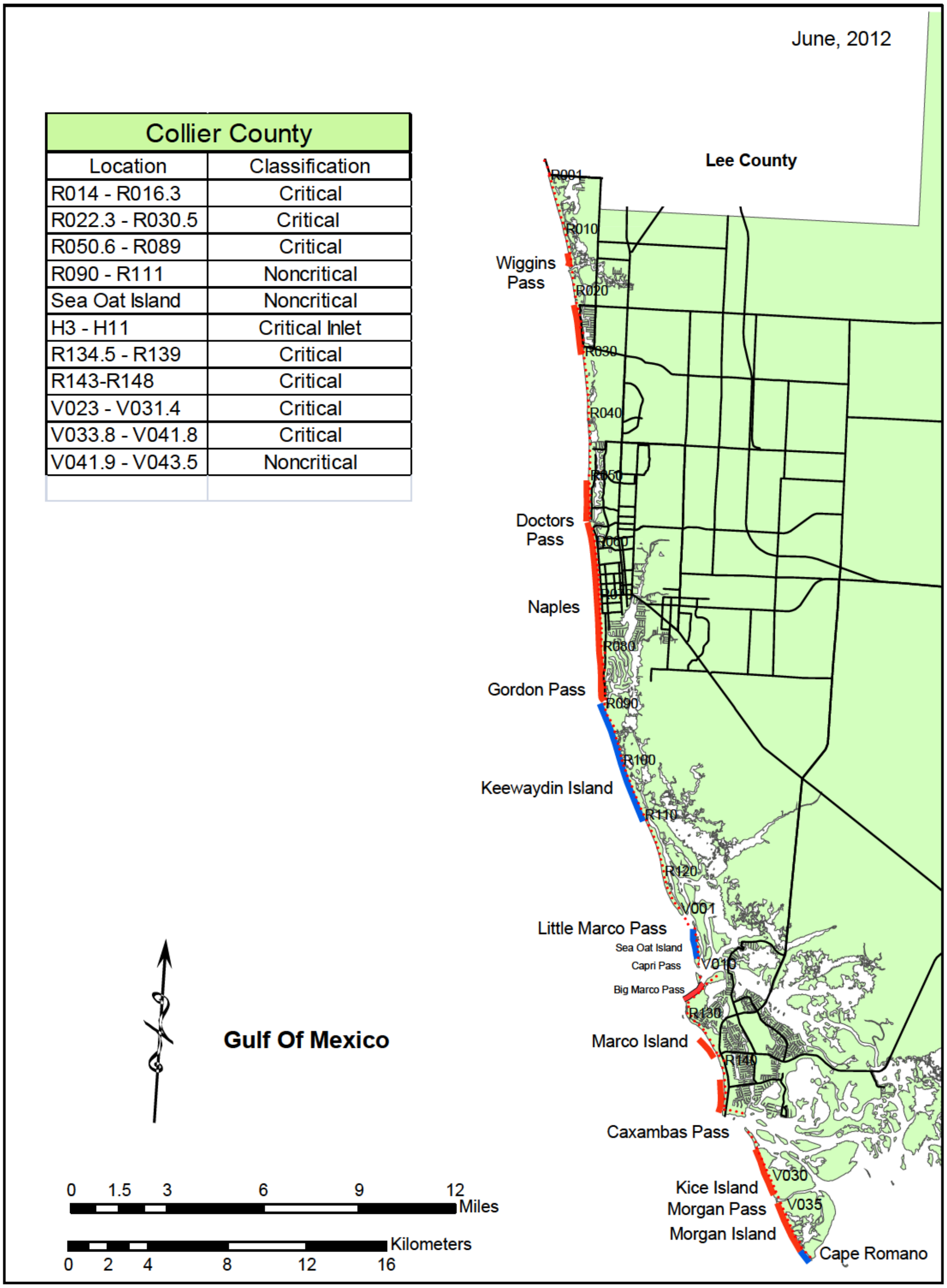
The City of Naples has two segments that are critically eroded threatening development interests north and south of Doctors Pass. North of Doctors Pass (R50.65-R57.5) is a 1.3-mile critically eroded segment, and between Doctors Pass and Gordon Pass (R57.8-R89) is a 5.6-mile critically eroded segment. These areas of Naples have a continuous beach restoration project. Numerous bulkheads and revetments also exist throughout Naples. Groins exist north of Gordon Pass.

South of Gordon Pass (R90-R111) is a 3.9-mile stretch that is non-critically eroded along the northern half of Keewaydin Island. Between Little Marco Pass and Capri Pass, Sea Oat Island has 0.9 mile of beach that is non-critically eroded.

Marco Island has three areas that are critically eroded threatening development interests. Along Hideaway Beach, the north shore of Marco Island (H3-H11) fronting on Big Marco Pass has 0.8 mile of inlet shoreline that is critically eroded. The central gulf beach of Marco Island (R134.5R139) has 0.8 mile that is critically eroded and the southern stretch of beach (R143-R148) has 0.9 mile that is critically eroded. All three critically eroded areas on Marco Island have beach restoration projects, and the northern segment also has a rock groin field along Hideaway Beach.

Erosion on the two southern barrier islands in Collier County has progressed into the backshore mangrove forest resulting in the loss of beach wildlife habitat. Following Hurricane Wilma (2005), a 1.6-mile segment of Kice Island (V23-V31.4) is critically eroded. South of Morgan Pass, Morgan Island has a 1.5-mile segment (V33.8-V41.8) that is critically eroded and a 0.3mile segment (V41.8-V43.5) that is non-critically eroded.

A search of the NCDC database and SHELDUS database resulted in no past occurrences of coastal erosion or canal bank erosion. This is most likely due to the fact that coastal erosion is often a secondary hazard to hurricane, storm surge, and severe storms. Collier County does experience canal erosion with several known localized instances. The County map and table below depicts the areas of coastal erosion designated as either critically or non-critically eroded.



Collier County	
Location	Classification
R014 - R016.3	Critical
R022.3 - R030.5	Critical
R050.6 - R089	Critical
R090 - R111	Noncritical
Sea Oat Island	Noncritical
H3 - H11	Critical Inlet
R134.5 - R139	Critical
R143-R148	Critical
V023 - V031.4	Critical
V033.8 - V041.8	Critical
V041.9 - V043.5	Noncritical

Source: Florida Department of Environmental Protection, Division of Water Resource Management, Bureau of Beaches and Coastal Systems, *Critically Eroded Beaches in Florida*, Updated June 2012

Frequency/Likelihood of Future Occurrence

Highly Likely - In general, the low dune elevations along the Gulf of Mexico make this region more vulnerable to erosion hazards during hurricanes. Average dune elevations along the shores of the Gulf of Mexico are just 2.4 meters high, making approximately 71% of these beaches very likely to experience extreme erosion due to overwash in the direct landfall of a category 1 storm. In the Gulf of Mexico, waves play a large role in elevating shoreline water levels. During a category 1 hurricane in the Gulf of Mexico, the contribution of waves to storm-induced extreme water levels is nearly twice that of surge. The United States Geological Survey (USGS) completed a national assessment of hurricane-induced coastal erosion hazards in 2013 which provides the following key findings for the Gulf of Mexico:

- For a category 1 hurricane landfall, 99% of sandy beaches along the U.S. Gulf of Mexico coast are very likely (P>90%) to experience dune erosion, 71% are very likely to overwash, and 27% are very likely to inundate.
- For category 5 hurricane landfall, 98% of the U.S. Gulf of Mexico beaches are very likely to experience overwash and associated erosion, and 89% are very likely to be vulnerable to erosion due to inundation.
- During a category 1 hurricane landfall in the Gulf of Mexico, waves increase water levels at the shoreline, on average, by 170% above surge alone. The predicted wave-driven component of shoreline water levels was 2.8 meters, high enough to erode the Gulf-coast averaged dune toe elevation (1.1 meters) as well as overwash the average dune crest (2.4 meters), even without surge.
- Hurricanes are not required for significant coastal change in the Gulf region. Waves and storm surge associated with tropical storms and winter cold fronts provide sufficient energy to put low-elevation beaches and dunes at risk to erosion.

Climate Change and Coastal/Canal Bank Erosion

Sea-level rise will raise all tide levels, from low tide to storm surge. Wave action at higher tide levels may cause erosion of sandy beaches. Higher storm surges, which may be accompanied by stronger storm winds, could wash over the tops of sand dunes, flooding the burrows of dune-nesting animals. The combined effects of wind and waves could damage dunes, leaving the beachfront more vulnerable (UF/IFAS Extension, 2013).

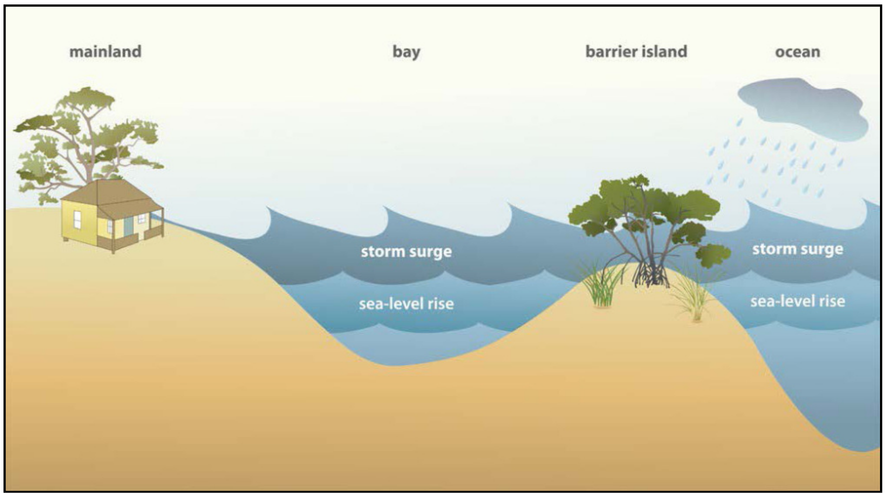


Figure 4.5 - Seal Level Rise and Coastal Erosion of Dunes
Credits: Jane Hawkey, IAN Image Library (ian.umces.edu/imagelibrary/)

According to the Center of Ocean Solutions, there has been a dramatic increase in coastal erosion over the last two decades and this is expected to continue as sea level rises and storm frequency and severity increase. Rather than occurring over the same time scale with sea level rise, erosion of beaches and coastal cliffs is expected to occur in large bursts during storm events as a result of increased wave height and storm intensity. Because of these large events, scientific models predict that shoreline erosion may outpace sea level rise by 50 to 200 fold. Erosion will have significant effects on coastal habitats, which can lead to social and economic impacts on coastal communities. With the reduction of coastal habitats and the ecological services they provide, coastal communities will experience more frequent and destructive flooding, compromised water supplies and smaller or fewer beaches. According to the U.S. EPA, a 1-foot rise would erode most Florida beaches 100-200 feet unless measures were taken to hold back the sea. A 3-foot rise would require the state to spend $4 to 8 billion just to replace the sand that would be lost to beach erosion.

4.2.3 Dam/Levee Failure

Hazard/Problem Description

Dam Failure

A dam is a barrier constructed across a watercourse that stores, controls, or diverts water. Dams are usually constructed of earth, rock, or concrete. The water impounded behind a dam is referred to as the reservoir and is measured in acre-feet. One acre-foot is the volume of water that covers one acre of land to a depth of one foot. Dams can benefit farm land, provide recreation areas, generate electrical power, and help control erosion and flooding issues.

A dam failure is the collapse or breach of a dam that causes downstream flooding. Dam failures may be caused by natural events, human-caused events, or a combination. Due to the lack of advance warning, failures resulting from natural events, such as hurricanes, earthquakes, or landslides, may be particularly severe. Prolonged rainfall and subsequent flooding is the most common cause of dam failure.

Dam failures usually occur when the spillway capacity is inadequate and water overtops the dam or when internal erosion in dam foundation occurs (also known as piping). If internal erosion or overtopping cause a full structural breach, a high-velocity, debris-laden wall of water is released and rushes downstream, damaging or destroying anything in its path. Overtopping is the primary cause of earthen dam failure in the United States.

Dam failures can result from any one or a combination of the following:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity, resulting in excess overtopping flows;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross-section of the dam and abutments, or maintain gates, valves, and other operational components;
- Improper design, including the use of improper construction materials and construction practices;
- Negligent operation, including the failure to remove or open gates or valves during high flow periods;
- Failure of upstream dams on the same waterway; and
- High winds, which can cause significant wave action and result in substantial erosion.

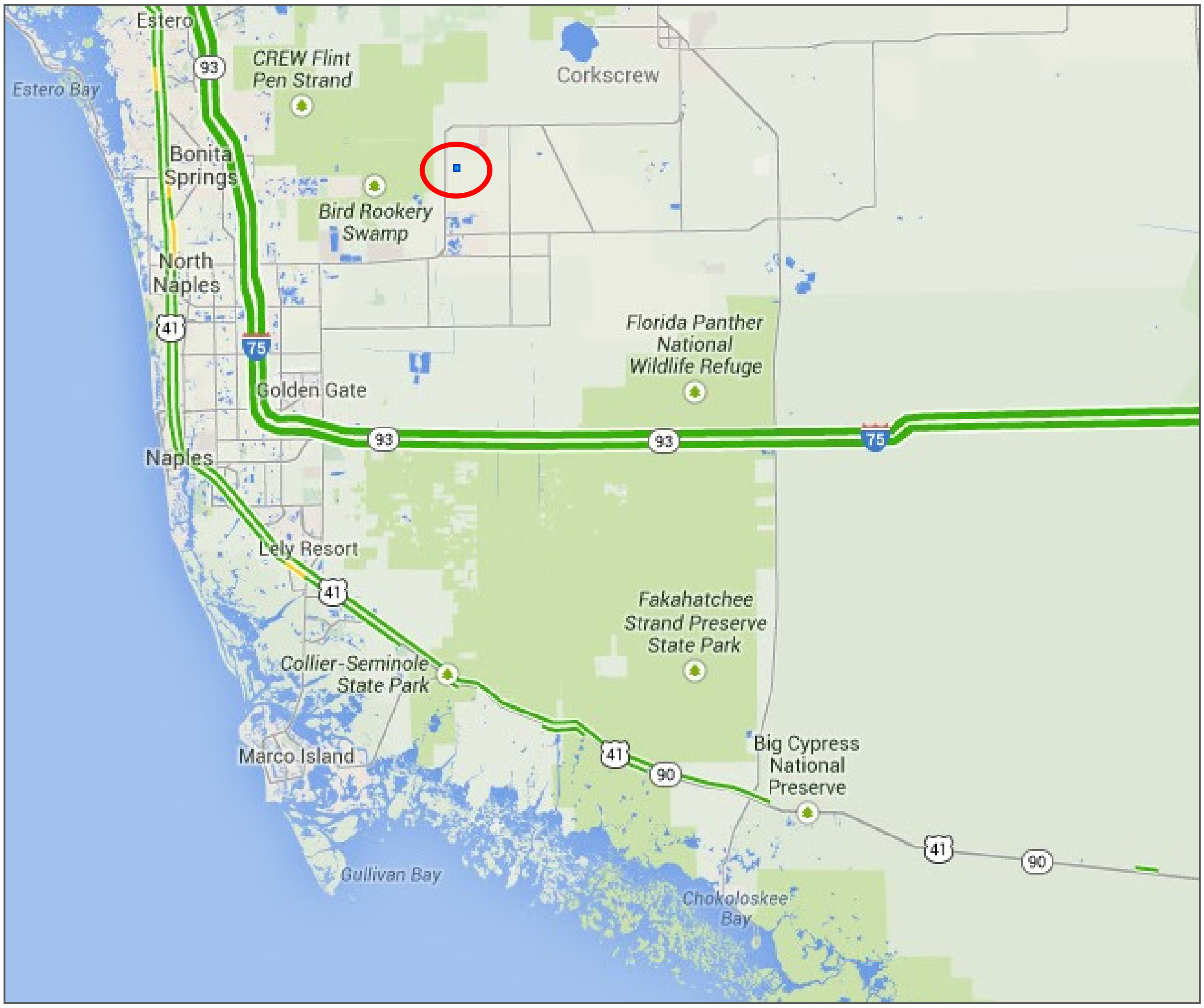
Water released by a failed dam generates tremendous energy and can cause a flood that is catastrophic to life and property. A catastrophic dam failure could challenge local response capabilities and require evacuations to save lives. Impacts to life safety will depend on the warning time and the resources available to notify and evacuate the public. Major casualties and loss of life could result, as well as water quality and health issues. Potentially catastrophic effects to roads, bridges, and homes are also of major concern. Associated water quality and health concerns could also be issues. Factors that influence the potential severity of a full or partial dam failure are the amount of water impounded; the density, type, and value of development and infrastructure located downstream; and the speed of failure.

The National Inventory of Dams (NID) is a database of dams in the United States which was developed and is maintained by the USACE. Congress authorized the USACE to inventory dams as part of the 1972 National Dam Inspection Act. Several subsequent acts have authorized maintenance of the NID and provided funding. The USACE collaborates with FEMA and state regulatory offices to collect data on dams. The goal of the NID is to include all dams in the United States which meet at least one of the following criteria:

1. High hazard classification - loss of at least one human life is likely if the dam fails
2. Significant hazard classification - possible loss of human life and likely significant property or environmental destruction
3. Equal or exceed 25 feet in height and exceed 15 acre-feet in storage
4. Equal or exceed 50 acre-feet storage and exceed 6 feet in height

Low hazard dams which do not meet the criteria specified in number 3 or 4 are not included in the NID even if they are regulated according to state criteria. In some states, the number of these dams is several times the number of dams included in the NID.

Figure 4.6 reflects all dams included in the NID that are located in and around Collier County. As shown, there is one dam located within the jurisdictional boundaries of Collier County which is the State Road 846 Land Trust earthen dam. Table 4.7 provides details for this dam as provided in the NID.



Source: U.S. Army Corps of Engineers, National Inventory of Dams

Figure 4.6- National Inventory of Dams for Collier County

Table 4.7 - National Inventory of Dams, Collier County

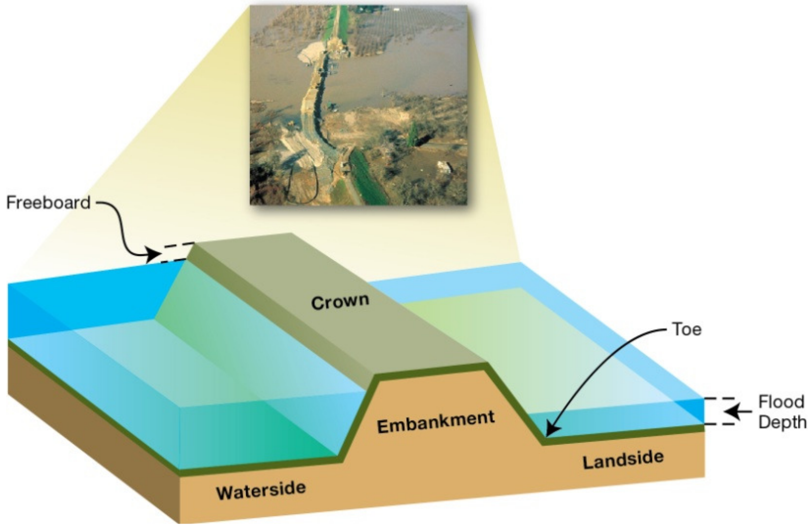
Dam Name	NIDID	Owner	Height (Ft.)	NID Storage (acre-feet)	Dam Type	River
St. Road 846 Land Trust IMP	FL75010	St. Road 846 Land Trust	9	350	Earthen	Cocohatchee

Source: U.S. Army Corps of Engineers, National Inventory of Dams

Levee Failure

FEMA defines a levee as "a man-made structure, usually an earthen embankment, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water in order to reduce the risk from temporary flooding." Levee systems consist of levees, floodwalls, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices. Levees often have "interior drainage" systems that work in conjunction with the levees to take water from the landward side to the water side. An interior drainage system may include culverts, canals, ditches, storm sewers, and/or pumps.

Levees and floodwalls are constructed from the earth, compacted soil or artificial materials, such as concrete or steel. To protect against erosion and scouring, earthen levees can be covered with grass and gravel or hard surfaces like stone, asphalt, or concrete. Levees and floodwalls are typically built parallel to a waterway, most often a river, in order to reduce the risk of flooding to the area behind it. Figure 4.7 below shows the components of a typical levee.

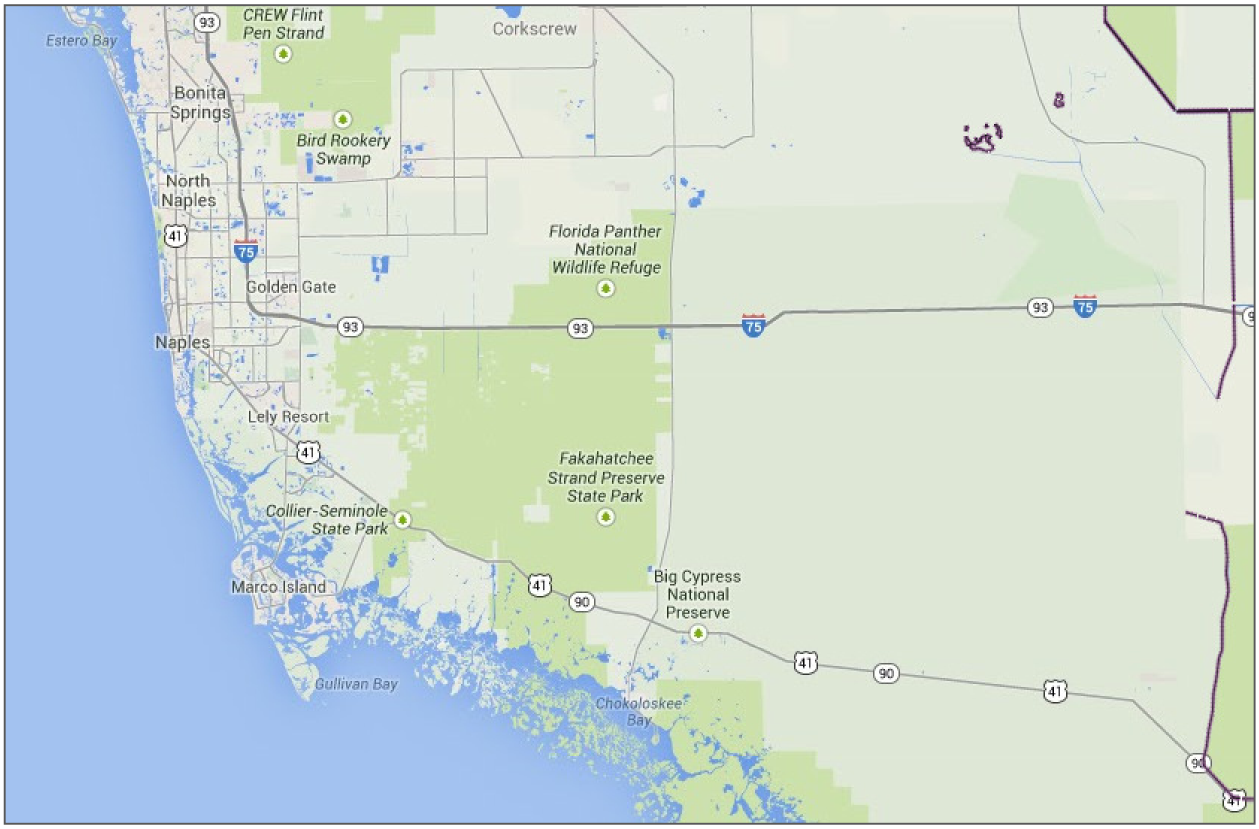


Source: FEMA, *What is a Levee Fact Sheet*, August 2011

Figure 4.7- Components of a Typical Levee

Levees provide strong flood protection, but they are not failsafe. Levees are designed to protect against a specific flood level and could be overtopped during severe weather events. Levees reduce, not eliminate, the risk to individuals and structures behind them. A levee system failure or overtopping can create severe flooding and high water velocities. It is important to remember that no levee provides protection from events for which it was not designed, and proper operation and maintenance are necessary to reduce the probability of failure.

Figure 4.8 below reflects all levees included in the U.S. Army Corps of Engineers National Levee Database (NLD) that are located in or around Collier County. Levee centerlines are indicated in purple. Table 4.8 details all levees located in Collier County as included in the NLD.



Source: U.S. Army Corps of Engineers National Levee Database

Figure 4.8 - National Levee Database for Collier County

Table 4.8 - National Levee Database, Collier County Planning Area

County(ies)	System Name	Sponsor	Length (mi)	Inspection Rating	Leveed Area Type
Broward, Collier, Hendry	East Big Cypress Seminole IR	SFWMD	26.1	Minimally Acceptable	Agricultural
Broward, Collier, Miami-Dade, Monroe	L-29	SFWMD	45.4	Unacceptable	Agricultural

Past Occurrences

There are no past reported dam breaches or levee failures within Collier County.

Frequency/Likelihood of Future Occurrence

Unlikely –There are no high or significant hazard dams that could impact the County. Since no occurrences of levee failure have happened and there are no significant levees in the County, future levee failure is unlikely.

Climate Change and Dam/Levee Failure

Given the fact that there are no high or significant hazard dams or levees that would affect the County, climate change is unlikely to change the risk of the County to dam and/or levee failure. However, future levees and sea walls may need to be built to combat the effects of sea level rise and storm surge which would affect future risk.

4.2.4 Flood: 100-/500-year

Hazard/Problem Description

Flooding is defined by the rising and overflowing of a body of water onto normally dry land. Flooding can result from an overflow of inland or tidal waters or an unusual accumulation or runoff of surface waters from any source. Flooding within Collier County can be attributed to tidal flooding resulting from hurricanes and tropical storms and heavy rainfall that overburdens the drainage system within the community.

Flooding and Floodplains

The area adjacent to a channel is the floodplain, as shown in Figure 4.9. A floodplain is flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current. Floodplains are made when floodwaters exceed the capacity of the main channel or escape the channel by eroding its banks. When this occurs, sediments (including rocks and debris) are deposited that gradually build up over time to create the floor of the floodplain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream.

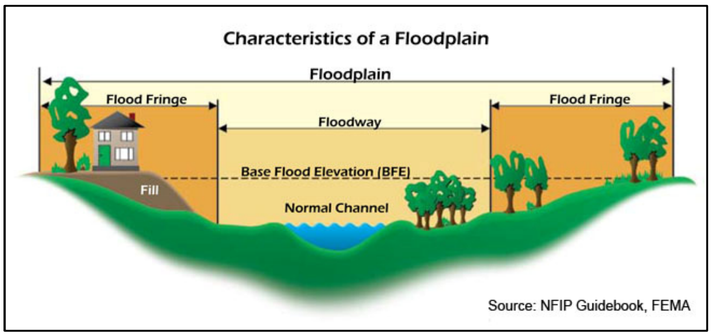


Figure 4.9 - Characteristics of a Floodplain

In its common usage, the floodplain most often refers to that area that is inundated by the 100-year flood, the flood that has a 1% chance in any given year of being equaled or exceeded. The 100-year flood is the national minimum standard to which communities regulate their floodplains through the National Flood Insurance Program (NFIP). The 500-year flood is the flood that has a 0.2 percent chance of being equaled or exceeded in any given year. The potential for flooding can change and increase through various land use changes and changes to land surface, which result in a change to the floodplain. A change in environment can create localized flooding problems inside and outside of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

The 100-year flood, which is the minimum standard used by most federal and state agencies, is used by the NFIP as the standard for floodplain management and to determine the need for flood insurance. Participation in the NFIP requires adoption and enforcement of a local floodplain management ordinance which is intended to prevent unsafe development in the floodplain, thereby reducing future flood damages. Participation in the NFIP allows for the federal government to make flood insurance available within the community as a financial protection against flood losses. Since floods have an annual probability of occurrence, have a known magnitude, depth and velocity for each event, and in most cases, have a map indicating where they will occur, they are in many ways often the most predictable and manageable hazard.

Collier County has been a participant in the NFIP since September 1979. Collier County has achieved a Class 6 flood insurance rating through participation in the NFIP's Community Rating System which rewards all policyholders in the County with a 20 percent reduction in their flood insurance premiums. Tables 4.9 – 4.12 reflect NFIP policy and claims data for the County categorized by structure type, flood zone, Pre-FIRM and Post-FIRM.

Table 4.9 - NFIP Policy and Claims Data by Structure Type

Structure Type	Number of Policies in Force	Total Premium	Total Coverage	Number of Closed Paid Losses	Total of Closed Paid Losses
Single Family	34,130	$19,349,728	$9,628,294,600	531	$5,986,383.74
2-4 Family	6,284	$2,550,280	$1,275,909,300	36	$446,753.69
All Other Residential	28,594	$8,512,093	$5,375,592,400	23	$191,263.96
Non-Residential	2,082	$3,521,880	$870,440,200	75	$1,950,061.94
Total	**71,090**	**$33,933,981**	**$17,150,236,500**	**665**	**$8,574,460.00**

Source: FEMA Community Information System, August 2014

Table 4.10 - NFIP Policy and Claims Data by Flood Zone

Flood Zone	Number of Policies in Force	Total Premium	Total Coverage	Number of Closed Paid Losses	Total of Closed Paid Losses
A01-30 & AE Zones	39,561	$19,686,241	$8,714,802,600	534	$6,540,712.53
A Zones	14	$13,556	$2,485,200	0	$0.00
AO Zones	0	$0	$0	0	$0.00
AH Zones	9,747	$2,600,704	$1,993,240,200	4	$82,040.27
AR Zones	0	$0	$0	0	$0.00
A99 Zones	0	$0	$0	0	$0.00
V01-30 & VE Zones	999	$2,357,499	$254,572,400	30	$1,144,569.83
V Zones	0	$0	$0	0	$0.00
D Zones	35	$55,669	$8,382,500	0	$0.00
B, C & X Zone					
Standard	971	$874,906	$215,054,100	36	$229,610.56
Preferred	19,763	$8,345,406	$5,961,699,500	59	$559,784.70
Total	**71,090**	**$33,933,981**	**$17,150,236,500**	**663**	**$8,556,715.00**

Source: FEMA Community Information System, August 2014

Table 4.11 - NFIP Policy and Claims Data Pre-FIRM

Flood Zone	Number of Policies in Force	Total Premium	Total Coverage	Number of Closed Paid Losses	Total of Closed Paid Losses
A01-30 & AE Zones	7,469	$6,859,706	$1,407,907,800	460	$5,950,738.00
A Zones	6	$5,336	$965,300	0	$0.00
AO Zones	0	$0	$0	0	$0.00
AH Zones	1,109	$344,469	$189,291,500	0	$0.00
AR Zones	0	$0	$0	0	$0.00
A99 Zones	0	$0	$0	0	$0.00

Flood Zone	Number of Policies in Force	Total Premium	Total Coverage	Number of Closed Paid Losses	Total of Closed Paid Losses
V01-30 & VE Zones	337	$550,967	$90,397,400	14	$516,814.94
V Zones	0	$0	$0	0	$0.00
D Zones	2	$3,426	$376,100	0	$0.00
B, C & X Zone	2,445	$1,117,638	$688,013,800	57	$523,877.28
Standard	168	$144,763	$34,912,800	23	$134,443.89
Preferred	2,277	$972,875	$653,101,000	34	$389,433.39
Total	**11,368**	**$8,881,542**	**$2,376,951,900**	**531**	**$6,991,429.00**

Source: FEMA Community Information System, August 2014

Table 4.12 - NFIP Policy and Claims Data Post-FIRM

Flood Zone	Number of Policies in Force	Total Premium	Total Coverage	Number of Closed Paid Losses	Total of Closed Paid Losses
A01-30 & AE Zones	32,092	$12,826,535	$7,306,894,800	74	$589,974.53
A Zones	8	$8,220	$1,519,900	0	$0.00
AO Zones	0	$0	$0	0	$0.00
AH Zones	8,638	$2,256,235	$1,803,948,700	4	$82,040.27
AR Zones	0	$0	$0	0	$0.00
A99 Zones	0	$0	$0	0	$0.00
V01-30 & VE Zones	662	$1,806,532	$164,175,000	16	$627,754.89
V Zones	0	$0	$0	0	$0.00
D Zones	33	$52,243	$8,006,400	0	$0.00
B, C & X Zone	18,289	$8,102,674	$5,488,739,800	40	$283,263.42
Standard	803	$730,143	$180,141,300	13	$95,166.67
Preferred	17,486	$7,372,531	$5,308,598,500	27	$188,096.75
Total	**59,722**	**$25,052,439**	**$14,773,284,600**	**134**	**$1,583,031.00**

Source: FEMA Community Information System, August 2014

Regulated floodplains are illustrated on inundation maps called Digital Flood Insurance Rate Maps (DFIRMs). It is the official map for a community on which FEMA has delineated both the special flood hazard areas (SFHAs) and the risk premium zones applicable to the community. SFHAs represent the areas subject to inundation by the 1-percent-annual chance flood event. Structures located within the SFHA have a 26-percent chance of flooding during the life of a standard 30-year mortgage. Flood zones are geographic areas that FEMA has defined according to varying levels of flood risk and type of flooding. Flood prone areas were identified within Collier County using the most current Flood Insurance Study (FIS) and associated DFIRMs developed by FEMA and adopted by ordinance on May 16, 2012. Table 4.13 summarizes the flood insurance zones identified by the DFIRMs. Figure 4.10 reflects the mapped flood insurance zones for Collier County.

Table 4.13 – Mapped Flood Insurance Zones within Collier County

Zone	Description
VE	Also known as the coastal high hazard areas. They are areas subject to high velocity water including waves; they are defined by the 1% annual chance (base) flood limits (also known as the 100-year flood) and wave effects 3 feet or greater. The hazard zone is mapped with base flood elevations (BFEs) that reflect the combined influence of stillwater flood elevations, primary frontal dunes, and wave effects 3 feet or greater.
AE	AE Zones, also within the 100-year flood limits, are defined with BFEs that reflect the combined influence of stillwater flood elevations and wave effects less than 3 feet. The AE Zone generally extends from the landward VE zone limit to the limits of the 100-year flood from coastal sources, or until it reaches the confluence with riverine flood sources. The AE Zones also depict the SFHA due to riverine flood sources, but instead of being subdivided into separate zones of differing BFEs with possible wave effects added, they represent the flood profile determined by hydrologic and hydraulic investigations and have no wave effects.
AH	Areas subject to inundation by 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are 1–3 feet. BFEs derived from detailed hydraulic analyses are shown in this zone.
A	Areas subject to inundation by the 1-percent-annual-chance flood event generally determined using approximate methodologies. Because detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) or flood depths are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply.
0.2% Annual Chance (shaded Zone X)	Moderate risk areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by a levee. No BFEs or base flood depths are shown within these zones. (Zone X (shaded) is used on new and revised maps in place of Zone B.)
Zone X (unshaded)	Minimal risk areas outside the 1-percent and .2-percent-annual-chance floodplains. No BFEs or base flood depths are shown within these zones. (Zone X (unshaded) is used on new and revised maps in place of Zone C.)

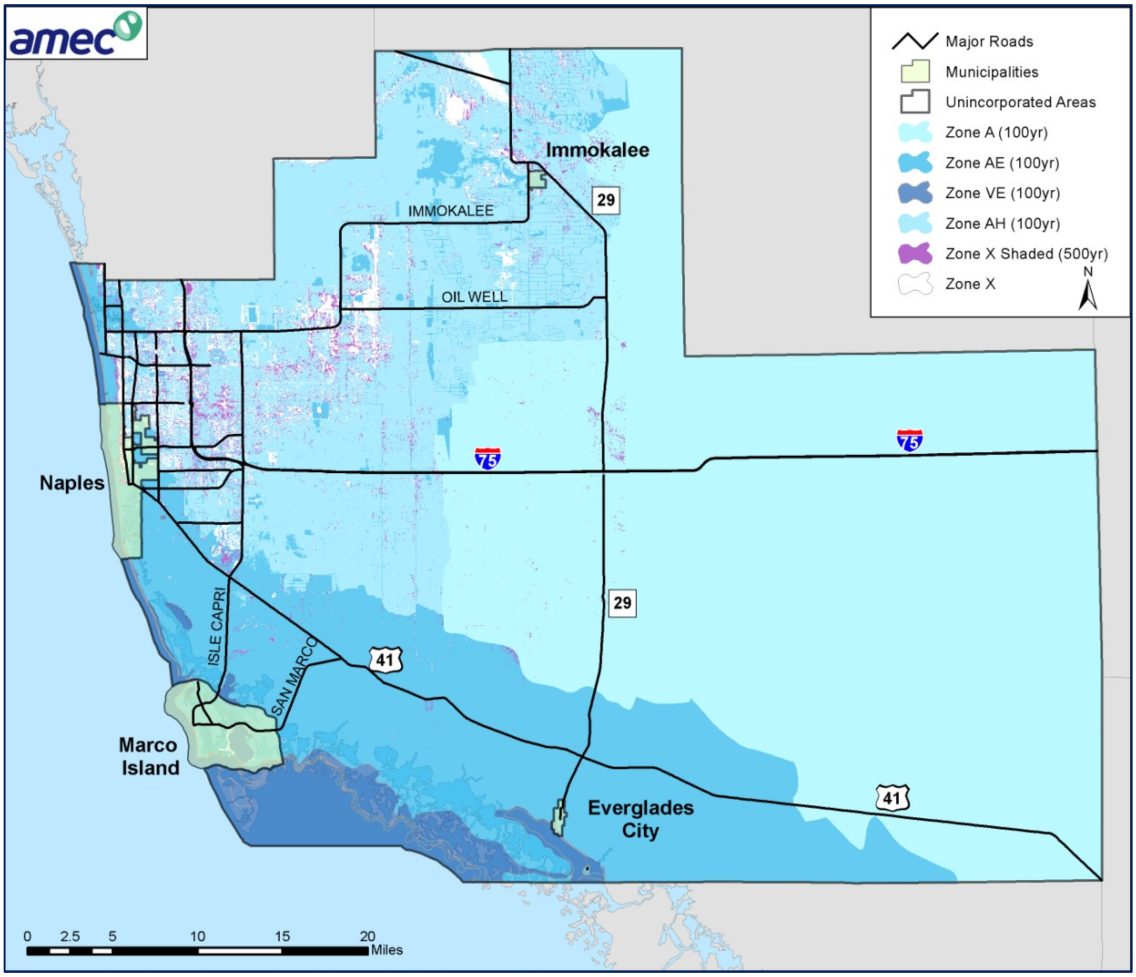


Figure 4.10- Collier County DFIRM Flood Zones

The NFIP utilizes the 100-year flood as a basis for floodplain management. The FIS defines the probability of flooding as flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 100 year period (recurrence intervals). Or considered another way, properties within a 100-year flood zone have a one percent probability of being equaled or exceeded during any given year. Mortgage lenders require that owners of properties with federally-backed mortgages located within SFHAs purchase and maintain flood insurance policies on their properties. Consequently, newer and recently purchased properties in the community are insured against flooding. Due to the risk of flooding from hurricanes, all property owners in the County, even if the property is not located in a SFHA, should be encouraged to purchase and maintain flood insurance policies.

Past Occurrences

Collier County is located within a sub-tropical environment and is subject to intense thunderstorms and tropical cyclones (hurricanes). Roughly 80% of the 53.5" average annual rainfall occurs during the months of May through October, with approximately 65% of that occurring during the months of June through September. Flooding can occur in Collier County year-around but is most frequent during the summer months which often bring persistent thunderstorms, and in late summer the heavy rains associated with tropical storms and hurricanes are more prevalent. Past occurrences for tropical storms and hurricanes can be found in Section 4.2.6.

Table 4.14 shows the flood events from causes other than hurricanes reported by the NCDC since 1950 for Collier County. Table 4.15 shows the flood events from causes other than hurricanes reported by SHELDUS from 1960 through 2013.

Table 4.14 - NCDC Flooding in Collier County – January 1950 to May 2014

Location	Date	Event Type	Injuries/Deaths	Damages
Naples	09/20/9199	Flash Flood	0/0	$200,000
Immokalee	07/04/2000	Flash Flood	0/0	$0
Marco	07/23/2001	Flash Flood	0/0	$150,000
West Portion	09/29/2003	Flash Flood	0/0	$100,000
Immokalee	08/30/2006	Flash Flood	0/0	$0
Marco	07/16/2008	Flash Flood	0/0	$10,000
Coastal Collier	12/30/1997	Flood	0/0	$0
Collier County	05/28/1998	Flood	0/0	$0
Naples	09/07/2000	Flood	0/0	$0
Naples	09/11/2000	Flood	0/0	$0
Coastal Collier	06/26/2012	Coastal Flood	0/0	$70,000
Marco	07/12/1998	Heavy Rain	0/0	$0
Marco Is Arpt	07/20/1998	Heavy Rain	0/0	$0
Naples	09/28/2001	Heavy Rain	0/0	$0
Golden Gate	06/12/2005	Heavy Rain	0/0	$0
Golden Gate	02/03/2006	Heavy Rain	0/0	$60,000
Evans Pines	04/06/2008	Heavy Rain	0/0	$0

Source: NCDC

Table 4.15 - SHELDUS Flooding in Collier County - 1960 to 2013

Date	Hazard Type	Injuries/Fatalities	Crop Damage	Property Damage
05/1996	Coastal	1/1	$0.00	$0.00
09/1997	Coastal	0/2	$0.00	$0.00
06/1998	Coastal	0/1	$0.00	$0.00
08/2008	Coastal	0/0	$0.00	$64,919.00
10/1974	Flooding	0/0	$656.00	$65,629.00
06/1992	Flooding	0/0	$7,547.00	$754,736.00
09/1994	Flooding	0/0	$0.00	$1,455.00
10/1995	Flooding	0/0	$56,557,802.00	$76,429.00
09/1999	Flooding	0/0	$0.00	$279,660.00
07/2001	Flooding	0/0	$0.00	$197,309.00
09/2003	Flooding	0/0	$0.00	$126,607.00
07/2008	Flooding	0/0	$0.00	$10,819.00
06/2012	Flooding	0/0	$0.00	$71,025.00
08/2012	Flooding	0/0	$0.00	$6,087,885.00
02/1969	Severe Storm/Thunder Storm	0/0	$0.00	$15,632.00
03/1969	Severe Storm/Thunder Storm	0/0	$0.00	$9,309.00
06/1991	Severe Storm/Thunder Storm	0/0	$0.00	$85.00
07/1991	Severe Storm/Thunder Storm	4/0	$0.00	$17,104.00
07/1992	Severe Storm/Thunder Storm	0/0	$0.00	$83.00
08/1992	Severe Storm/Thunder Storm	0/0	$0.00	$83.00
02/2006	Severe Storm/Thunder Storm	0/0	$0.00	$69,332.00

Source: SHELDUS v13.1

The following provides details on flood events detailed in the NCDC database and from members of the FMPC.

May 28, 1998 - Street flooding and overflowing canals resulted as a line of thunderstorms dumped near three inches of rain in the morning hours. The Collier County Government Center measured 2.73 inches between 7:30 and 11:45 am.

July 20, 1998 – Rainfall was estimated at three inches in one half hour at Marco Island Airport.

September 20, 1999 - Eight inches of rain fell during the afternoon of September 20 causing major street flooding which submerged six vehicles and caused minor flooding to 34 structures in Naples.

July 23, 2001 - At least four residences and 20 vehicles were damaged by flood waters on Marco Island and in East Naples. 48-hour rainfall amounts of 4 to 10 inches of rain were measured over southwest Florida as a trough of low pressure stalled in the eastern Gulf of Mexico. Radar estimated 8-12 inches of rain fell over a 96-hour period in Marco Island. Strong onshore winds caused some minor tidal flooding of streets.

September 28, 2001 – Between 3 and 5 inches of rain with local amounts of 8 inches caused street flooding in Naples.

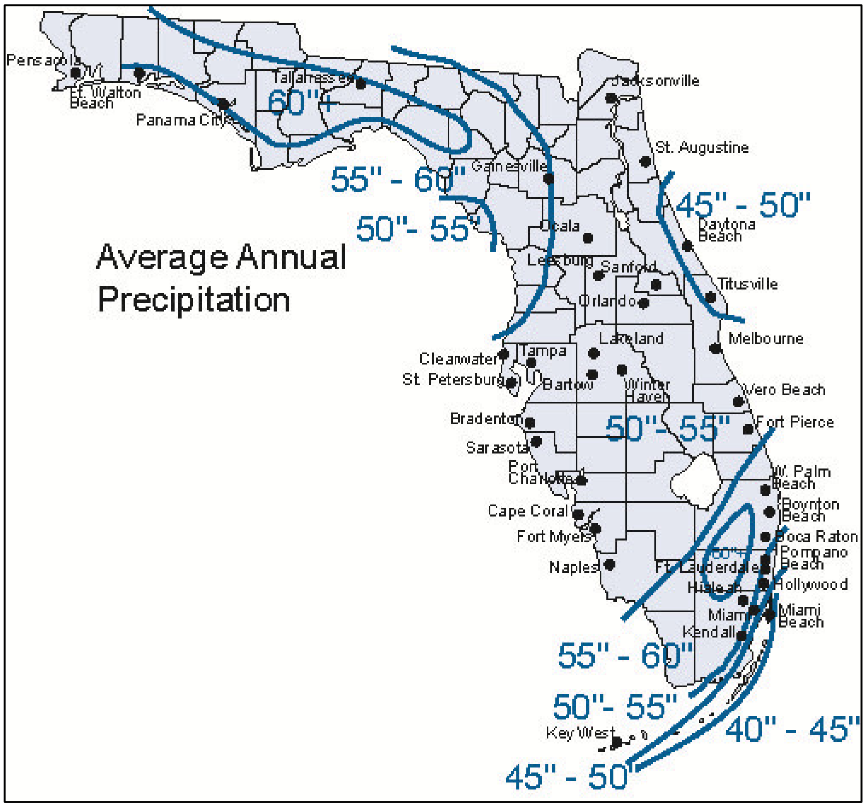
September 29, 2003 - Very heavy rainfall fell across southwest Florida with radar estimated amounts of 8 to 10 inches. Naples measured a record 6.99 inches. The resulting flood closed numerous roads in Collier County. Numerous cars were stalled. Houses and businesses including a shopping mall suffered minor flooding damage.

July 16, 2008 - A combination of 6-8 inches of rain over a short period of time and high tide caused flooding on Marco Island. Coconuts, palm fronds, and plastic bags also clogged storm drains at some locations exacerbating the flooding. One towing company on Marco Island pulled out 35 to 40 cars alone. Water reached around 2 feet deep in some roadways and a few inches deep in some residences. Several roads were closed, including the main bridge connecting Marco Island to the mainland.

June 26, 2012 – Persistent and strong southerly winds pushed water onshore over southern Collier County in the Everglades City area. Minor flooding occurred over several consecutive high tide cycles beginning on June 23rd, with the highest water levels occurring during the high tide cycle of the morning of June 26th. Streets in Everglades City were flooded, damaging roads and water pumps.

Frequency/Likelihood of Future Occurrence

Occasional - By definition of the 1-percent-annual-chance flood event, Collier County has a 1 percent chance of a 100-year or significant flood being equaled or exceeded in any given year. As shown in Figure 4.11, the annual precipitation for Collier County averages 53.5 inches. A similar amount of precipitation should be anticipated in the future, and occasional flooding is likely to occur.



Source: Florida Climate Center, Florida State University

Figure 4.11 - Average Annual Precipitation for Florida

Climate Change and Flood: 100-/500-year

With its populous coastal community and low topography, Collier County is particularly vulnerable to the effects of climate change and sea level rise. While average annual rainfall may increase or decrease slightly, the intensity of individual rainfall events is likely to increase which can overwhelm stormwater drainage systems.

4.2.5 Flood: Stormwater/Localized Flooding

Hazard/Problem Description

Localized stormwater flooding can also occur throughout Collier County. Localized stormwater flooding occurs when heavy rainfall and an accumulation of runoff overburden the stormwater drainage system within the community. Collier County has a natural terrain that is extremely flat. From a high point near Immokalee the drainage pattern is south and southwesterly toward the coast with an average slope of one foot per mile.

A Primary and a Secondary canal system form a major surface water / stormwater control network in the County. Together, their function is for flood prevention and stormwater quality treatment, wetlands preservation, and surface recharge of the groundwater aquifers. The Secondary system consists of a network of ditches, canals, weirs and pump stations that collect stormwater run-off from neighborhoods and public roadside drainage systems. It is linked to, and operates in close cooperation with the Primary system. The Primary system consists of canals and water level control structures that store stormwater run-off from the Secondary system, roadways and neighborhoods. The Collier County canal system is shown in Figure 4.12.

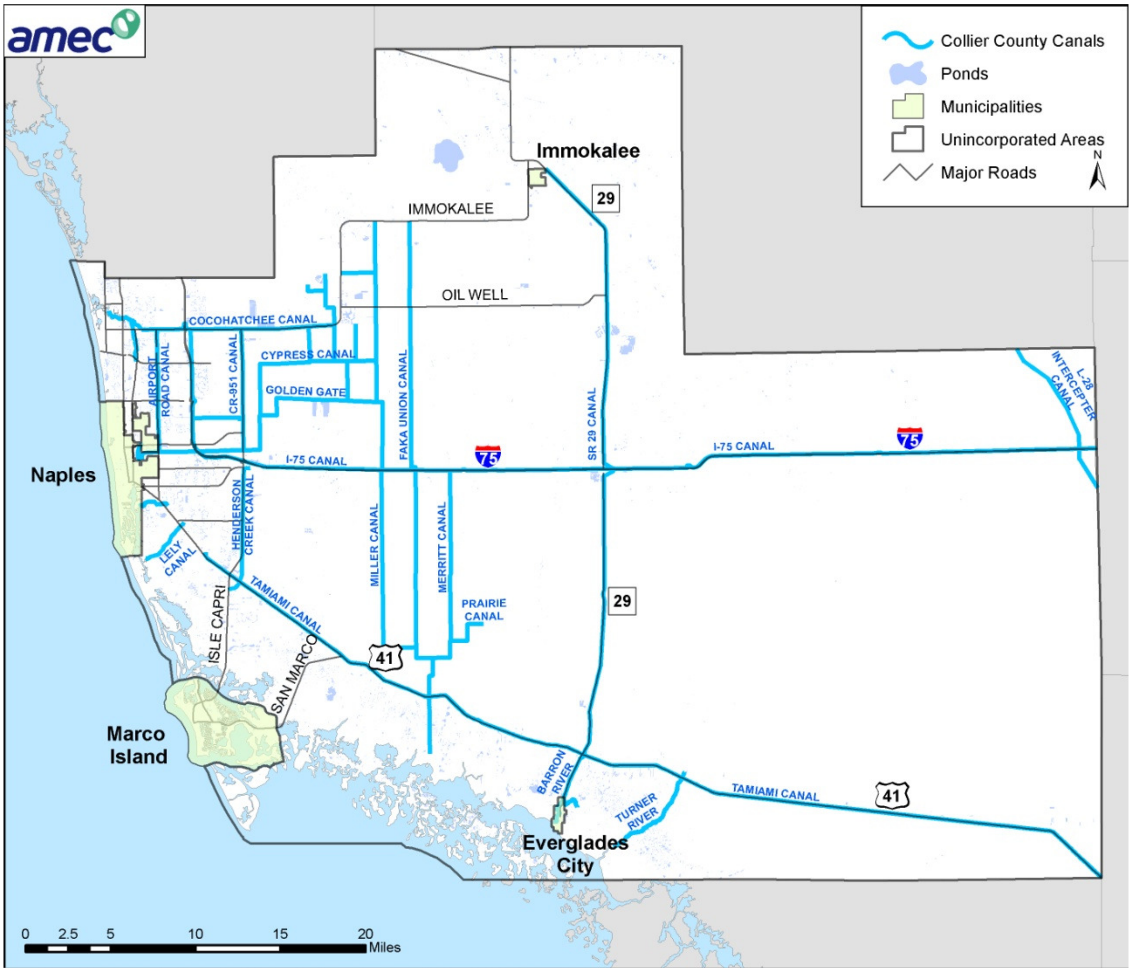


Figure 4.12 - Collier County Canal System

Past Occurrences

Figure 4.13 depicts the areas of localized flooding identified by the FMPC. The areas of localized flooding include: (example bulleted list is a placeholder - to be updated following September 30 FMPC Meeting)

- Sterling Dr and SW 93 St
- Parcels between SW 195 St and SW 196 St
- The parcels bordered by Caribbean Blvd, Anchor Rd, Pan American Dr and Blue Water Rd
- Manta Drive at Old Cutler Rd
- Old Cutler Rd southwest of the intersection of Franjo Rd
- The intersection of SW 89 Ct, Franjo Rd and SW 200 St
- SW 186 St
- SW 77 Ave and SW 188 St through the intersection of SW 78 Ave
- SW 79 Ave at SW 79 Ct
- SW 197 Terrace at SW 196 Terrace
- SW 84 Ave at SW 199 Terrace
- SW 212 St between SW 85 Ave and SW 87 Ave
- SW 92 Ave between Old Cutler Road and SW 208 St

Placeholder for Localized Flooding Figure
(to be created following September 30 FMPC Meeting)

Figure 4.13 - Localized Flooding Identified by the FMPC

Localized flooding may be caused by the following maintenance related issues:

Clogged Inlets – debris covering the asphalt apron and the top of grate at catch basin inlets may contribute to an inadequate flow of stormwater into the system which may cause flooding near the structure. Debris within the basin itself may also reduce the efficiency of the system by reducing the carrying capacity.

Blocked Drainage Outfalls – debris blockage or structural damage at drainage outfalls may prevent the system from discharging runoff which may lead to a back-up of stormwater within the system.

Improper Grade – poorly graded asphalt around catch basin inlets may prevent stormwater from entering the catch basin as designed. Areas of settled asphalt may create low spots within the roadway that allow for areas of ponded water.

Frequency/Likelihood of Future Occurrence

***Highly Likely* -** Due to the low elevations, a flat terrain, a consistent level of annual precipitation and the tidal influence on canal drainage resulting from heavy rainstorms, tropical storms, and hurricanes, it is highly likely that unmitigated properties will continue to experience localized flooding.

Climate Change and Flood: Stormwater/Localized Flooding

Climate change and sea level rise do have the potential to affect localized flooding in Collier County. The intensity of individual rainfall events is likely to increase which can overwhelm stormwater drainage systems. It is possible that average soil moisture and runoff could decline, however, due to increasing temperature, evapotranspiration rates and spacing between rainfall events.

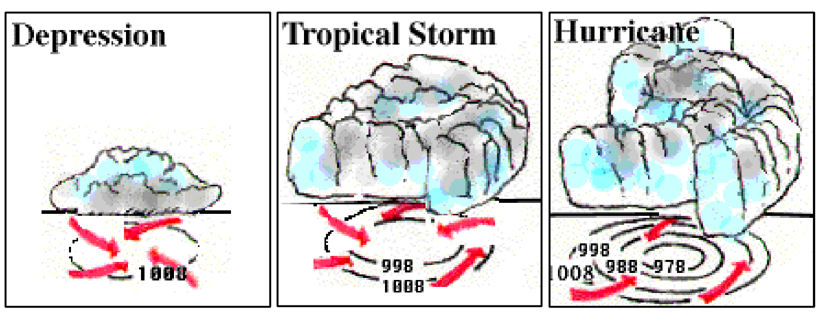
4.2.6 Hurricane and Tropical Storm (including Storm Surge)

Hazard/Problem Description

A hurricane is a type of tropical cyclone or severe tropical storm that forms in the southern Atlantic Ocean, Caribbean Sea, Gulf of Mexico, and in the eastern Pacific Ocean. A typical cyclone is accompanied by thunderstorms, and in the Northern Hemisphere, a counterclockwise circulation of winds near the earth's surface. All Atlantic and Gulf of Mexico coastal areas are subject to hurricanes. The Atlantic hurricane season lasts from June to November, with the peak season from mid-August to late October.

Hurricanes evolve through a life cycle of stages from birth to death. While hurricanes pose the greatest threat to life and property, tropical storms and depressions also can be devastating. Floods from heavy rains and severe weather, such as tornadoes, can cause extensive damage and loss of life. A tropical disturbance can grow to a more intense stage through an increase in sustained wind speeds. The progression of a tropical disturbance is described below and can be seen in Figure 4.14.

- **Tropical Depression:** A tropical cyclone with maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm:** A tropical cyclone with maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane:** A tropical cyclone with maximum sustained winds of 74 mph (64 knots) or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- **Major Hurricane:** A tropical cyclone with maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Hurricane Wind Scale.



Source: Department of Atmospheric Sciences at the University of Illinois at Urbana-Champaign

Figure 4.14 - Life Cycle of a Hurricane

Tropical Storm

Tropical depressions and tropical storms are both categorized by the National Weather Service as a tropical cyclone. The differentiation between these two is wind speed and organization:

Tropical Depression - a tropical cyclone in which the maximum 1-minute sustained surface wind is 33 knots (38 mph) or less. When viewed from a satellite, tropical depressions appear to have little organization. However, the slightest amount of rotation can usually be perceived when looking at a series of satellite images. Instead of a round appearance similar to hurricanes, tropical depressions look like individual thunderstorms that are grouped together.

Tropical Storm - a tropical cyclone in which the maximum 1-minute sustained surface wind ranges from 34 to 63 knots (39 to 73 mph) inclusive. As the storm transitions from tropical depression to tropical storm, the storm itself becomes more organized and begins to become more circular in shape - resembling a hurricane.

Hurricane

A hurricane is a tropical cyclone in which the maximum sustained surface wind is 74 mph or more. Hurricanes are classified by intensity into one of five categories on the Saffir-Simpson Hurricane Wind Scale as shown in Table 4.16. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures.

Table 4.16 – Saffir-Simpson Hurricane Wind Scale, 2012

Category	Wind Speed (mph)	Potential Damage
1	74-95	**Very dangerous winds will produce some damage**: Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	96-110	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	111-129	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	130-156	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	$\geq$ 157	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center/NOAA

Wind speed is the determining factor in the scale, as storm surge values are highly dependent on the slope of the continental shelf and the shape of the coastline in the landfall region. The following describes the characteristics of each category storm from the Saffir-Simpson Hurricane Wind Scale Extended Table:

Category 1 Hurricane - Winds 74 – 95 mph. Very dangerous winds will produce some damage. People, livestock, and pets struck by flying or falling debris could be injured or killed. Older (mainly pre-1994 construction) mobile homes could be destroyed, especially if they are not anchored properly as they tend to shift or roll off their foundations. Newer mobile homes that are anchored properly can sustain damage involving the removal of shingle or metal roof coverings, and loss of vinyl siding, as well as damage to carports, sunrooms, or lanais. Some poorly constructed frame homes can experience major damage, involving loss of the roof covering and damage to gable ends as well as the removal of porch coverings and awnings. Unprotected windows may break if struck by flying debris. Masonry chimneys can be toppled. Well-constructed frame homes could have damage to roof shingles, vinyl siding, soffit panels, and gutters. Failure of aluminum, screened-in, swimming pool enclosures can occur. Some apartment building and shopping center roof coverings could be partially removed. Industrial buildings can lose roofing and siding especially from windward corners, rakes, and eaves. Failures to overhead doors and unprotected windows will be common. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. There will be occasional damage to commercial signage, fences, and canopies. Large branches of trees will snap and shallow rooted trees can be toppled. Extensive damage to power lines and poles will likely result in power outages that could last a few to several days.

Category 2 Hurricane - Winds 96-110 mph. Extremely dangerous winds will cause extensive damage. There is a substantial risk of injury or death to people, livestock, and pets due to flying and falling debris. Older (mainly pre-1994 construction) mobile homes have a very high chance of being destroyed and the flying debris generated can shred nearby mobile homes. Newer mobile homes can also be destroyed. Poorly constructed frame homes have a high chance of having their roof structures removed especially if they are not anchored properly. Unprotected windows will have a high probability of being broken by flying debris. Well-constructed frame homes could sustain major roof and siding damage. Failure of aluminum, screened-in, swimming pool enclosures will be common. There will be a substantial percentage of roof and siding damage to apartment buildings and industrial buildings. Unreinforced masonry walls can collapse. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. Commercial signage, fences, and canopies will be damaged and often destroyed. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks. Potable water could become scarce as filtration systems begin to fail.

Category 3 Hurricane - Winds 111-129 mph. Devastating damage will occur. There is a high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. Most newer mobile homes will sustain severe damage with potential for complete roof failure and wall collapse. Poorly constructed frame homes can be destroyed by the removal of the roof and exterior walls. Unprotected windows will be broken by flying debris. Well-built frame homes can experience major damage involving the removal of roof decking and gable ends. There will be a high percentage of roof covering and siding damage to apartment buildings and industrial buildings. Isolated structural damage to wood or steel framing can occur. Complete failure of older metal buildings is possible, and older unreinforced masonry buildings can collapse. Numerous windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Most commercial signage, fences, and canopies will be destroyed. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to a few weeks after the storm passes.

Category 4 Hurricane - Winds 130 to 156 mph. Catastrophic damage will occur. There is a very high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. A high percentage of newer mobile homes also will be destroyed. Poorly constructed homes can sustain complete collapse of all walls as well as the loss of the roof structure. Well-built homes also can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Extensive damage to roof coverings, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will break most unprotected windows and penetrate some protected windows. There will be a high percentage of structural damage to the top floors of apartment buildings. Steel frames in older industrial buildings can collapse. There will be a high percentage of collapse to older unreinforced masonry buildings. Most windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months.

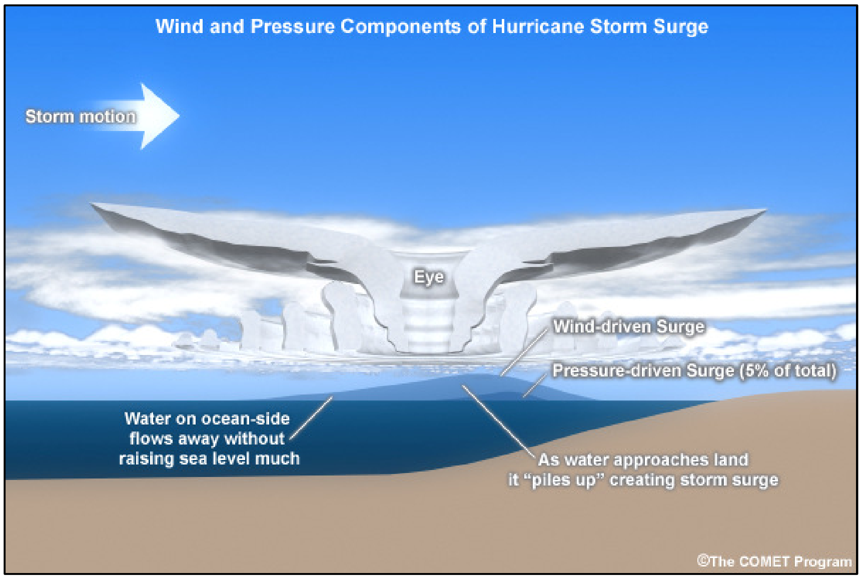
Category 5 Hurricane - Winds 157 mph or higher. Catastrophic damage will occur. People, livestock, and pets are at very high risk of injury or death from flying or falling debris, even if indoors in mobile homes or framed homes. Almost complete destruction of all mobile homes will occur, regardless of age or construction. A high percentage of frame homes will be destroyed, with total roof failure and wall collapse. Extensive damage to roof covers, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will occur to nearly all unprotected windows and many protected windows. Significant damage to wood roof commercial buildings will occur due to loss of roof sheathing. Complete collapse of many older metal buildings can occur. Most unreinforced masonry walls will fail which can lead to the collapse of the buildings. A high percentage of industrial buildings and low-rise apartment buildings will be destroyed. Nearly all windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Nearly all trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months. Hurricane Andrew (1992) is an example of a hurricane that brought Category 4 conditions to Collier County.

Hurricanes can cause catastrophic damage to coastlines and several hundred miles inland. Hurricanes can produce winds exceeding 157 miles per hour as well as tornadoes and mircrobursts. Additionally, hurricanes can create storm surges along the coast and cause extensive damage from heavy rainfall. Floods and flying debris from the excessive winds are often the deadly and destructive results of these weather events. Flash flooding can also occur due to intense rainfall.

Storm Surge

The greatest potential for loss of life related to a hurricane is from the storm surge. Storm surge is simply water that is pushed toward the shore by the force of the winds swirling around the storm as shown in Figure 4.15. This advancing surge combines with the normal tides to create the hurricane storm tide, which can increase the mean water level to heights impacting roads, homes and other critical infrastructure. In addition, wind driven waves are superimposed on the storm tide. This rise in water level can cause severe flooding in coastal areas, particularly when the storm tide coincides with the normal high tides.

The maximum potential storm surge for a particular location depends on a number of different factors. Storm surge is a very complex phenomenon because it is sensitive to the slightest changes in storm intensity, forward speed, size (radius of maximum winds-RMW), angle of approach to the coast, central pressure (minimal contribution in comparison to the wind), and the shape and characteristics of coastal features such as bays and estuaries. Other factors which can impact storm surge are the width and slope of the continental shelf. A shallow slope will potentially produce a greater storm surge than a steep shelf. For example, a Category 4 storm hitting the Louisiana coastline, which has a very wide and shallow continental shelf, may produce a 20-foot storm surge, while the same hurricane in Miami Beach, Florida, where the continental shelf drops off very quickly, might see an 8 or 9-foot surge.



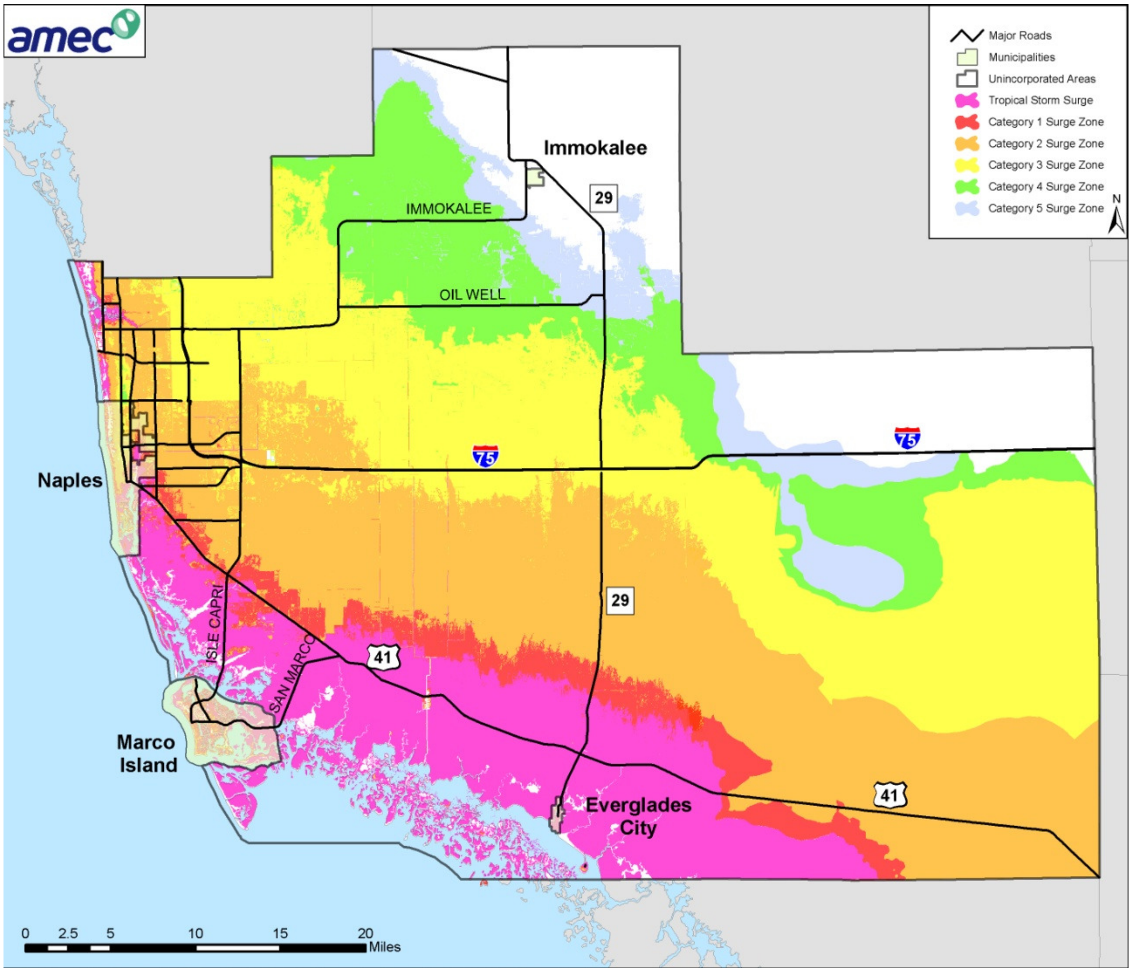
Source: NOAA/The COMET Program

Figure 4.15 - Components of Hurricane Storm Surge

Storm Surge Mapping

The Sea, Lake and Overland Surges from Hurricanes (SLOSH) model is a computerized numerical model developed by the National Weather Service (NWS) to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes by taking into account the atmospheric pressure, size, forward speed, and track data. These parameters are used to create a model of the wind field which drives the storm surge. The SLOSH model consists of a set of physics equations which are applied to a specific locale's shoreline, incorporating the unique bay and river configurations, water depths, bridges, roads, levees and other physical features.

Anticipated SLOSH model surge elevations for Category 1-5 hurricanes are shown for Collier County in Figure 4.16. The feature set depicting surge zones in this figure was created using a Surge Modeling application created for the Florida Statewide Regional Evacuation Update Study. The data was derived from National Hurricane Center SLOSH model runs on all the NOAA SLOSH basins throughout Florida. The runs create outputs for all different storm simulations from all points of the compass. Each direction has a MEOW (maximum envelope of water) for each category of storm (1-5), and all directions combined result in a MOMs (maximum of maximums) set of data. The MOMs are used in this surge model.



Source: Florida Division of Emergency Management (http://www.floridadisaster.org)

Figure 4.16 – Category 1 through Category 5 Storm Surge Zones for Collier County

Past Occurrences

Table 4.17 shows hurricane and tropical storm data reported by NCDC since 1950 for Collier County. Major disaster declarations for hurricanes and tropical storms in Collier County can be found in Table 4.3. Figures 4.17 and 4.18 reflect past hurricane strike data for land falling major hurricanes in Collier County as provided by the National Hurricane Center. The following is a description of past occurrences of hurricanes and tropical storms from NCDC.

August 2004 - Hurricane Charley (DR-1539) intensified to Category 4 status before making landfall near Port Charlotte. In Collier County, a peak wind gust of 84 mph was measured on the top of a condominium at Vanderbilt Beach before the equipment failed. Rainfall in most locations in Collier County was around two inches with an unofficial amount of 7.5 inches reported in North Naples. Radar rainfall estimates of locally 8 to 10 inches were made in North Naples. The highest Storm Tide along the southwest Florida Coast was estimated at three feet near Wiggins Pass with heights of one to two feet from Naples to Marco Island to Everglades City. Tidal flooding was minimal. Lake Okeechobee levels increased up to three feet above normal along the north and northeast shores.

September 2004 – The 70-mile diameter eye of Hurricane Frances (DR-1545) crossed south Florida. At the Naples Municipal Airport the ASOS measured a maximum sustained wind of 38 mph with a peak gust of 54 mph. Widespread storm-total amounts of 3 to 5 inches occurred in southeast and interior south

Florida with southwest Florida averaging 1 to 3 inches. There were no known direct deaths, but at least 9 people died in the aftermath.

October 2005 – Hurricane Wilma (DR-1609) was a classic October hurricane which struck South Florida as a Category 3 hurricane on October 24th, 2005. Wilma exhibited a very large 55 to 65 mile-wide eye while crossing the state, and the eye covered large portions of South Florida, including the eastern two-thirds of Collier County. Rainfall amounts across South Florida generally ranged from 2 to 4 inches across southern sections of the peninsula to 4 to 6 inches across western Collier County.

Table 4.17 - NCDC Hurricane/Tropical Storm Data for Collier County, 1950-2014

Location	Date	Event Type	Deaths/ Injuries	Property Damage	Crop Damage
Coastal Collier	09/25/1998	Hurricane	0	$0	$0
Coastal Collier	08/13/2004	Hurricane	0	$2,500,000	$0
Coastal Collier	09/04/2004	Hurricane	0	$0	$0
Inland Collier	09/04/2004	Hurricane	0	$0	$0
Inland Collier	07/08/2005	Hurricane	0	$0	$0
Coastal Collier	10/24/2005	Hurricane	1	$0	$0
Inland Collier	09/25/2008	Tropical Storm	0	$0	$0
Coastal Collier	11/04/1998	Tropical Storm	0	$0	$0
Inland Collier	11/04/1998	Tropical Storm	0	$0	$0
Coastal Collier	09/20/1999	Tropical Storm	0	$325,000	$0
Coastal Collier	09/16/2000	Tropical Storm	0	$0	$0
Coastal Collier	09/13/2001	Tropical Storm	0	$50,000	$0
Inland Collier	08/30/2006	Tropical Storm	0	$0	$0
Coastal Collier	08/30/2006	Tropical Storm	0	$0	$0
Inland Collier	08/18/2008	Tropical Storm	0	$0	$0
Coastal Collier	08/18/2008	Tropical Storm	0	$20,000	$0
Coastal Collier	08/26/2012	Tropical Storm	0	$0	$0
			Total:	**$2,895,000**	**$0**

Source: NCDC

Table 4.18 shows SHELDUS events related to hurricanes and tropical storms from 1960 through 2013. Table 4.19 shows storm surge data reported by NCDC since 1950 for Collier County.

Table 4.18- SHELDUS Hurricane/Tropical Storm Data for Collier County - 1960 to 2013

Date	Hazard Type	Injuries/Fatalities	Crop Damage	Property Damage
09/1960	Hurricane/Tropical Storm	43/0	$0.00	$0.00
10/1964	Hurricane/Tropical Storm	2/0	$0.00	$1,633,639.00
09/1965	Hurricane/Tropical Storm	0/0	$0.00	$10,875,677.00
06/1966	Hurricane/Tropical Storm	0/0	$0.00	$678,304.00
10/1966	Hurricane/Tropical Storm	0/0	$513,573.00	$513,573.00
06/1968	Hurricane/Tropical Storm	0/0	$0.00	$8,163,617.00
10/1968	Hurricane/Tropical Storm	0/0	$0.00	$643,669.00
06/1972	Hurricane/Tropical Storm	1/0	$415.00	$83,181.00
06/1974	Hurricane/Tropical Storm	0/0	$1,968.00	$0.00
09/1979	Hurricane/Tropical Storm	0/0	$348,779.00	$3,487,797.00
08/1981	Hurricane/Tropical Storm	0/0	$985,685.00	$98,568.00
08/1985	Hurricane/Tropical Storm	0/0	$0.00	$161,569.00
10/1987	Hurricane/Tropical Storm	0/0	$0.00	$14,647.00
08/1992	Hurricane/Tropical Storm	0/3	$415,105,133.00	$10,377,628,331.00
11/1994	Hurricane/Tropical Storm	0/0	$3,274,806.00	$3,274,806.00
08/1995	Hurricane/Tropical Storm	0/0	$218,369.00	$131,021.00

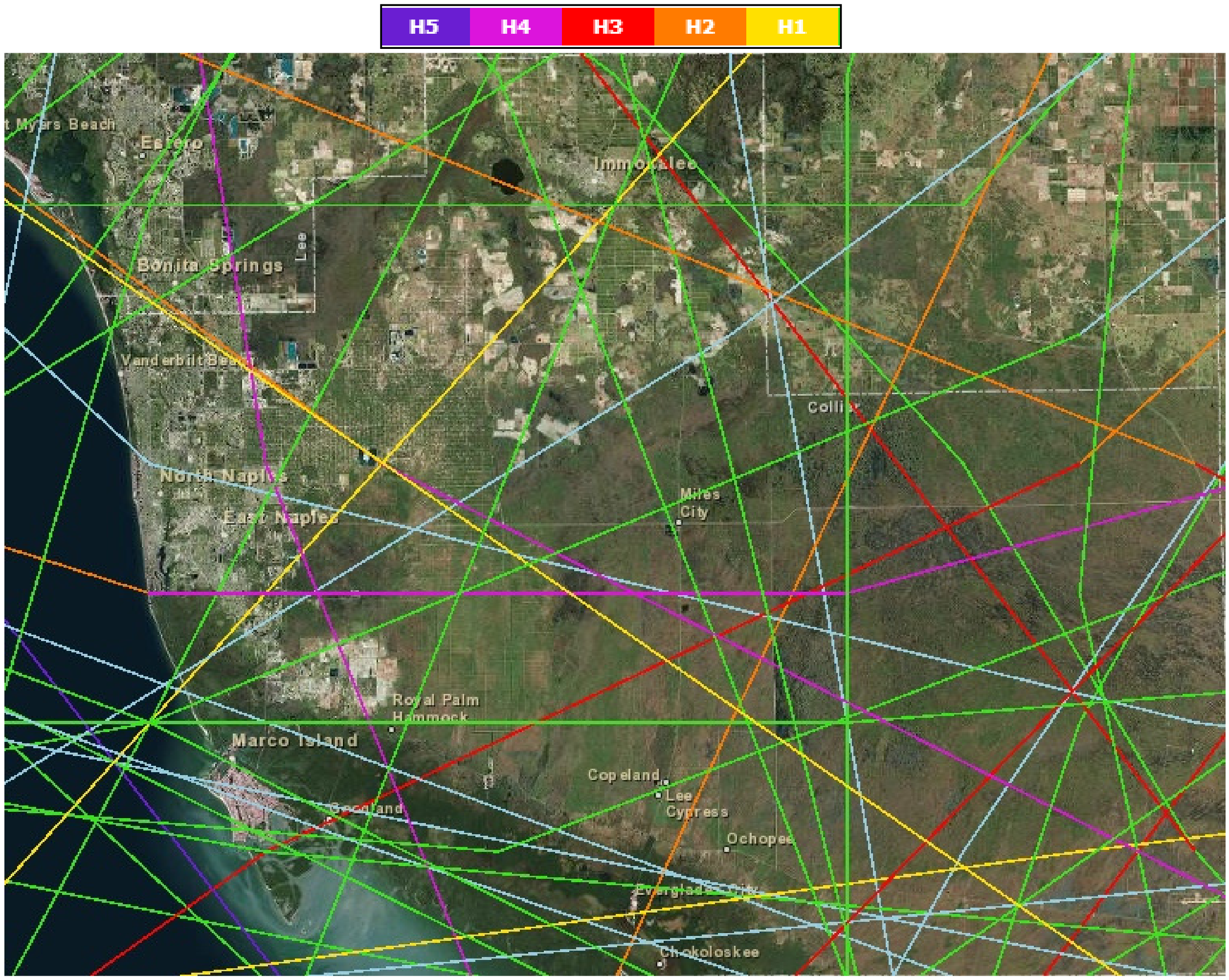
Date	Hazard Type	Injuries/Fatalities	Crop Damage	Property Damage
10/1995	Hurricane/Tropical Storm	0/0	$0.00	$3,057,178.00
11/1998	Hurricane/Tropical Storm	9/0	$4,083,383.00	$6,125,074.00
09/1999	Hurricane/Tropical Storm	0/0	$0.00	$113,611.00
09/2000	Hurricane/Tropical Storm	0/0	$0.00	$16,910.00
09/2001	Hurricane/Tropical Storm	0/0	$0.00	$21,923.00
08/2004	Hurricane/Tropical Storm	0/0	$0.00	$1,068,798.00
09/2004	Hurricane/Tropical Storm	0/0	$18,498,438.00	$127,639,224.00
10/2005	Hurricane/Tropical Storm	1/1	$0.00	$2,982,040,457.00
08/2008	Hurricane/Tropical Storm	0/0	$0.00	$3,606.00

Source: SHELDUS v13.1

Table 4.19 - NCDC Storm Surge Data for Collier County, 1950-2014

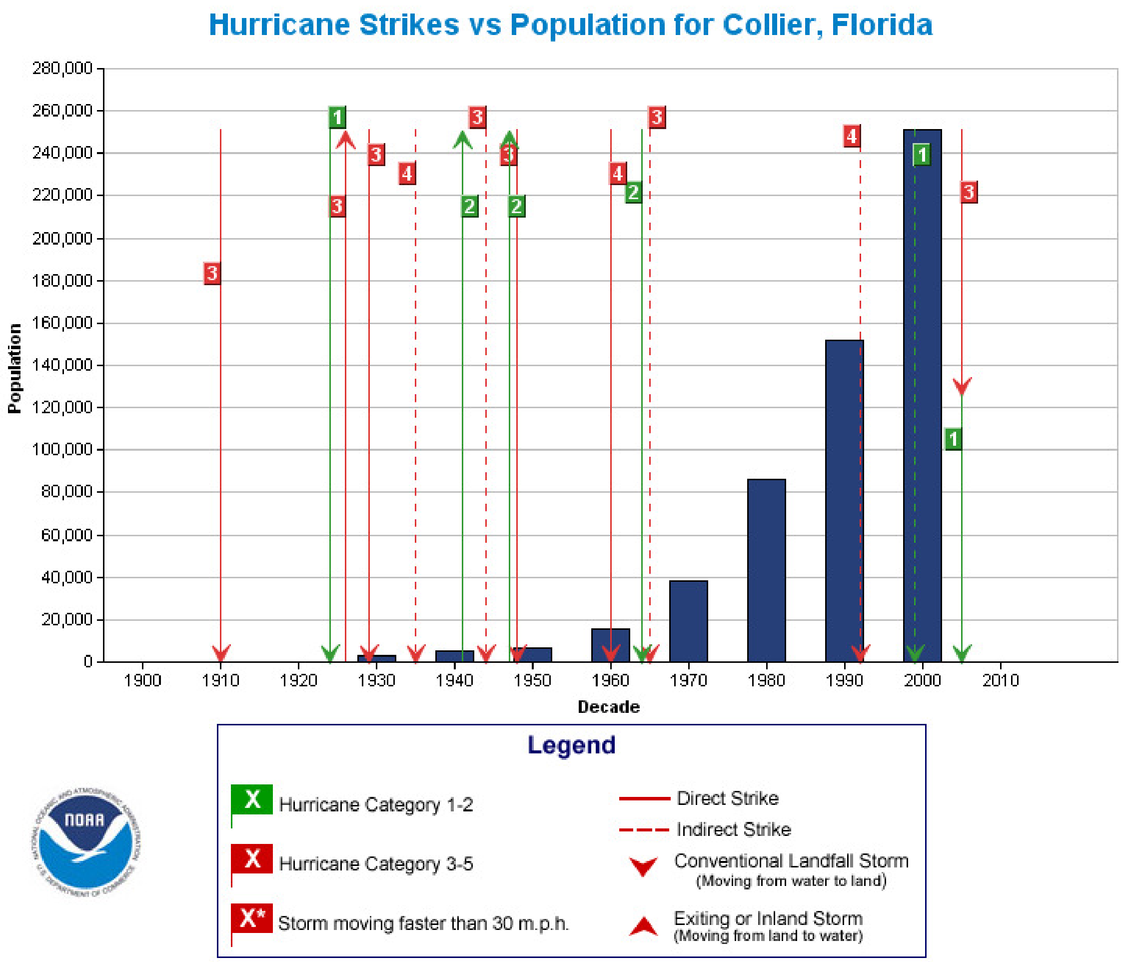
Location	Date	Event Type	Deaths/ Injuries	Property Damage	Crop Damage
Coastal Collier	10/24/2005	Storm Surge	0	$0	$0
Coastal Collier	08/19/2008	Storm Surge	0	$60,000	$0
Coastal Collier	08/27/2012	Storm Surge	0	$6,000,000	$0
			Total:	**$6,060,000**	**$0**

Source: NCDC



Source: NOAA/National Hurricane Center

Figure 4.17 – Historical Hurricane Tracks, Collier County



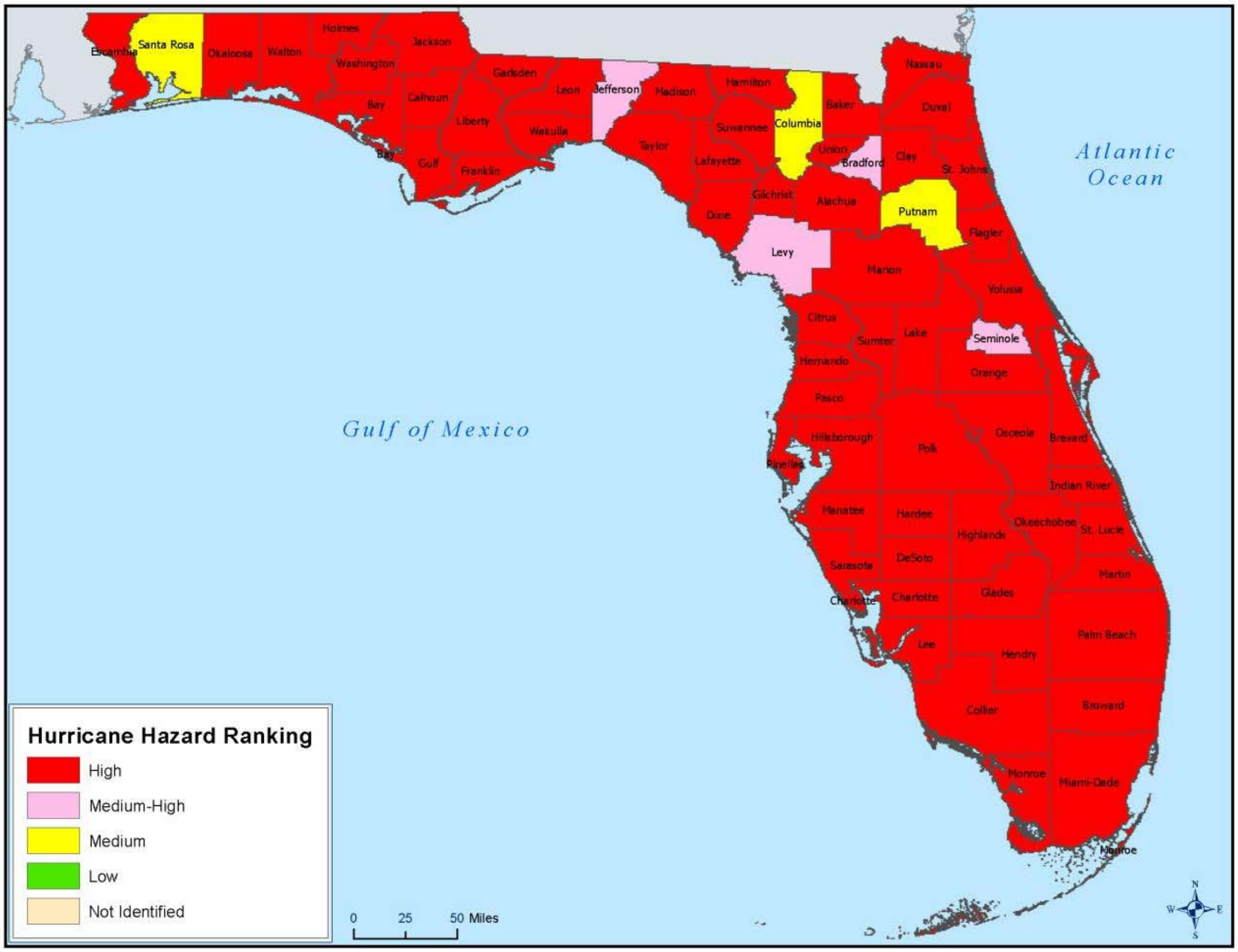
Hurricane Strike Data: National Hurricane Center
Population Data: U.S. Census Bureau
NOTE:Population values may be missing in some counties, particularly for earlier periods. This is most often attributable to the fact that the county had not yet been established.
NOTE:There may be discrepancies between the strike data shown in this chart and the HURDAT strike data used in the Historical Hurricanes Tracks Tool. The National Hurricane Center is currently updating the strike data used for these charts. For more information visit http://www.aoml.noaa.gov/hrd/data_sub/re_anal.html
NOTE:Population data is current as of 2000 U.S. Census. X-axis on graphs depict years through 2010 to illustrate storms that have occurred from 2000-2006.

Figure 4.18- Hurricane Strikes for Collier County

Frequency/Likelihood of Future Occurrence

Hurricane and Tropical Storm

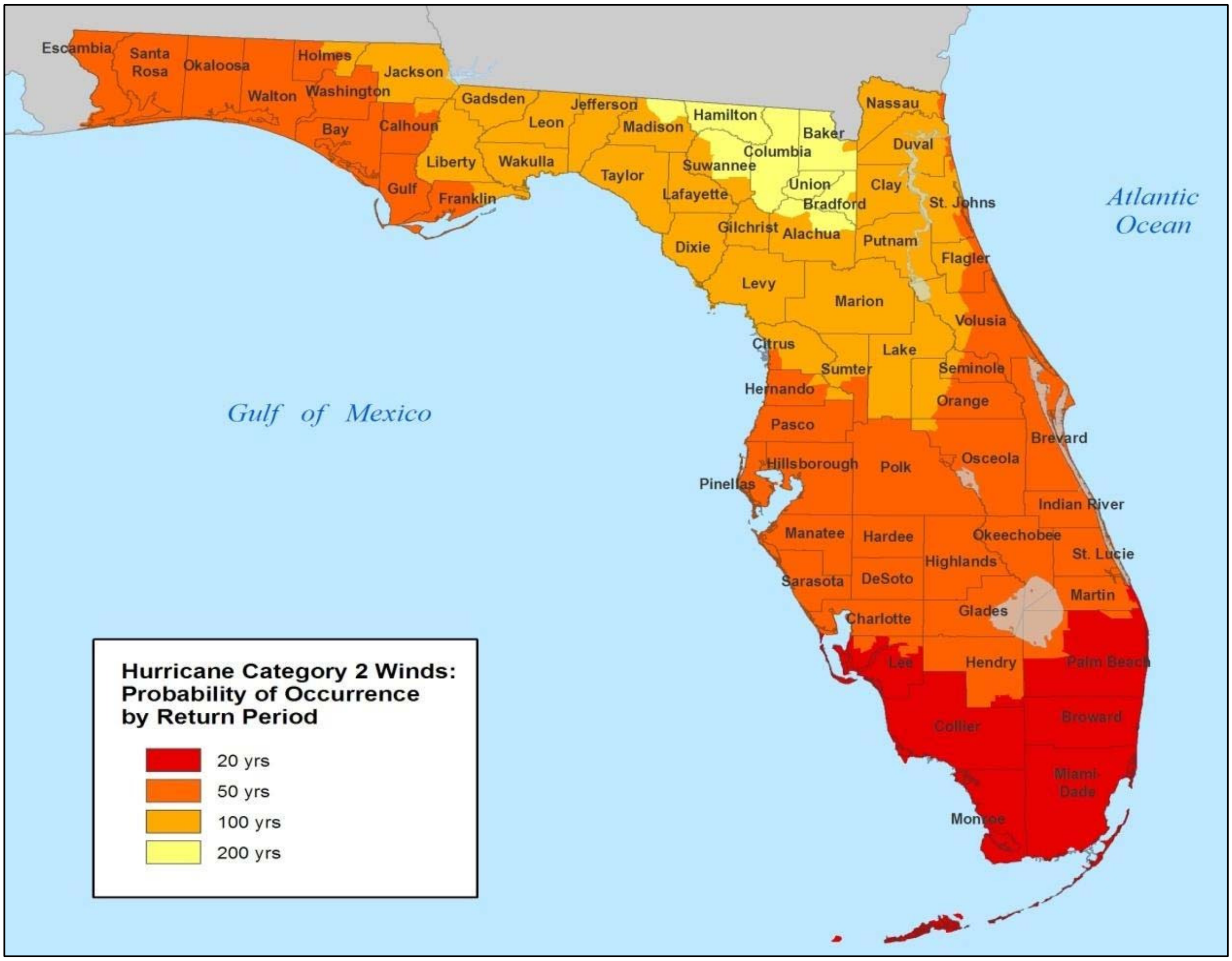
Likely – Given the 17 hurricane and tropical storm occurrences recorded by the NCDC over a period of 14 years (1998 - 2012), 1.2 hurricanes or tropical storm events affect Collier County on average each year. According to a vulnerability analysis completed for the State of Florida Hazard Mitigation Plan, Collier County is considered a high-risk jurisdiction as shown in Figure 4.19.



Source: State of Florida Enhanced Hazard Mitigation Plan

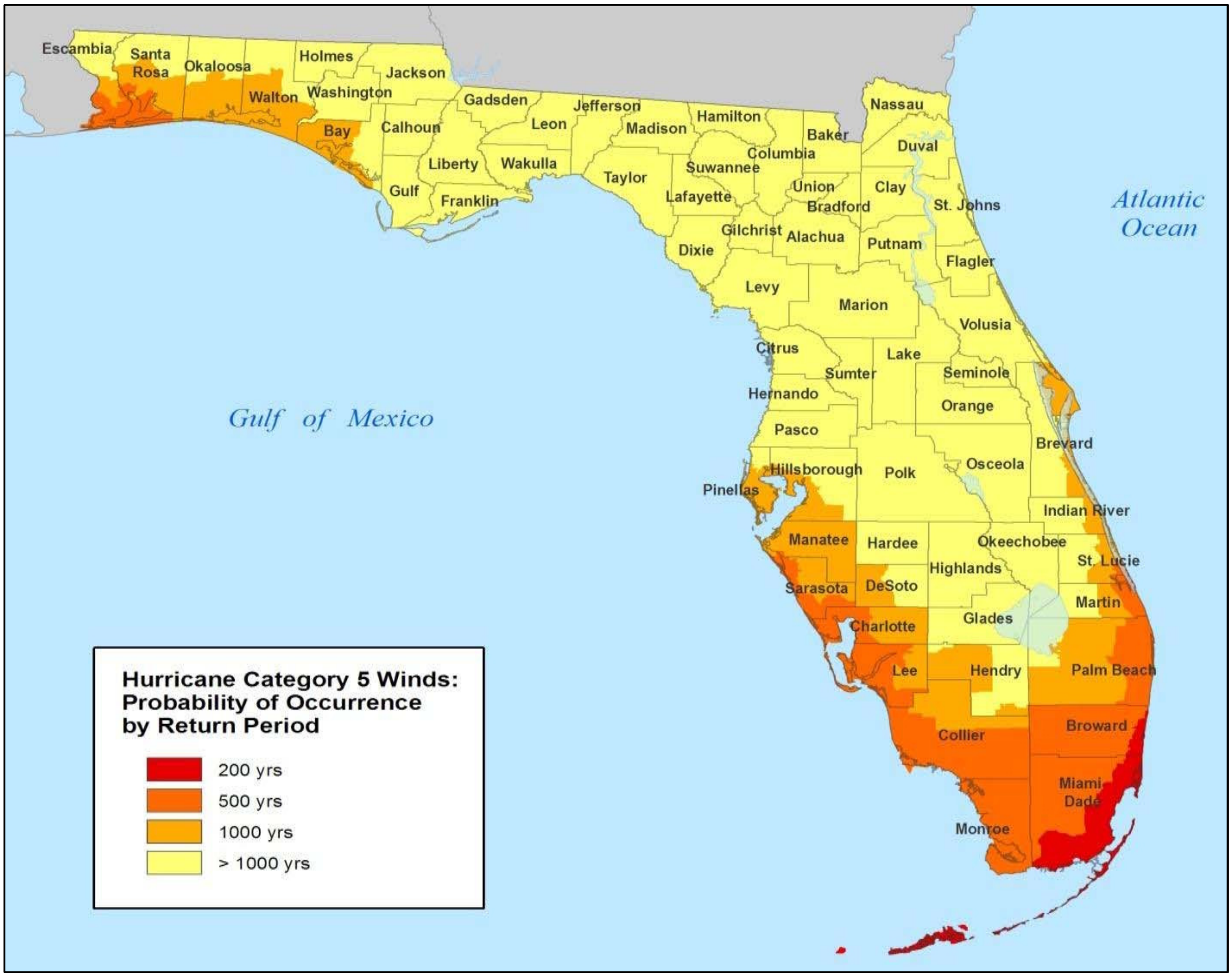
Figure 4.19 – Hurricane Hazard Ranking by County

Figure 4.20 contains a summary of the probability of occurrence that each county has based on geographic location for a return period of 20, 50, 100 or 200 years for a Category 2 hurricane; Collier County has a probability of experiencing a Category 2 hurricane at least once every 20 years. Figure 4.21 contains a summary of the probability of occurrence that each county has based on geographic location for a return period of 200, 500, 1,000 or greater than 1,000 years for a Category 5 hurricane; Collier County has a probability of experiencing a Category 5 hurricane at least once every 500-1,000 years.



Source: State of Florida Enhanced Hazard Mitigation Plan

Figure 4.20 - Hurricane Category 2 Probability of Occurrence



Source: State of Florida Enhanced Hazard Mitigation Plan

Figure 4.21 - Hurricane Category 5 Probability of Occurrence

Coastal Storm Surge

Likely – Given the 3 storm surge occurrences recorded by the NCDC over a period of seven years (2005-2012), 0.4 coastal storm surge events affect Collier County on average each year.

Climate Change and Hurricane and Tropical Storms

One of the primary factors contributing to the origin and growth of tropical storm and hurricanes systems is water temperature. Sea surface temperature may increase significantly in the main hurricane development region of the North Atlantic during the next century as well as in the Gulf of Mexico.

Sea level change will be particularly important in influencing storm surge flooding in the Collier County area, since the area is already is subject to flooding from above normal tides, surge and rainfall events from hurricanes and less powerful tropical storms. As a result of sea-level rise, flooding from just high tide events is becoming more common.

4.2.7 Flood Hazards Profile Summary

Table 4.20 summarizes the results of the hazard profile for Collier County based on hazard identification data and input from the FMPC. For each hazard profiled within Section 4.2, this table includes the likelihood of future occurrence and whether or not the hazard is considered a priority for the County.

Table 4.20 Summary of Flood Hazard Profile Results

Hazard	Likelihood of Future Occurrence	Priority Hazard
Climate Change and Sea Level Rise	Highly Likely	Y
Coastal/Canal Bank Erosion	Highly Likely	Y
Dam/Levee Failure	Unlikely	N
Flood: 100-/500-year	Occasional	Y
Flood: Stormwater/Localized Flooding	Highly Likely	Y
Hurricane and Tropical Storms (including Storm Surge)	Likely	Y