This information is included in Section 6 Mitigation Strategy. Additional documentation on the process the FMPC used to develop the goals and strategy has been included in Appendix B.

2.2.3.2 Planning Step 8: Draft an Action Plan

A complete first draft of the plan was prepared based on input from the FMPC regarding the draft risk assessment and the goals and activities identified in Planning Steps 6 and 7. This complete draft was posted for FMPC and public review and comment on the County's website. Other agencies were invited to comment on this draft as well. FMPC, public and agency comments were integrated into the final draft for the FDEM and FEMA Region IV to review and approve, contingent upon final adoption by Orange County.

2.2.4 Phase IV – Plan Maintenance

2.2.4.1 Planning Step 9: Adopt the Plan

To secure buy-in and officially implement the plan, the plan will be reviewed and adopted by the Board of County Commissioners. An example resolution is shown in Section 7 Plan Adoption.

2.2.4.2 Planning Step 10: Implement, Evaluate and Revise the Plan

Implementation and maintenance of the plan is critical to the overall success of hazard mitigation planning. Up to this point in the planning process, all of the FMPC's efforts have been directed at researching data, coordinating input from participating entities, and developing appropriate mitigation actions. Section 8 Plan Implementation and Maintenance provides an overview of the overall strategy for plan implementation and maintenance and outlines the method and schedule for monitoring, updating, and evaluating the plan. The Section also discusses incorporating the plan into existing planning mechanisms and how to address continued public involvement.

3 Hazard Identification

44 CFR Subsection D §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.

Chapter 3 identifies the flood hazards that may affect Orange County. This chapter also describes the Risk Assessment process, including how the FMPC met the following steps from the 10-step planning process:

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

As defined by FEMA, risk 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." Risk is a combination of hazard, vulnerability, and exposure.

This flood risk assessment covers the entire geographical area of the unincorporated areas of Orange 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 the community's potential risk to flood 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:

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

- **Chapter 3: Hazard Identification** identifies the flood hazards that threaten the planning area.
- **Chapter 4**: **Flood Risk & Vulnerability Assessment** summarizes the risk assessment methodology, presents the asset inventory, and profiles each hazard with a discussion of the threat to the planning area, a description of previous occurrences of hazard events, an estimate of the probability of future occurrences, and an analysis of vulnerability to each hazard considering assets at risk, critical facilities and infrastructure, and future development trends.

Starting with the hazards identified in the 2017 Orange County Floodplain Management Plan (FMP) and using existing flood hazard data and input gained through planning and public meetings, the FMPC determined an agreed upon list of flood hazards that could affect Orange County. The flood hazards identified in the 2017 FMP are listed in Table 3.1, which notes whether these hazards were included in the 2018 State of Florida Hazard Mitigation Plan or the 2021 Orange County Local Mitigation Strategy to support alignment with other relevant hazard mitigation planning efforts.

Table 3.1 – Hazard Profile Summary

Hazard	Included in 2018 State HMP	Included in 2021 Orange County LMS
Climate Change	Discussed with Flood	
Channel Bank Erosion	✓	
Dam/Levee Failure	Discussed with Flood	
Flood: 100-/500-year	✓	✓
Hurricane and Tropical Storm	✓	✓
Stormwater/Localized Flooding		Discussed with Flood

All hazards included in the 2017 FMP were re-evaluated for this plan update. Flood hazard data from the 2021 Orange County Local Mitigation Strategy (LMS), 2018 State of Florida Hazard Mitigation Plan, FEMA, the Florida Division of Emergency Management (FDEM), the National Oceanic and Atmospheric Administration (NOAA), 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, including deaths and injuries as well as property damage and economic losses.

To better reflect the nature of the riverine and flash flood hazard including the varying magnitudes of occurrence, "Flood: 100-/500-year" was renamed "Flood: Riverine and Flash" for this plan update.

In keeping with the 2017 FMP, the FMPC maintained that tsunami is not a prevalent hazard and did not warrant inclusion in this plan update. Following is a brief description of the hazard and the reason for its exclusion.

- **Tsunami** – 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. The Atlantic Ocean and the Florida coastline do not contain large fault lines like those found in the Pacific, and as such, the possibility of a tsunami on the East Coast is remote. Underwater landslides pose the greatest potential for causing tsunamis on the East Coast, but these events are extremely rare. Despite a history of earthquakes and subsequent tsunamis in the Caribbean region, the Florida coastline has gone largely unaffected by tsunamis. Moreover, Orange County is far enough inland that it is extremely unlikely a tsunami would affect the County if it did strike the Florida coast.

3.1 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 Orange County in order to identify and update known flood hazards. Table 3.2 displays flood related major disaster declarations that the state of Florida has received since 1960. This table reflects the vulnerability and historic patterns of flood hazards for Florida.

Table 3.2 – FEMA Major Disaster Declarations for Florida, 1960–2022

Hazard Type	Disaster #	Date
Severe Weather	*97*	*3/23/1960*
Hurricane Donna	*106*	*9/12/1960*
Abnormally High Tides	*141*	*12/17/1962*
Hurricane Cleo	*175*	*9/8/1964*
Hurricane Dora	*176*	*9/10/1964*
Hurricane Betsy	209	9/14/1965
Hurricane Gladys	252	11/7/1968
Heavy Rains, Flooding	289	7/3/1970
Tropical Storm Agnes	337	6/23/1972
Severe Storms, Flooding	387	5/26/1973
Flooding	479	8/22/1975
High Winds, Heavy Rains, Flooding	484	9/26/1975
Severe Winter Weather	526	1/31/1977
Severe Storms, Tornadoes, Flooding	586	5/15/1979
Hurricane Frederic	600	9/13/1979
Severe storms, flooding	607	9/29/1979
Severe storms, flooding	664	7/7/1982

Hazard Type	Disaster #	Date
Hurricane Elena	743	9/12/1985
Hurricane Kate	756	12/3/1985
Flooding, Severe Storm	862	4/3/1990
Flooding, Severe Storm	952	8/14/1992
Hurricane Andrew	955	8/24/1992
Flooding, Severe Storm, Tornadoes	966	10/8/1992
Tornadoes, Flooding, High Winds, Tides, Freezing	982	3/13/1993
Severe Storm, Flooding, Tropical Storm Alberto	1035	7/10/1994
Tropical Storm Gordon, Heavy Rain, Tornadoes, Flooding	1043	11/28/1994
Hurricane Erin	*1062*	*8/10/1995*
Hurricane Opal	1069	10/4/1995
Severe Storm, Flooding	1074	10/27/1995
Severe Storms/Flooding	1141	10/15/1996
Severe Storms, High Winds, Tornadoes, and Flooding	**1195**	**01/06/1998**
Severe Thunderstorms, Tornadoes and Flooding	1204	2/12/1998
Hurricane Earl	1241	9/4/1998
Hurricane Georges	1249	9/28/1998
Tropical Storm Mitch	1259	11/6/1998
Hurricane Floyd	1300	9/22/1999
Hurricane Irene	**1306**[1]	**10/20/1999**
Tropical Storm	1344	10/3/2000
Heavy Rains And Flooding	1345	10/4/2000
Tropical Storm Allison	1381	6/17/2001
Tropical Storm Gabrielle	1393	9/28/2001
Severe Storms and Flooding	1481	7/29/2003
Hurricane Charley and Tropical Storm Bonnie	**1539**[1]	**8/13/2004**
Hurricane Frances	**1545**[1]	**9/4/2004**
Hurricane Ivan	**1551**[1]	**9/16/2004**
Hurricane Jeanne	**1561**[1]	**9/26/2004**
Hurricane Dennis	1595	7/10/2005
Hurricane Katrina	1602	8/28/2005
Hurricane Wilma	1609	10/24/2005
Severe Storms and Tornadoes	1679	2/3/2007
Severe Storms, Tornadoes, and Flooding	1680	2/8/2007
Tropical Storm Fay	**1785**[1]	**8/24/2008**
Hurricane Gustav	1806	10/27/2008
Severe Storms, Flooding, Tornadoes, and Straight-line Winds	1831	4/21/2009
Severe Storms, Flooding, Tornadoes, and Straight-line Winds	1840	5/27/2009
Tropical Storm Debby	4068	7/3/2012
Hurricane Isaac	4084	10/18/2012
Severe Storms and Flooding	4138	8/2/2013
Severe Storms, Tornadoes, Straight-line Winds, and Flooding	4177	5/6/2014
Hurricane Hermine	4280	9/28/2016
Hurricane Matthew	**4283**	**10/8/2016**
Hurricane Irma	**4337**	**9/10/2017**
Hurricane Michael	4399	10/11/2018
Hurricane Dorian	4468	10/21/2019
Hurricane Sally	4564	9/23/2020
Hurricane Ian	**4673**	**09/29/2022**
Hurricane Nicole	**4680**	**12/13/2022**

Source: FEMA; **bold text indicates the Disaster Declaration included Orange County**; *Italic text indicates a Statewide declaration.*

A review of the major disaster declarations for Florida indicates that Orange County was included in 11 of the flood-related federal disaster declarations between 1965, when declarations first named affected counties, and 2022. These disaster declarations are detailed in Table 3.3. Disasters prior to 1965 did not name affected counties but may have caused damages in Orange County. For example, Hurricane Donna in 1960 caused major flooding throughout Orange County.

Individual Assistance (IA) dollars provide money and services to people in presidentially declared disaster areas. Public Assistance (PA) dollars are made available for communities to quickly respond to and recover from major disasters. Total dollars obligated shown in Table 3.3 below is inclusive of all counties included in the disaster declaration.

Table 3.3 – FEMA Major Disaster Declarations including Orange County, 1977-2022

Hazard	Disaster #	Date	Received IA Declaration?	IA Dollars Obligated[1]	Received PA Declaration?	PA Dollars Obligated[1]
Severe Storms, High Winds, Tornados, and Flooding	DR-1195	01/06/1998	Yes	--	Yes	--
Hurricane Irene	DR-1306	10/20/1999	Yes	N/A	No	$106,549,390
Hurricane Charley and Tropical Storm Bonnie	DR-1539	08/13/2004	Yes	$208,970,754	Yes (PA-A & B)	$612,142,181
Hurricane Frances	DR-1545	09/04/2004	Yes	$411,862,738	Yes (PA-A & B)	$677,307,267
Hurricane Ivan	DR-1551	09/16/2004	Yes	$164,517,308	No	$695,151,280
Hurricane Jeanne	DR-1561	09/26/2004	Yes	$398,624,417	Yes (PA A-G)	$522,175,653
Tropical Storm Fay	DR-1785	08/24/2008	Yes	$19,216,130	No	$97,207,118
Hurricane Matthew	DR-4283	10/08/2016	No	--	Yes	$81,750,537
Hurricane Irma	DR-4337	09/10/2017	Yes	$695,625,385	Yes	Unknown
Hurricane Ian	DR-4673	9/29/2022	Yes	TBD	Yes	TBD
Hurricane Nicole	DR-4680	12/13/2022	No	--	Yes	TBD

Source: FEMA, FDEM
[1]Dollar values are for all Counties included in the disaster declaration and are not solely indicative of Orange County assistance.
N/A = no data available

3.2 Flood Event History

NOAA's National Centers for Environmental Information (NCEI) has been tracking flood-related severe weather since 1996. The NCEI Storm Events Database contains an archive of destructive storm or weather data and information which includes local, intense and damaging events. NCEI receives storm data from the National Weather Service (NWS), which compiles their information from a variety of sources, which include but are not limited to: county, state and federal emergency management officials, local law enforcement officials, SkyWarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry and the general public. The NCEI database contains 24 flood related events that occurred in Orange County between January 1996 and February 2022.

Table 3.4 summarizes these events.

Table 3.4 – NCEI Severe Weather Reports for Orange County, 1996-2022

Type	# of Events	Property Damage	Crop Damage	Deaths	Injuries
Flash Flood	3	$10,000	$0	0	0
Flood	5	$1,000	$0	0	0
Heavy Rain	11	$20,000,000	$0	0	0
Hurricane/Typhoon	1	$500,000	$0	0	0
Tropical Depression	2	$0	$0	0	0
Tropical Storm	2	$110,000,000	$0	0	0
Total:	**15**	**$130,511,000**	**$0**	**0**	**0**

Source: NCEI Storm Events Database
Note: Losses reflect totals for all impacted areas.

The NCEI data on hurricanes and tropical storms is incomplete, given that major disaster declarations and funding have been issued for seven hurricane and tropical storm events in Orange County. We can assume that other hazard types may also be missing data and therefore this information should not be taken as a comprehensive review of impacts on the County. However, the NCEI data does provide an approximation of the severity of individual storm impacts over this time period.

3.3 Hazard Identification Results

Based on preliminary review of disaster declaration history, flood event history, and discussion by the FMPC, the following hazards were identified for full risk and vulnerability analysis in this plan:

- Climate Change
- Channel Bank Erosion
- Dam/Levee Failure
- Flood: Riverine and Flash
- Hurricane and Tropical Storm
- Stormwater/Localized Flooding

4 Flood Risk & Vulnerability Assessment

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

44 CFR Subsection D §201.6(c)(2)(ii): [The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description must include an overall summary of each hazard and its impact on the community. Plans approved after October 1, 2008 must also address NFIP insured structures that have been repetitively damaged by floods. The plan should describe vulnerability in terms of:

A) The types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard areas;

(B): An estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(ii)(A) of this section and a description of the methodology used to prepare the estimate; and

(C): Providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

The hazards identified in Chapter 3 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.

4.1 Risk Assessment Methodology

Each hazard is profiled in the following format:

Hazard Description

This section provides a description of the hazard followed by details specific to the Orange 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.

Location

This section describes or visualizes where the hazard may occur within the planning area.

Extent

This section provides information on the magnitude of the hazard and describes how the severity of the hazard can be measured.

Past Occurrences

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

Probability 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 11 and 99 percent chance of occurrence within the next year (recurrence interval of 10 years or less)
- ***Possible*** – 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).

Climate Change and Future Conditions

This section discusses the potential impacts of any changes in future conditions, including climate change, future development, or other changes.

Priority Risk Index

The findings from the above sections of the hazard profiles are summarized using the Priority Risk Index (PRI) to score and rank each hazard's significance to the planning area. The PRI provides a standardized numerical value so that hazards can be compared against one another (the higher the PRI value, the greater the hazard risk). PRI values are obtained by assigning varying degrees of risk in five categories (probability, impact, spatial extent, warning time, and duration). Each degree of risk is assigned a value (1 to 4) and a weighting factor as summarized in

Table 4.1 on the following page.

The sum of all five risk assessment categories equals the final PRI value, demonstrated in the equation below (the lowest possible PRI value is a 1.0 and the highest possible PRI value is 4.0).

PRI = [(Probability x .30) + (Impact x .30) + (Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]

The purpose of the PRI is to categorize and prioritize all potential hazards for planning area as high, moderate, or low risk. While all hazards were considered when developing mitigation action alternatives, those hazards determined to have a high or moderate risk rating were emphasized in the prioritization of selected actions. This process and these criteria allowed the FMPC to focus on the hazards of greatest significance for the identification and implementation of mitigation actions.

PRI levels are provided by category in a table at the beginning of each hazard profile. A summary of the resulting PRI score for each hazard is provided in Section 4.4.1.

Table 4.1 – Priority Risk Index

RISK ASSESSMENT	LEVEL	DEGREE OF RISK CRITERIA	INDEX	WEIGHT
PROBABILITY What is the likelihood of a hazard event occurring in a given year?	UNLIKELY	LESS THAN 1% ANNUAL PROBABILITY	1	30%
	POSSIBLE	BETWEEN 1 & 10% ANNUAL PROBABILITY	2	
	LIKELY	BETWEEN 10 &100% ANNUAL PROBABILITY	3	
	HIGHLY LIKELY	100% ANNUAL PROBABILTY	4	
IMPACT In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?	MINOR	VERY FEW INJURIES, IF ANY. ONLY MINOR PROPERTY DAMAGE & MINIMAL DISRUPTION ON QUALITY OF LIFE. TEMPORARY SHUTDOWN OF CRITICAL FACILITIES.	1	30%
	LIMITED	MINOR INJURIES ONLY. MORE THAN 10% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR > 1 DAY	2	
	CRITICAL	MULTIPLE DEATHS/INJURIES POSSIBLE. MORE THAN 25% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR > 1 WEEK.	3	
	CATASTROPHIC	HIGH NUMBER OF DEATHS/INJURIES POSSIBLE. MORE THAN 50% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES > 30 DAYS.	4	
SPATIAL EXTENT How large of an area could be impacted by a hazard event? Are impacts localized or regional?	NEGLIGIBLE	LESS THAN 1% OF AREA AFFECTED	1	20%
	SMALL	BETWEEN 1 & 10% OF AREA AFFECTED	2	
	MODERATE	BETWEEN 10 & 50% OF AREA AFFECTED	3	
	LARGE	BETWEEN 50 & 100% OF AREA AFFECTED	4	
WARNING TIME Is there usually some lead time associated with the hazard event? Have warning measures been implemented?	MORE THAN 24 HRS	SELF DEFINED	1	10%
	12 TO 24 HRS	SELF DEFINED	2	
	6 TO 12 HRS	SELF DEFINED	3	
	LESS THAN 6 HRS	SELF DEFINED	4	
DURATION How long does the hazard event usually last?	LESS THAN 6 HRS	SELF DEFINED	1	10%
	LESS THAN 24 HRS	SELF DEFINED	2	
	LESS THAN 1 WEEK	SELF DEFINED	3	
	MORE THAN 1 WEEK	SELF DEFINED	4	

Vulnerability Assessment

The FMPC conducted a vulnerability assessment of the priority hazards in order to assess the impact that each hazard would have on the County. The vulnerability assessment quantifies, to the extent feasible using best available data, assets at risk to natural hazards and estimates potential losses.

Vulnerability assessments followed the methodology described in the FEMA publication *Understanding Your Risks—Identifying Hazards and Estimating Losses* (August 2001). Total exposure and values at risk are summarized in the Asset Inventory in Section 4.2. An evaluation of vulnerability by hazard, based on this asset inventory, is provided in each relevant hazard profile, including a discussion of total vulnerability and values at risk, where possible.

Data used to support this assessment included the following:

- County GIS data (hazards, base layers, and assessor's data)
- Hazard layer GIS datasets from federal agencies
- Written descriptions of inventory and risks provided by the State Hazard Mitigation Plan
- Other existing plans and studies provided by the County

Two distinct risk assessment methodologies were used in the formation of this vulnerability assessment. The first consists of a quantitative analysis that relies upon best available data and technology, while the second approach consists of a qualitative analysis that relies on local knowledge and rational decision making. Vulnerability can be quantified in those instances where there is a known, identified hazard area, such as a mapped floodplain. In these instances, the numbers and types of buildings subject to the identified hazard can be counted and their values tabulated. Other information can be collected in regard to the hazard area, such as the location of critical facilities, historic structures, and valued natural resources (e.g., an identified wetland or endangered species habitat). Together, this information conveys the impact, or vulnerability, of that area to that hazard.

The quantitative analysis involved the use of the most recent version of Hazards U.S. Multi-Hazard (Hazus) software, a nationally applicable standardized set of models available from FEMA for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses a statistical approach and mathematical modeling of risk to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information. The Hazus risk assessment methodology is parametric, in that distinct hazard and inventory parameters—such as wind speed and building type—were modeled using the Hazus software to determine the impact on the built environment.

Vulnerability is summarized in general, qualitative terms and encompasses the exposure and potential impact based on past occurrences, spatial extent, and damage and casualty potential. It is categorized into the following classifications:

- **Extremely Low** – The occurrence and potential cost of damage to life and property is very minimal to non-existent.
- **Low** – Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.
- **Medium** – Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.
- **High** – Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have occurred in the past.
- **Extremely High** – Very widespread with catastrophic impact.

4.2 Asset Inventory

Using Orange County's 2022 parcel layer, an inventory of assets was compiled to estimate property exposure to the identified hazards. By understanding the type and number of assets that exist and their location relative to known hazard areas, the risk and vulnerability for such assets can be assessed.

4.2.1 Properties at Risk

Building exposure counts by FEMA flood zone were determined using a spatial intersection of the parcel layer provided by Orange County, Microsoft building footprint data, and the effective FEMA flood zones provided in the Orange County DFIRM database effective September 24, 2021. Building values are based on 2022 Orange County tax assessor data. Accessory buildings were estimated at those 600 square feet or less and were excluded from the inventory. Table 4.2 summarizes the overall property inventory by occupancy type for all property in unincorporated Orange County. Table 4.3 summarizes the property inventory by occupancy and flood zone.

Table 4.2 – Properties Exposure by Occupancy Type

Occupancy Type	Building Count	Structure Value	Estimated Content Value	Total Value
Agriculture	759	$37,936,146	$37,936,146	$75,872,291
Commercial	2,030	$3,393,984,581	$3,393,984,581	$6,787,969,162
Education	158	$178,525,294	$178,525,294	$357,050,588
Government	2,326	$6,304,027,212	$6,304,027,212	$12,608,054,424
Industrial	3,163	$4,414,776,628	$6,622,164,942	$11,036,941,569
Religion/Non-Profit	989	$553,164,665	$553,164,665	$1,106,329,330
Residential	250,708	$71,894,728,438	$35,947,364,219	$107,842,092,657
Total	**260,133**	**$86,777,142,963**	**$53,037,167,058**	**$139,814,310,021**

Source: Orange County 2022 Parcel Data, Microsoft building footprints, FEMA 2021 DFIRM

Table 4.3 – Properties at Exposure by Flood Zone and Occupancy Type

Occupancy Type	Total Number of Buildings	Total Building Value	Estimated Content Value	Total Value
Zone A				
Agricultural	200	$7,194,157	$7,194,157	$14,388,313
Commercial	87	$292,650,921	$292,650,921	$585,301,841
Education	24	$54,181,792	$54,181,792	$108,363,584
Government	863	$2,320,672,126	$2,320,672,126	$4,641,344,251
Industrial	292	$345,810,200	$518,715,301	$864,525,501
Religion/Non-Profit	98	$94,357,439	$94,357,439	$188,714,879
Residential	15,404	$5,774,693,729	$2,887,346,864	$8,662,040,593
Total	**16,968**	**$8,889,560,363**	**$6,175,118,599**	**$15,064,678,962**
Zone AE				
Agricultural	52	$4,786,263	$4,786,263	$9,572,527
Commercial	120	$629,283,644	$629,283,644	$1,258,567,287
Education	38	$59,946,528	$59,946,528	$119,893,056
Government	358	$918,833,841	$918,833,841	$1,837,667,682
Industrial	447	$886,137,702	$1,329,206,553	$2,215,344,254
Religion/Non-Profit	148	$80,960,301	$80,960,301	$161,920,603
Residential	20,845	$10,650,531,219	$5,325,265,610	$15,975,796,829
Total	**22,008**	**$13,230,479,499**	**$8,348,282,740**	**$21,578,762,238**

Occupancy Type	Total Number of Buildings	Total Building Value	Estimated Content Value	Total Value
Zone AH				
Agricultural	0	$0	$0	$0
Commercial	0	$0	$0	$0
Education	0	$0	$0	$0
Government	1	$26,298	$26,298	$52,596
Industrial	0	$0	$0	$0
Religion/Non-Profit	0	$0	$0	$0
Residential	2	$639,129	$319,565	$958,694
Total	**3**	**$665,427**	**$345,863**	**$1,011,290**
Zone D				
Agricultural	0	$0	$0	$0
Commercial	11	$50,101,571	$50,101,571	$100,203,142
Education	0	$0	$0	$0
Government	0	$0	$0	$0
Industrial	0	$0	$0	$0
Religion/Non-Profit	0	$0	$0	$0
Residential	2	$595,599	$297,800	$893,399
Total	**13**	**$50,697,170**	**$50,399,371**	**$101,096,541**
Zone X Shaded				
Agricultural	0	$0	$0	$0
Commercial	6	$4,964,686	$4,964,686	$9,929,372
Education	0	$0	$0	$0
Government	1	$921,894	$921,894	$1,843,788
Industrial	3	$88,681,535	$133,022,303	$221,703,838
Religion/Non-Profit	5	$657,371	$657,371	$1,314,742
Residential	1,481	$351,984,666	$175,992,333	$527,976,999
Total	**1,496**	**$447,210,152**	**$315,558,587**	**$762,768,739**
Zone X Unshaded				
Agricultural	507	$25,955,726	$25,955,726	$51,911,451
Commercial	1,819	$2,475,672,003	$2,475,672,003	$4,951,344,005
Education	96	$64,396,974	$64,396,974	$128,793,948
Government	1,092	$3,041,676,458	$3,041,676,458	$6,083,352,915
Industrial	2,421	$3,094,776,040	$4,642,164,059	$7,736,940,099
Religion/Non-Profit	738	$377,189,553	$377,189,553	$754,379,106
Residential	212,972	$59,737,111,531	$29,868,555,765	$89,605,667,296
Total	**219,645**	**$68,816,778,284**	**$40,495,610,538**	**$109,312,388,822**

Source: Orange County 2022 Parcel Data, Microsoft building footprints, FEMA 2021 DFIRM

Note: Content value estimations are based on the FEMA Hazus methodology of estimating value as a percent of improved structure values by property type. The residential property type assumes a content replacement value equal to 50% of the building value. Agricultural, commercial, education, government, and religious property types assume a content replacement value equal to 100% of the building value. The industrial property type assumes a content replacement value equal to 150% of the building value.

4.2.2 Critical Facilities Inventory

Of significant concern with respect to any disaster event is the location of critical facilities and infrastructure in the planning area. Facilities and infrastructure are considered critical when they provide essential services and, if damaged, unusable, or unreachable during a hazard event, would result in adverse consequences to public health, safety, and welfare. Critical facilities were identified by the FMPC and are summarized by FEMA Lifeline category in Table 4.4 and are further refined by location relative to the mapped flood zones in Table 4.5. Critical facility and infrastructure locations are shown in Figure 5.1.

Table 4.4 – Critical Facilities by FEMA Lifeline Category

FEMA Lifeline Category	Count	Structure Value
Communications	18	$132,504,979
Energy (Power & Fuel)	1	$846,060
Food, Water, Shelter	34	$296,206,493
Hazardous Materials	22	$124,813,450
Health and Medical	34	$652,635,983
Safety and Security	39	$2,079,704,429
Transportation	0	$0
Total	**148**	**$3,286,711,394**

Source: Orange County

Table 4.5 – Critical Facilities by FEMA Lifeline Category and Flood Zone

FEMA Lifeline Category	Count
Zone AE	
Hazardous Material	1
Health and Medical	1
Zone A	
Health and Medical	2

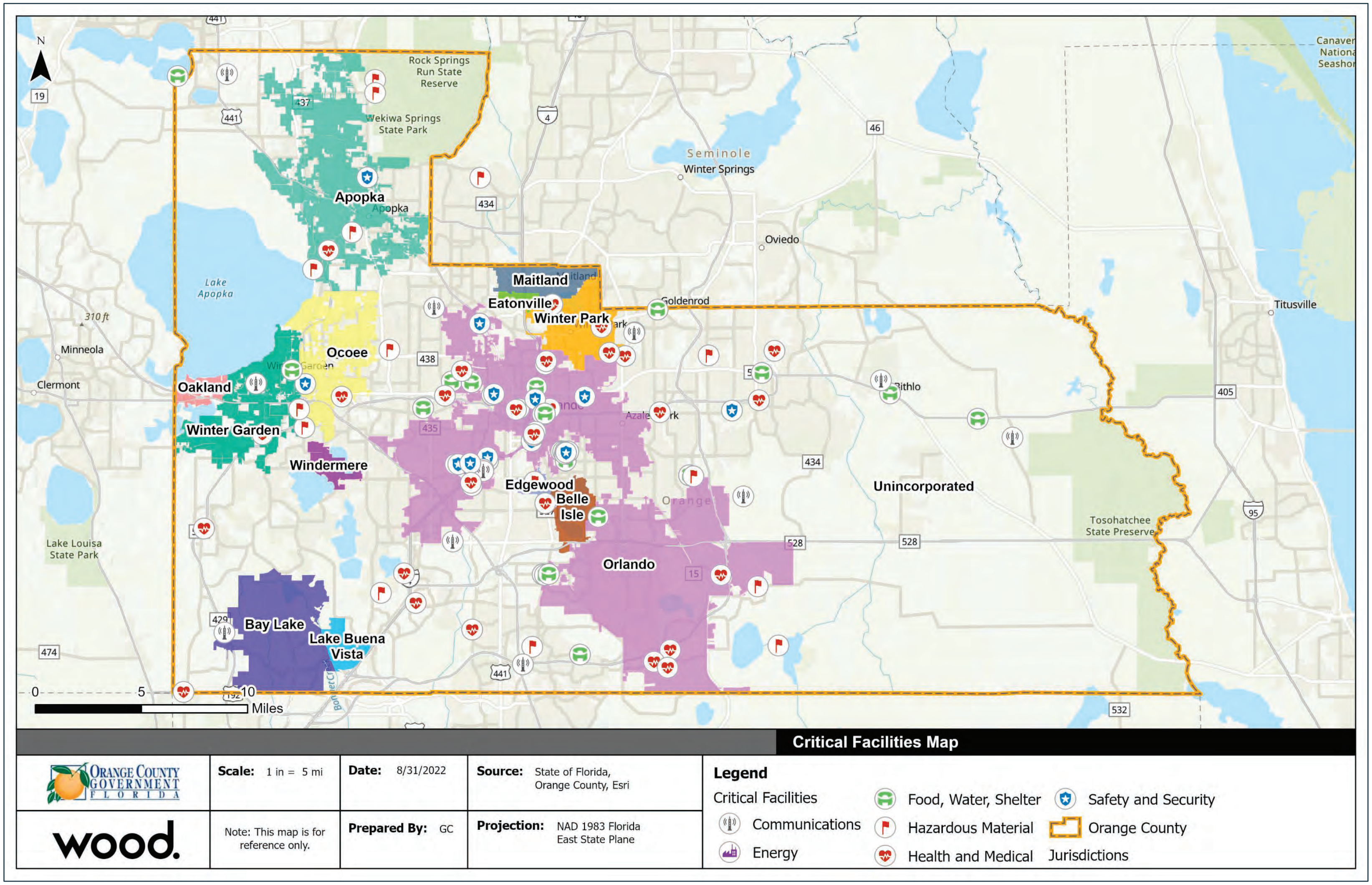
Source: Orange County; FEMA 2021 DFIRM

4.2.3 Planning for Critical Facility and Infrastructure Protection

The Orange County FMPC considered critical facility and infrastructure protection as a priority when evaluating vulnerability and considering mitigation alternatives. Deciding on protection for critical facilities depends on each facility type and its use before, during, and after a hazard event. The four critical facilities in high-risk flood zones are the Blanchard Park Lift Station, University Behavioral Center, Orlando Health Randal Park, and an Animal Services building designated with Emergency Support Function #17. The lift station is essential to continued utility operations and sanitation. Animal Services would play an important role in post-event response. Medical buildings must maintain continued operations during floods to protect the health and safety of patients. Flood protection for all of these facilities is important, so that during and after a flood event they can continue operation without interruption.

The County should work with facility operators to ensure that mechanical and electrical equipment is floodproofed or elevated and that multiple backup power systems are in place to ensure resilience to flooding. Though evacuation is not ideal, the medical buildings should also have emergency procedures, including evacuation plans, to be prepared for the worst-case scenario.

Figure 4.1 – Orange County Critical Facilities



4.3 Hazard Profiles, Analysis, and Vulnerability

4.3.1 Climate Change

Probability	Impact	Spatial Extent	Warning Time	Duration
Highly Likely	Limited	Large	> 24 hours	> 1 week

Hazard Description

Climate change refers to long-term shifts in temperature and weather patterns. Climate change can be due to natural internal processes or external forces 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). However, the recent and rapid warming of the earth that has been observed over the past century has been cause for concern, as this warming is due to the accumulation of human-caused greenhouse gases, such as CO_2, in the atmosphere (IPCC, 2007). Global average temperature is estimated to have increased by about 1 degree Celsius since the pre-industrial period, and it is currently increasing by about 0.2 degrees Celsius per decade. This global increase in temperatures is having broad range of effects on global, regional and local climates. According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate or adapt to change.

Climate change has the potential to alter the intensity and frequency of flood-related hazards that the County already experiences such as hurricanes, heavy rainfall, and erosion. The potential for climate change influences on each flood hazard evaluated in this plan is noted within each hazard's "Climate Change and Future Conditions" discussion section.

Location

Climate change affects large-scale weather and climate patterns and as such, will impact all of Orange County.

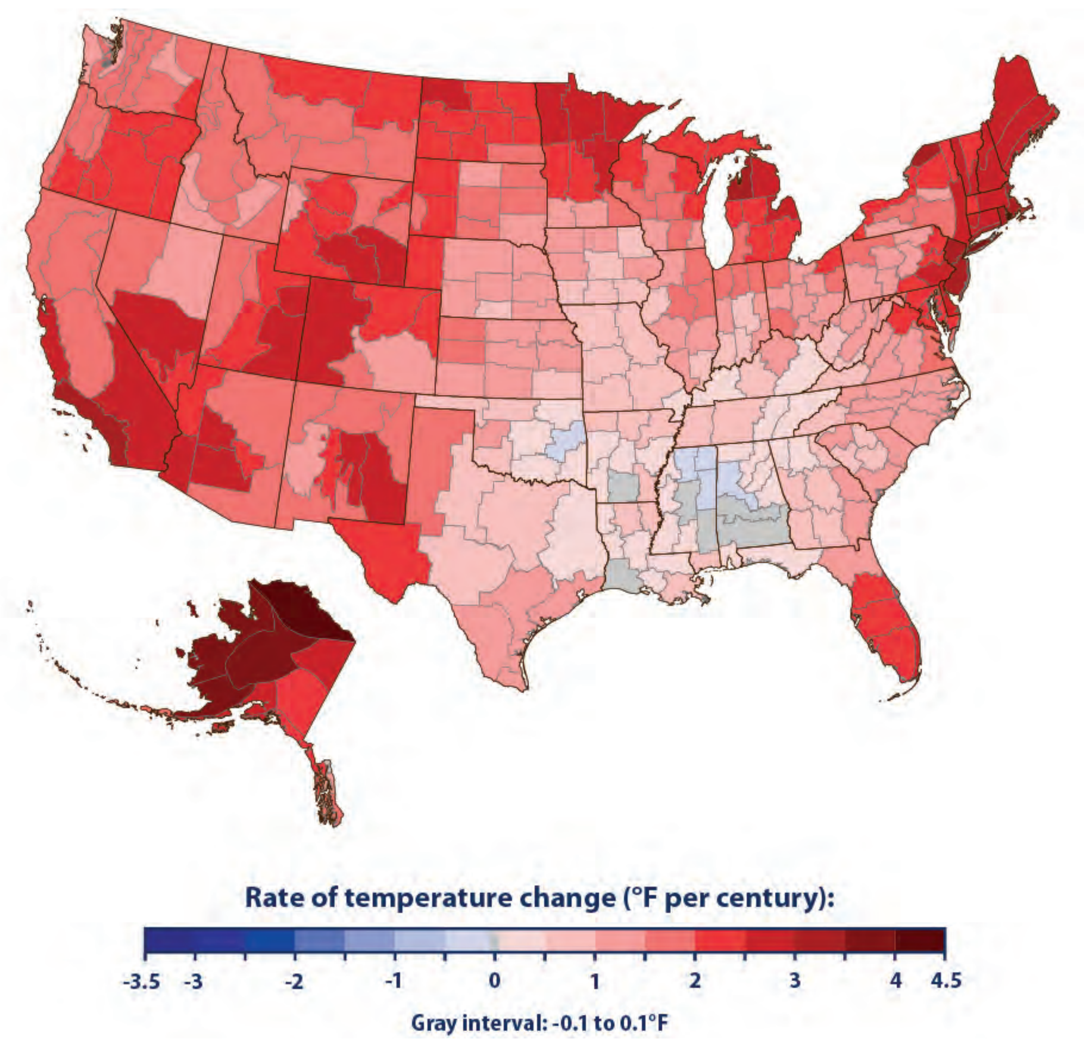
Extent

The extent of climate change depends on greenhouse gas emissions and the degree to which these emissions are limited. Many projections for climate change provide a range of potential future conditions based on varying emissions scenarios. Generally speaking, under higher emissions scenarios changes are more severe than under lower emissions scenarios.

Past Occurrences

Climate change is an ongoing process, and it is difficult to tie it to any individual weather event. However, some changes and trends related to climate change have already been observed. Since 1901, the average surface temperature across central Florida has risen at a rate of 2 to 2.5 degrees Fahrenheit per century or 0.2 degrees per decade. Figure 4.2 on the following page shows how annual average air temperatures have changed across the United States since 1901. Average temperatures have risen more quickly since the late 1970s (0.36 to 0.55°F per decade). According to NOAA, the years 2013 through 2021 all rank within the ten warmest years on record.

Figure 4.2 – Temperature Change in the United States, 1901-2020



Source: US EPA Climate Change Indicators; NOAA, 2021

In addition to changes in average temperature, climate change is also causing changes in precipitation patterns. On average, total precipitation has increased across the United States, although there is significant regional variability in these changes. As shown in Figure 4.3, there is no statistically significant trend in average precipitation in central Florida. However, as shown in Figure 4.4, since 1995 five-year averages of extreme precipitation events have been at or above average. Similarly, according to the Fourth National Climate Assessment, there has been a significant increase in observed heavy precipitation across the Southeast.

Figure 4.3 – Observed Total Annual Precipitation (1900-2020)

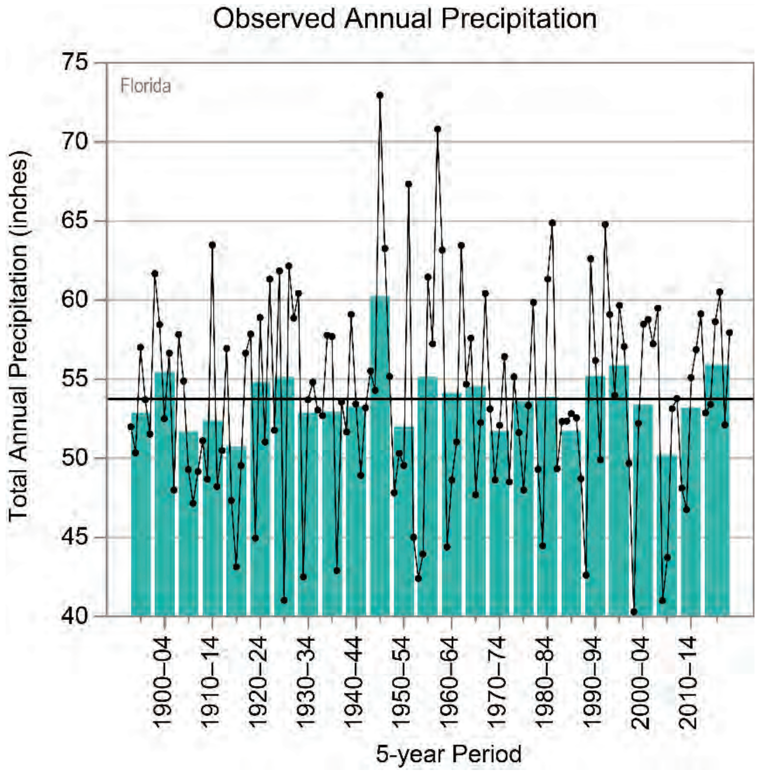
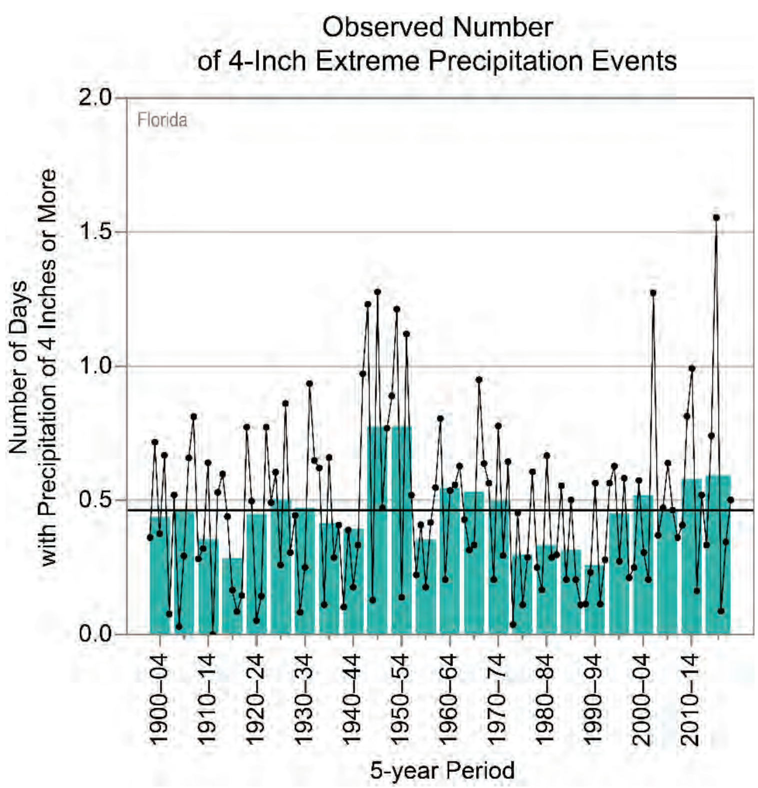


Figure 4.4 – Observed Number of Days with Extreme Precipitation (1900-2020)



Source: NOAA

These precipitation observations mean that while overall annual precipitation amounts may not be changing, rainfall events are generally more extreme when they do occur. For example, from 1901 to 2016, the Southeast experienced a 27 percent increase in the amount of precipitation falling in daily events that exceed the 99th percentile of all non-zero precipitation days and a 58 percent increase in the number of two-day events with a precipitation total exceeding the largest 2-day amount expected to occur on average only once every five years.

Climate change is also expected to cause changes in the frequency and intensity of hurricane and tropical storm events. According to NOAA, while the record of past hurricane events in Florida is highly variable, and overall annual frequency has remained stable, an increase in hurricane rainfall is expected for Florida as the climate continues to warm.

Probability of Future Occurrence

Highly Likely – Under current climate change models, changes in global temperatures, hydrologic cycles, and storm frequency and intensity are expected to continue. Projections in the Fourth National Climate Assessment indicate that the Southeast United States could experience a general increase in average temperatures anywhere from 3.4°F to 4.3°F by mid-century (2036-2065) and up to 7.7°F by late century (2071-2100). Under all emissions scenarios, trends in extreme precipitation are expected to continue. With continued high emissions, extreme precipitation events are expected to increase by two to three times the historical average. By mid-century, daily 20-year extreme precipitation is expected to increase by 9 percent under lower emissions scenarios and by 12 percent under higher emissions scenarios. By late-century, that increase is projected to grow to 13 percent and 21 percent, respectively. Rainfall rates from tropical cyclones are also expected to increase by anywhere from 8 to 17 percent according to the Fourth National Climate Assessment.

Rainfall may also increase because of increased hurricane activity, however, the impacts of climate change on hurricanes are still not fully understood. The overall number of hurricanes is projected to decline slightly, but the number of strong storms (Category 4 and 5) is expected to increase. Additionally, hurricane precipitation rates are expected to increase by up to 17%.

Vulnerability Assessment

Medium – Orange County is vulnerable to the potential impacts of climate change, though due to its location inland, is safe from the impacts of sea level rise. Climate-driven hazards such as hurricanes and flooding are likely to increase in intensity, and possibly frequency, in the future. Thus the 25-year flood of today may become the 10-year event in the future. In general, the potential impacts of climate change include increased flooding frequency, potential damage to critical infrastructure, and increasing public costs associated with flood insurance claims, infrastructure repair and maintenance, environmental impacts and increased costs associated with emergency management efforts. Hazard mitigation efforts to address climate change should include property protection strategies to reduce exposure to flooding and public outreach strategies to increase awareness of the likelihood of increased future risk.

Refer to the vulnerability assessments in Sections 4.3.4, 4.3.5, and 4.3.6 for the current exposure and risk to these hazards with the perspective that climate change has the potential to exacerbate the existing risk and vulnerabilities. Each hazard profile in this plan also has a "Climate Change and Future Conditions" section which discussed potential impacts of climate change on the magnitude and probability of each hazard.

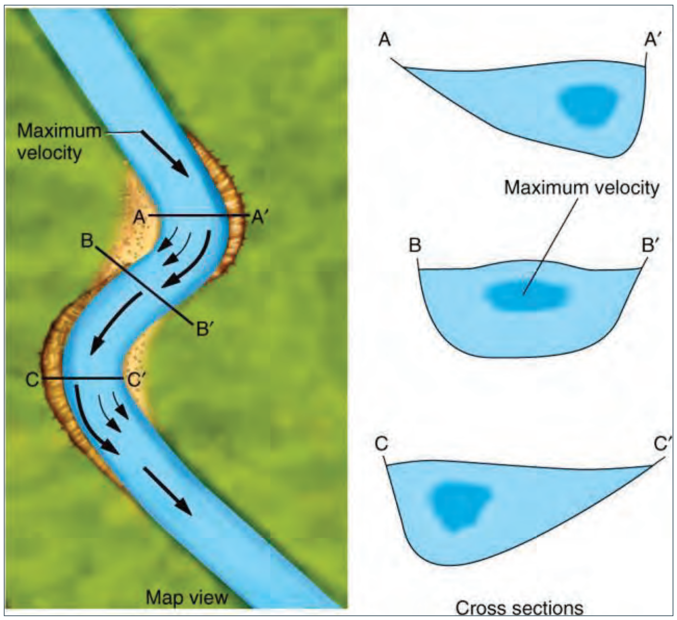
4.3.2 Channel Bank Erosion

Probability	Impact	Spatial Extent	Warning Time	Duration
Likely	Minor	Negligible	> 24 hours	> 1 week

Hazard Description

Streams and canals erode by a combination of direct stream processes, such as down cutting and lateral erosion, and indirect processes, such as mass-wasting accompanied by sediment transportation. When a 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 4.5. This distribution of velocity results in erosion occurring on the outside of the bend and deposition occurring on the inside of the bend.

Figure 4.5 – 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 flowering plants, 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 if appropriate erosion protection methods are not installed. Addressing the problem of streambank erosion requires an understanding of both stream dynamics and the management of streamside vegetation.

Although erosion is an ongoing process, the warning time for severe erosion events can be considered linked to warning time for heavy rains and storms. However, while these events are only temporary, the impacts of erosion are permanent.

Location

Erosion can occur anywhere along Orange County's rivers, streams, and other channels.

Extent

Erosion rates and potential impacts are highly localized and data is not available on the extent of past erosion. Erosion is generally an ongoing process, but severe storms and heavy rains can exacerbate erosion and may serve as an indicator of severity.

Past Occurrences

Orange County 2030 Comprehensive Plan notes historic problems with erosion of the banks of the Little Wekiva River, threatening nearby homes, roads, and bridges. No other specific streams or canals are mentioned as experiencing substantial erosion. However, the plan does indicate extensive urbanization and loss of natural floodplain around many canals and streams, which indicates the possibility for increased flows and thus increased erosion in these channels.

The State's Critical Erosion Report, included in the 2018 State Hazard Mitigation Plan, focuses on beach erosion and does not identify any areas of critical erosion within Orange County.

Probability of Future Occurrence

Likely – In addition to normal levels of erosion likely to occur, urbanization is placing an increasing burden on streams and canals by increasing runoff to these drainage systems. This, in turn, increases the potential volume and speed of flows in these channels. As a result, additional channel bank erosion is likely to occur.

Climate Change and Future Conditions

Current studies suggest climate change will result in more severe storms and more intense rainfalls. With larger amounts of rainfall in shorter amounts of time, canals and streams will experience greater flows at higher velocities, increasing the likelihood of erosion of their banks.

Vulnerability Assessment

Low – Data is not available to assess the degree to which Orange County assets may be impacted by channel bank erosion. However, given the limited extent of erosion and lack of notable damages in the past, vulnerability is considered low.

4.3.3 Dam/Levee Failure

Probability	Impact	Spatial Extent	Warning Time	Duration
Unlikely	Critical	Moderate	6 to 12 hours	< 1 week

Hazard 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 farmland, 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 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.

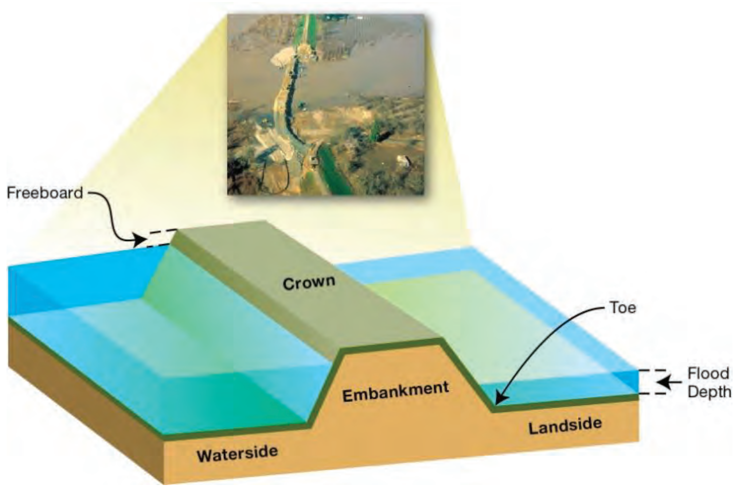
Dam failure can occur with little warning. Intense storms may produce flash flooding within a few hours or even minutes of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams or the accumulation of melting snow. The duration of the flood will vary but may last as long as a week.

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 4.6 below shows the components of a typical levee.

Figure 4.6 – Components of a Typical Levee



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

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.

Location

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. Low hazard or undetermined classification – dams equal or exceed 25 feet in height and exceed 15 acre-feet in storage; OR dams equal or exceed 50 acre-feet storage and exceed 6 feet in height

Low hazard dams that do not meet the criteria specified above 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 4.7 on the following page shows the location of all dams included in the NID that are located in Orange County. As shown, there are six dams located within the jurisdictional boundaries of Orange County, three of which are classified as high hazard. Table 4.6 provides details for the dams as provided in the NID.

Table 4.6 – National Inventory of Dams Listings in Orange County, FL

Dam Name	NID ID	Owner	Height (Ft.)	Storage (acre-feet)	Hazard	River
Michaels Dam	FL00160	Orange County	26	1,929	High	Little Econ River
Banner Dam	FL00161	Orange County	17	282	High	Little Econ River
Cheney Dam	FL00162	Orange County	29	31	High	Little Econ River
Control Structure 6	FL00163	Orange County	28	90	Low	Canal E-6
Control Structure 7	FL00164	Orange County	26	136	Low	Canal E-6
Structure 62	FL00165	SFWMD	19	56,000	Low	Ajay-Hart Canal (C-29A)

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

Figure 4.7 – National Inventory of Dams for Orange County

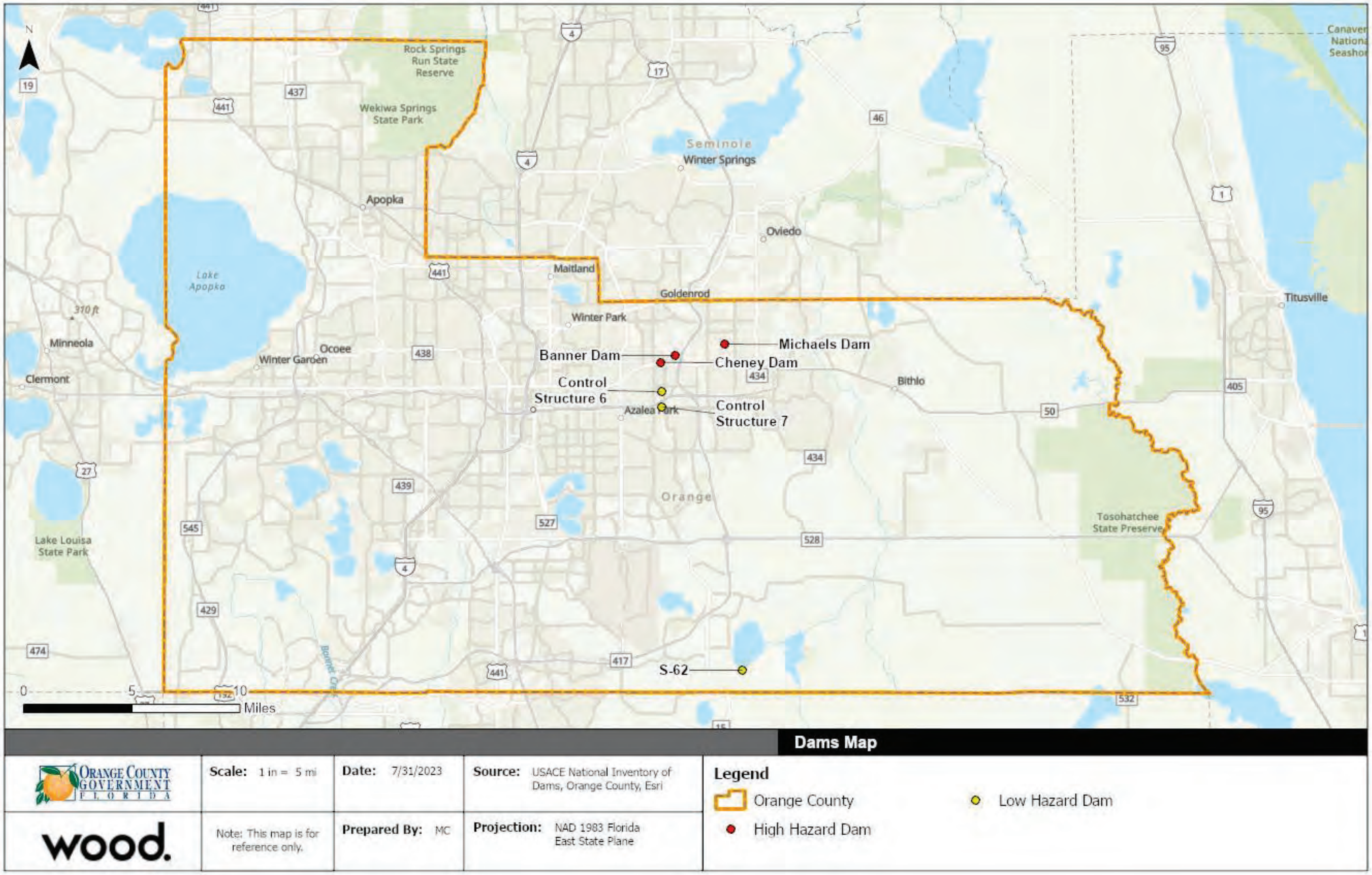


Figure 4.8 reflects the location of all levees included in the U.S. Army Corps of Engineers National Levee Database (NLD) that protect areas of Orange County. Table 4.7 below summarizes system details for these levees. A more detailed description of each levee from the USACE is provided below.

Table 4.7 – National Levee Database, Orange County Planning Area

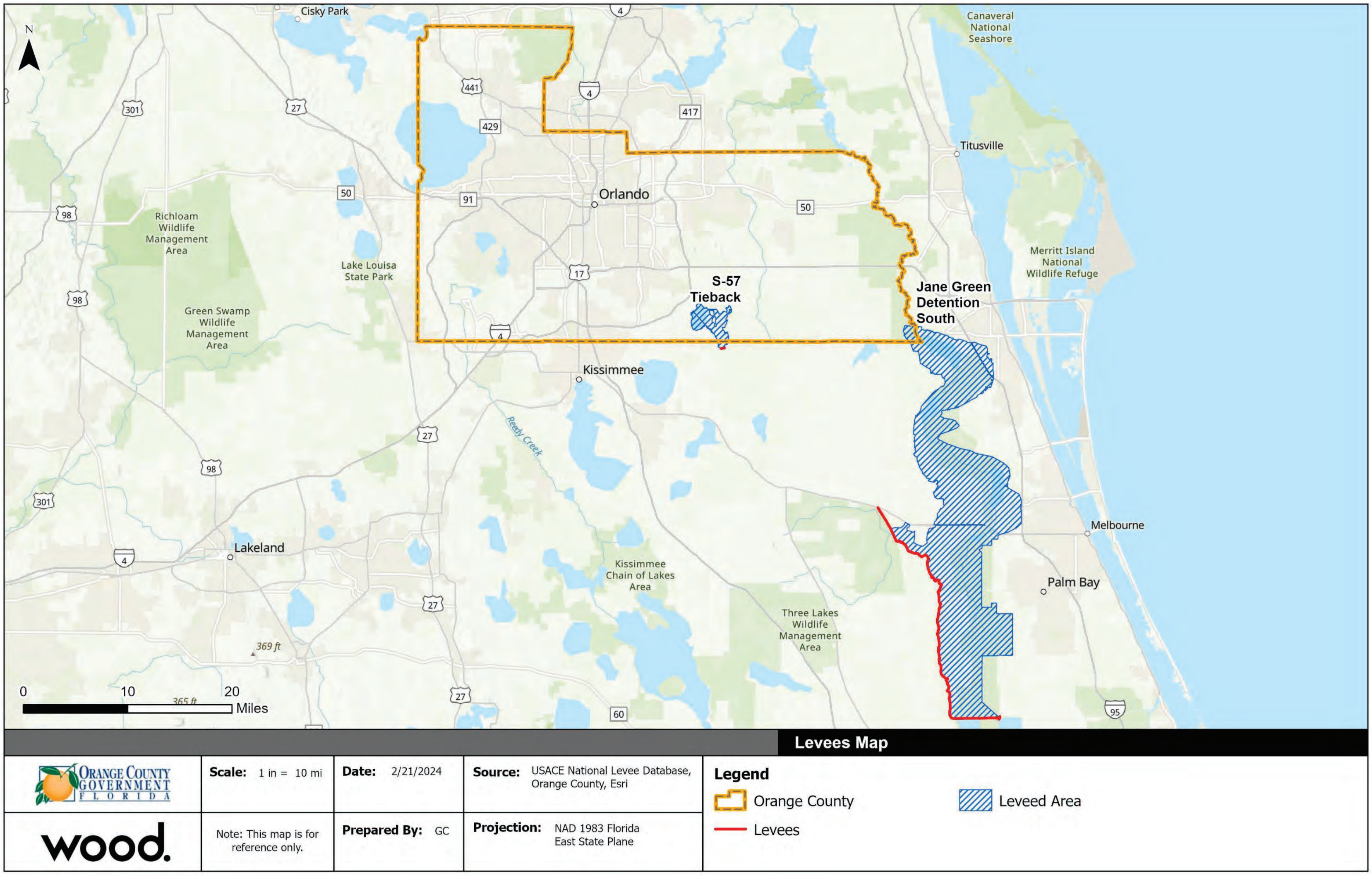
System Name	Counties	Sponsor	Length (mi)	Leveed Area (sq. mi)	Year Constructed	Last Inspection	Inspection Rating
S-57 Tieback*	Orange, Osceola	SFWMD	0.1	7.89	1969	2021	Unacceptable
Jane Green Detention South**	Brevard, Indian River, Orange, Osceola	St. John's River WMD	17.09	207.91	1995	2020	Unacceptable

Source: U.S. Army Corps of Engineers National Levee Database
*Note: The S-57 Tieback is located in Osceola County but protects portions of Orange County.
**Note: The Jane Green Detention South is located in three counties. A small portion of southeast Orange County is protected by this levee.

The following levee system descriptions are provided by USACE:

- The S-57 Tieback levee system is located in Osceola County. The system was constructed to reduce the occurrence of flooding in the Kissimmee River Basin. The levee is 7 feet high and one-tenth mile long. It is located along a drainage canal known as C-30 north of Lake Myrtle, and ties into a water control structure called S-57. The system was constructed by the U.S. Army Corps of Engineers (USACE) in 1969 and turned over to the South Florida Water Management District (SFWMD) who is responsible for operating and maintaining the levee, canal, and structure. The leveed area extends from Osceola into Orange County. The area is mostly undeveloped and rural, and includes two lakes and several canals. Residential development is located away from the levee. There are approximately 200 people that work or live within this area, with $22 million in property value.
- The Jane Green South levee system is located in Brevard, Indian River, and Osceola Counties, Florida. The system consists of four levee segments (L-74 West Sections 1 and 2, L-72 Section 2 Jane Green, and S-96B Tieback) that form the boundaries of the Jane Green Detention Area, St. Johns Water Management Area, Blue Cypress Marsh Water Conservation Area, and Kenansville Lake. These water storage areas were constructed to reduce the occurrence of flooding, with other purposes that include water supply for municipal and agricultural uses, wildlife habitat, and recreation. The levees range from 9 to 20 feet high and are 17 miles combined length. The U.S. Army Corps of Engineers (USACE) completed construction of the system in 1995 and turned it over to the St. Johns River Water Management District (SJRWMD) who is responsible for operating and maintaining the levees and associated structural components. The leveed area is primarily in Brevard County, with portions of it extending into Indian River, Osceola, and Orange Counties. The land use is mostly agricultural, and there is residential and commercial development concentrated away from the levee. The system provides benefits to the region surrounding the Upper St. Johns River Basin. There are approximately 1,600 people that work or live behind the levee, with $178 million in property value.

Figure 4.8 – National Levee Database for Orange County



Extent

As discussed above, the potential magnitude of a dam failure can be measured by the NID hazard classification. There are three high hazard dams and three low hazard dams in Orange County. All three high hazard dams are located on the Little Econlockhatchee River. All high hazard dams have Emergency Action Plans (EAPs); however, these EAPs have not been updated since they were originally prepared. Two of these dams were rated satisfactory during their last inspection in 2014; the third does not have inspection or condition information on record. Table 4.8 summarizes this information related to the high hazard dams' conditions and emergency response preparedness.

Table 4.8 – High Hazard Dams Conditions

Dam Name	Year Built	Condition Assessment	Last Inspection Date	Emergency Action Plan?	Last EAP Revision
Michaels Dam	1965	Satisfactory	8/5/2014	Yes	N/A
Banner Dam	1966	Not Rated	N/A	Yes	N/A
Cheney Dam	1970	Satisfactory	8/5/2014	Yes	N/A

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

The National Levee Database also provides risk ratings for structures, which can be used to approximate the magnitude of the hazard. Table 4.9 provides the levee performance and risk ratings from the two levees in Orange County according to USACE risk assessments, which consider flooding frequency, the likelihood of the levee breaching or overtopping, and the resulting potential loss of lives and damage to homes, businesses, and the environment.

Table 4.9 – Levee Performance and Risk Ratings

Levee	Risk	Assessment Date	Levee Performance Details
S-57 Tieback	Low	11/29/2018	The S-57 Tieback system reduces but does not eliminate the risk of loss of life or economic damages from flood events in the Kissimmee River Basin. Based on the most recent risk assessment in 2018, USACE considers this levee to have a low risk. The most likely threat to the system is seepage and slope instability due to unwanted vegetation. Seepage is when the water on the flood side of the levee seeps through to the land side. Seepage can carry soil particles with it and if enough soil is moved through the levee, the levee may be weakened and breach. There is no immediate concern the levee will breach. Water would be anticipated to overtop the levee in a storm that has a 1 in 1,000 chance of occurring in any given year. If the levee breaches or overtops, the range of flooding in portions of the leveed area could be up to 3 feet deep.
Jane Green Detention South	Low	06/01/2018	The system reduces but does not eliminate the risk of loss of life or economic damages from high water or flood events in the Upper St. Johns River Basin. Based on the most recent risk assessment of the system in 2018, USACE considers this levee to have a low risk. The most likely threat to the levee is seepage related to the presence of unwanted vegetation, animal burrows, and the erodible nature of the embankment materials. Some water seeping through the levee is normal, and there is no immediate concern that the levee will breach. The system is performing as designed. Water would be anticipated to overtop the levee in a storm that has a 1 in 200 chance of occurring in any given year. If the levee breaches or overtops, the range of flooding in portions of the leveed area could be up to 8 feet deep. A combination of population located a significant distance from the levee along with effective evacuation planning reduces the risk.

Source: USACE National Levee Database

Past Occurrences

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

Probability of Future Occurrence

Unlikely – Given there is no precedent of any dam or levee failure affecting Orange County, we can reasonably conclude that the change of such an occurrence is low. However, it should be noted that the "unacceptable" ratings of the levees could indicate an increased likelihood of failure if action is not taken to bring these structures up to acceptable standards. Additionally, there are three high hazard dams in the County, so although dam failure may be unlikely, the effects of a failure could be extremely damaging.

Climate Change and Future Conditions

Future development may increase the overall risk of dam failure by increasing downstream exposure of people and property. Regular inspection and evaluation of dam hazard potential can ensure appropriate safety precautions, such as the preparation of an Emergency Action Plan and the establishment of procedures for warning and evacuation of all at-risk structures should a failure occur.

Dam and levee failure is already tied to flooding and the increased pressure that it places on flood control structures. Climate change impacts on dams and levees will most likely be those related to changes in precipitation and flood probability. The Fourth National Climate Assessment indicates that heavy precipitation events are already becoming more frequent and intense and that this trend is likely to continue. This change may increase risk of flooding and the likelihood of dam or levee failure. A recent study evaluated the safety of dams for the future climate based on an evaluation of changes in design floods and the freeboard available to accommodate an increase in flood levels. The study results indicated that the design floods and the corresponding outflow floods and flood water levels will increase in the future, and this increase will affect the safety of the dams in the future. The study concluded that the total hydrological failure probability of a dam will increase in the future climate and that the extent and depth of flood waters will increase by the future dam break scenario (Chernet, 2013).

Vulnerability Assessment

High – Given the current dam inventory, satisfactory inspections ratings, and lack of past occurrences, a dam breach of a high hazard dam is considered in the future. Regular monitoring can help mitigate or prevent failures if appropriate actions are taken when it is determined a failure may occur.

As noted above, there are six dams located within the jurisdictional boundaries of Orange County; three of the dams are classified as high hazard: Michael's Dam, Banner Dam, and Cheney Dam. The flood risk associated with the Michael's, Banner, and Cheney dams has been determined based on a dam breach analysis performed by Geosyntec. The dam breach analysis consists of modeling a dam failure, a piping failure in this case, and evaluating the resulting downstream hydraulics. The failure scenario was modeled to occur during the 100-year storm, i.e. the boundary conditions related to flow hydrographs and water surface elevations were consistent with those during the 100-year storm. Once the failure scenario was modeled, flood inundation maps were generated to show the extent of the flooding resulting from dam failure. This analysis was performed by a consulting group called CSI in 2014 for Banner and Michaels Dam and 2015 for Cheney Dam.

To create the flood inundation maps, Geosyntec recreated the CSI generated flood inundation extents and then utilized ArcGIS to evaluate what structures and roads would be impacted in the event of a dam failure. Both maximum water surface elevations and water depth rasters were generated and then overlayed on the 2016 Orange County aerials. Based on visual inspection, structures and roads were identified as being impacted and to what extent (i.e. expected depth of flooding). Figure 4.9 on the following page depicts an overview map for the Banner and Michael's dam inundation.

Figure 4.10 depicts an overview map for Cheney dam inundation.

For inundation details including inundation depth and peak flood elevation of the structures and streets that experience flooding during dam failure, refer to the Emergency Action Plan prepared by Geosyntec Consultants for Orange County in December 2016.

Vulnerability to levee failure was analyzed based on the spatial extent of the leveed areas for the two identified levees. Information was not available on the depth of flooding that would affect these areas; therefore, potential losses could not be estimated. However, a spatial analysis of the leveed areas and the property inventory provides an estimate of total exposure to levee failure. Table 4.10 summarizes property exposure within the S-57 Tieback leveed area. There was no property exposure in Orange County within the area protected by the Jane Green Detention South levee. In total, $78 million in property value is exposed to levee failure, of which 98% is residential property.

Table 4.10 – Property Exposure to Failure of S-57 Tieback Levee

Occupancy Type	Number of Buildings	Estimated Building Value	Estimated Content Value	Estimated Total Value
Agriculture	4	$297,938	$148,969	$446,907
Commercial	0	-	-	-
Education	0	-	-	-
Government	7	$887,202	$126,743	$1,013,945
Industrial	0	-	-	-
Religion/Non-Profit	0	-	-	-
Residential	313	$58,682,200	$18,027,367	$76,709,567
Total	**324**	**$59,867,340**	**$18,303,080**	**$78,170,420**

Source: National Levee Database; Orange County parcel data

Figure 4.9 – Banner and Michael's Dam Flood Overview Map

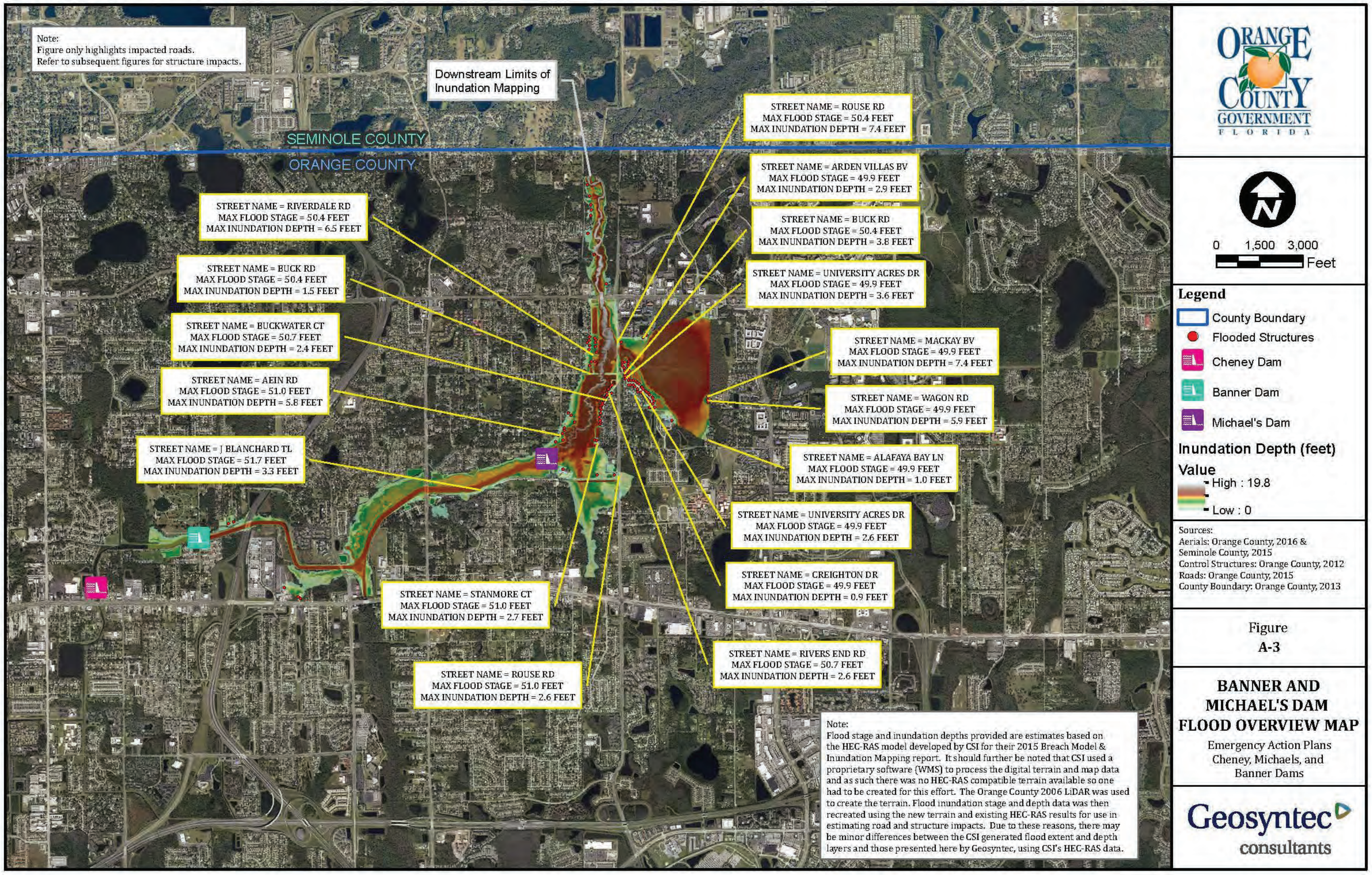
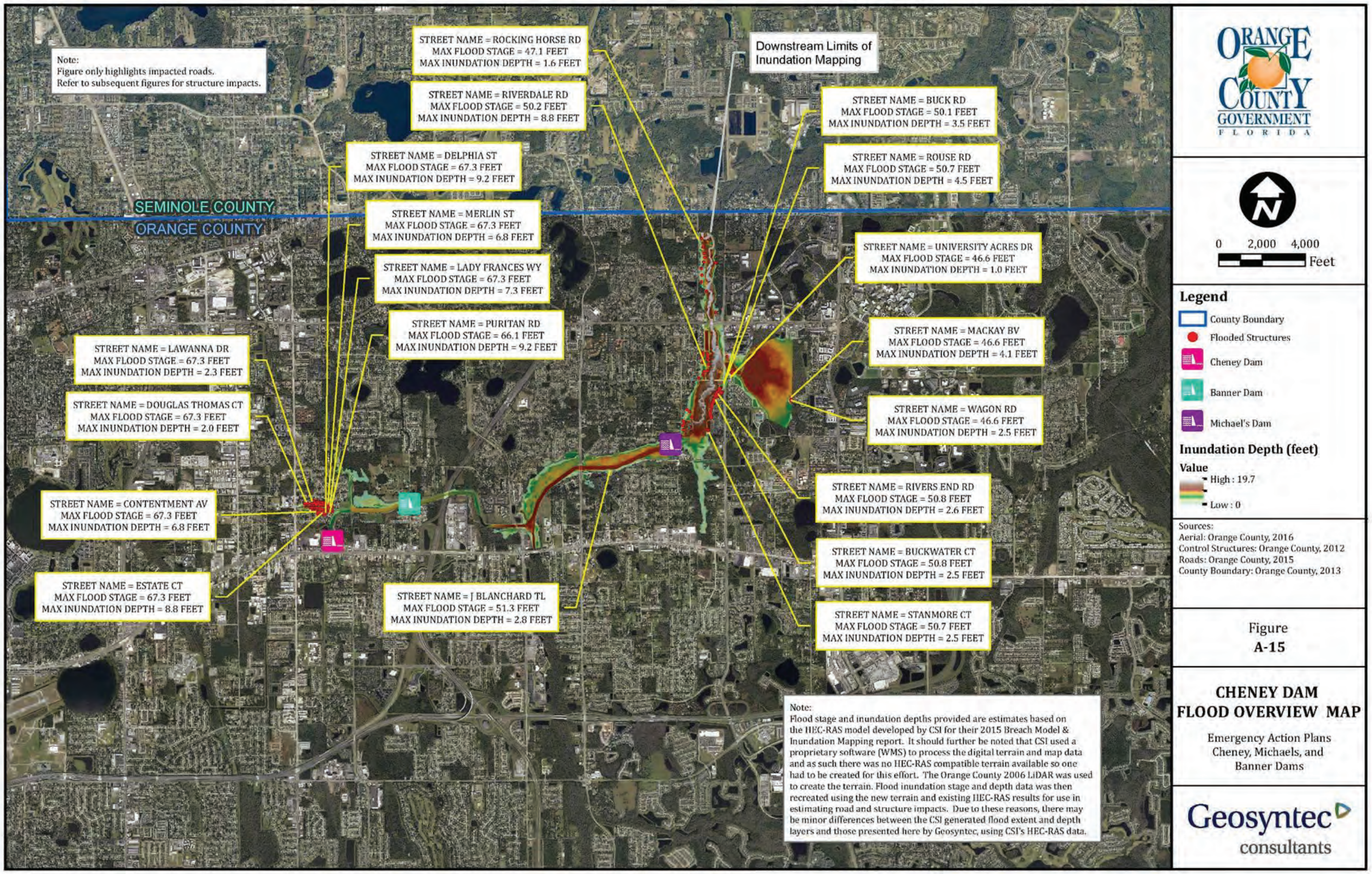


Figure 4.10 – Cheney Dam Flood Overview Map



4.3.4 Flood: Riverine and Flash

Probability	Impact	Spatial Extent	Warning Time	Duration
Likely	Critical	Moderate	12 to 24 hours	< 1 week

Hazard Description

Flooding is defined by the rising and overflowing of a body of water onto normally dry land. According to the USGS, floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin. 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 Orange County can be attributed to prolonged heavy rainfall over large areas. Flooding is often more severe when rainfall results from hurricanes and tropical storms and when ground conditions are already saturated and/or drainage systems within the community are already overburdened.

Current flood protection measures include development regulation as well as stream channelization and manmade canals. However, these canals are not built to contain the 1% annual chance flood.

Sources and Types of Flooding

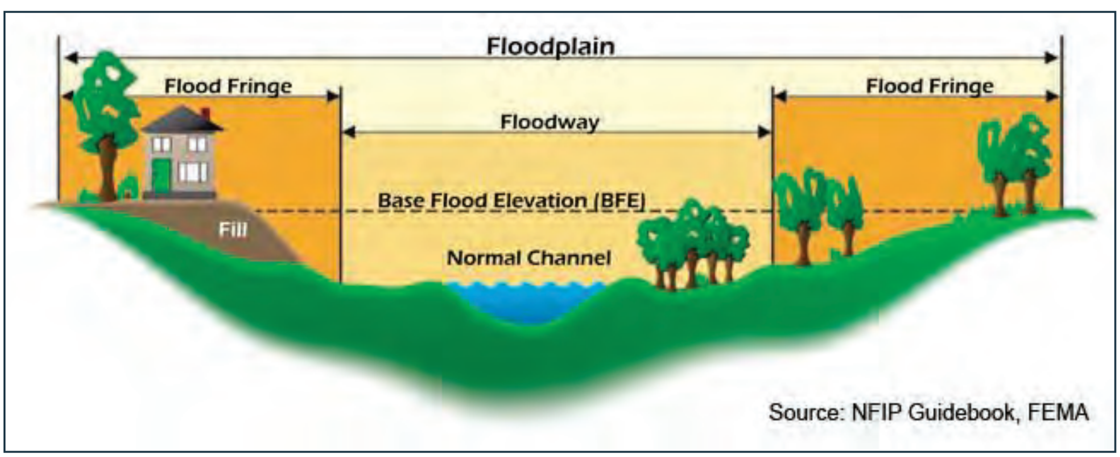
According to the 2021 Flood Insurance Study (FIS) Report for Orange County, flooding results from heavy rainfall over large areas, primarily during thunderstorms in the summer months and from June to October during hurricane season. Flooding occurs along the County's lakes and streams. Orange County lies far enough inland that coastal flooding and storm surge pose no threat.

The general topography of Orange County is very flat with some gentle hills. The lack of steep slopes limits rapid runoff; therefore, water accumulates in ponded areas and slowly infiltrates the groundwater system or sluggishly drains over the land depending on the soils. The soils in Orange County range from "somewhat excessively drained" to "very poorly drained." Near Apopka the soil's high percolation rate reduces surface runoff, near Maitland and Winter Park the soils are well drained and interspersed with many lakes, and around Orlando the soils are poorly drained and mixed with grassy sloughs and swamps.

Flooding and Floodplains

In its common usage, the floodplain most often refers to that area that is inundated by the flood that has a 1% chance in any given year of being equaled or exceeded, sometimes called the 100-year flood. As shown in the diagram in Figure 4.11, a floodplain is the 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.

Figure 4.11 – Characteristics of a Riverine Floodplain



The 1%-annual-chance flood is the national minimum standard to which communities regulate their floodplains through the National Flood Insurance Program (NFIP). FEMA also identifies the flood that has a 0.2 percent chance of being equaled or exceeded in any given year, sometimes called the 500-year flood. 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.

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 the most predictable and manageable hazard.

Location

Regulated floodplains are illustrated on inundation maps called Flood Insurance Rate Maps (FIRMs). A FIRM 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%-annual chance flood event. According to FEMA, 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 within Orange County were identified using the FIS Report and Effective FIRMs developed by FEMA with a revised date of September 24, 2021. Table 4.11 summarizes the flood insurance zones identified by the FIRMs and FIS Report.

Table 4.11 – Mapped Flood Insurance Zones within Orange County

Zone	Description
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.
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.
D	Areas where there are possible but undetermined flood hazards, as no analysis of flood hazards has been conducted. The designation of Zone D is also used when a community incorporates portions of another community's area where no map has been prepared.
Zone X Shaded (0.2% Annual Chance)	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	Description
Zone X (unshaded)	Minimal risk areas outside the 1-percent and 0.2-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 4.12 on the following page reflects the mapped flood insurance zones for Orange County. A summary of the unincorporated County's acreage by flood zone is provided in Table 4.12. Approximately 177,819.6 acres of unincorporated Orange County fall within the SFHA, which equates to 36.6% of the total planning area.

Table 4.12 – Flood Zone Acreage

	Flood Zone Acreage					
	Zone A	**Zone AE**	**Zone AH**	**Zone X Shaded (500-year)**	**Zone X Unshaded**	**Total**
Total Area (% of Total Area)	54,112.7 (11.1%)	122,145.7 (25.1%)	1,561.3 (0.3%)	8,708.3 (1.8%)	299,446.8 (61.6%)	486,217.9

Extent

The severity of a flood can be measured by its depth and velocity. The depth of flooding that impacts a property is correlated with the property damages that result, where greater depths cause more substantial damages.

Figure 4.13 shows the flood depths throughout Orange County for the 1%-annual-chance flood event, as defined by the County's Effective FIRMs and the September 24, 2021 Revised Flood Insurance Study.

Flood extent varies throughout the floodplain, but overall flooding impacts can be critical, with the potential for severe damage and destruction of property and the possibility of injuries and deaths.

Figure 4.12 – FEMA Flood Zones

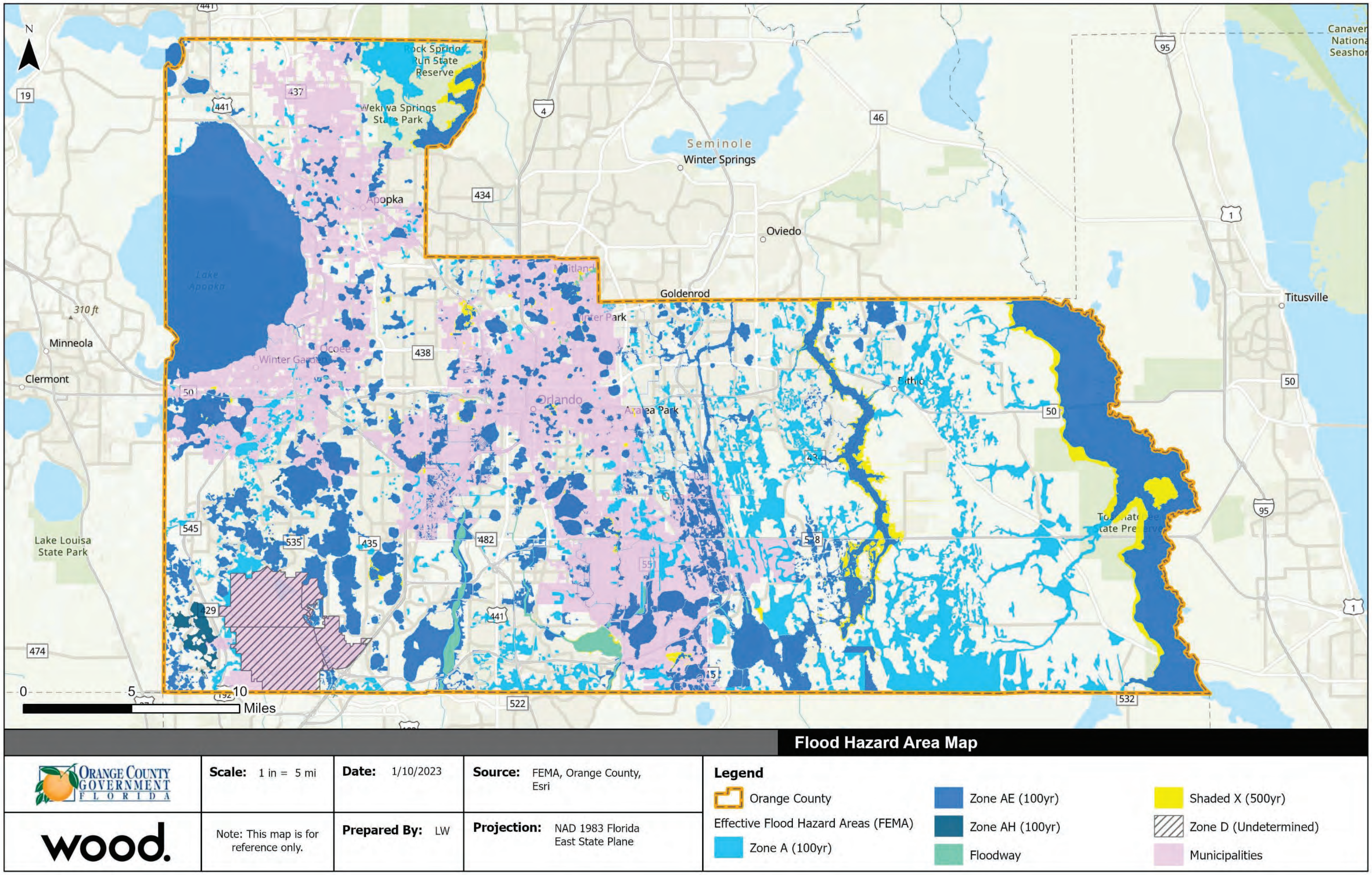
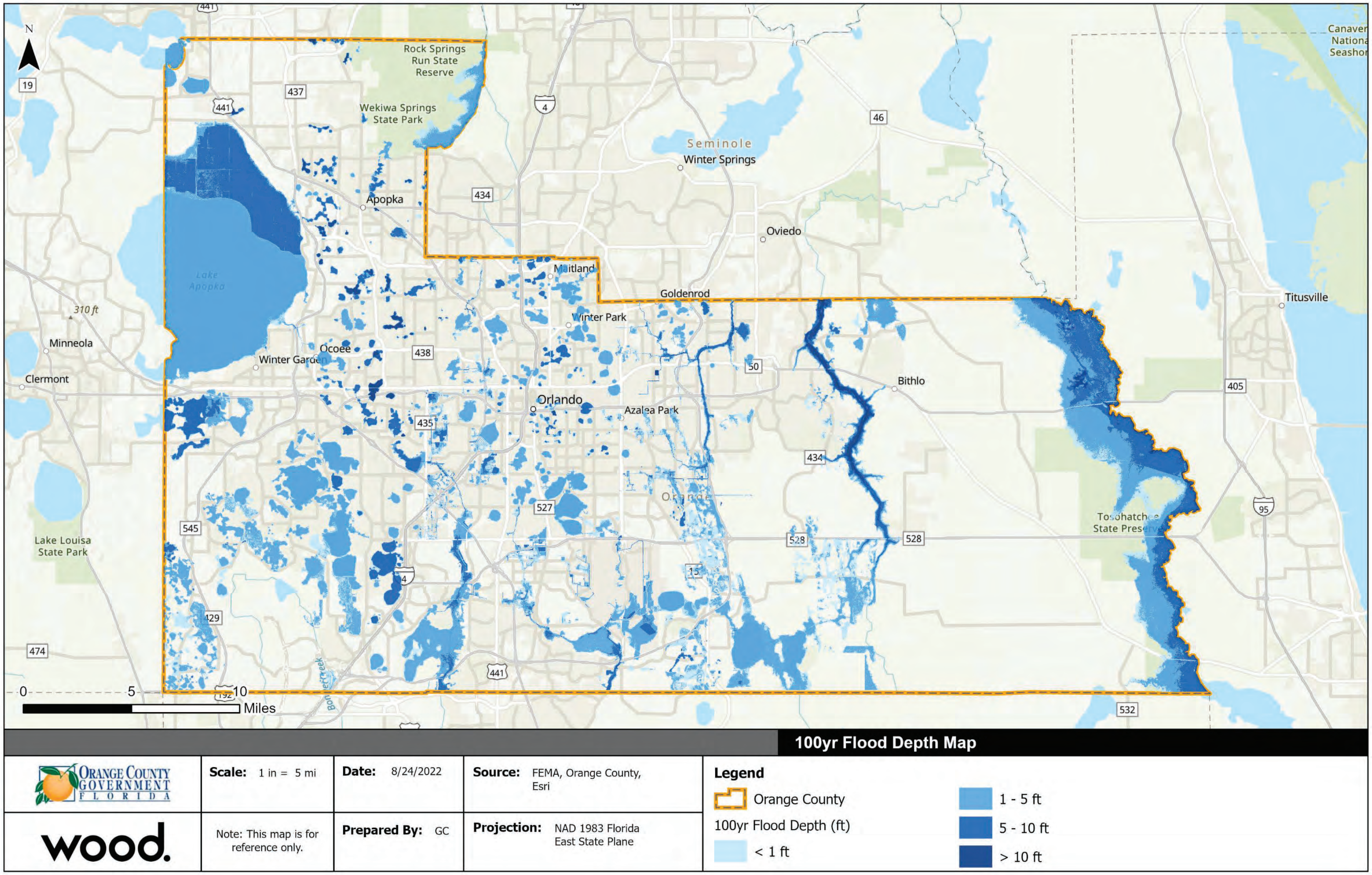


Figure 4.13 – FEMA 1% Annual Chance Flood Depth



Past Occurrences

Orange County is located within a semi-tropical environment and is subject to intense thunderstorms and tropical cyclones (hurricanes). Table 4.13 shows the monthly average precipitation from 1991-2020 measured at the Orlando International Airport weather station. About 72 percent of the 51.45" average annual rainfall occurs during the months of May through October; concentrated during the peak rainfall months of June through September. Flooding can occur year-round in Orange County but is most frequent during the summer months, which often bring persistent thunderstorms. 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 4.3.6.

Table 4.13 – Monthly Precipitation Normals, 1991-2020, Orlando International Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Total	2.48	2.04	3.03	2.58	4.02	8.05	7.46	7.69	6.37	3.46	1.79	2.48	51.45

Source: Florida Climate Center

Table 4.14 shows the flood events from causes other than hurricanes or tropical storms reported by the NCEI since 1996 for Orange County. NCEI receives Storm Data from the National Weather Service (NWS). The NWS receives their information from a variety of sources, which include but are not limited to: county, state and federal emergency management officials, local law enforcement officials, SkyWarn spotters, NWS damage surveys, newspaper clipping services, the insurance industry and the general public, among others. The NWS makes a best guess for damages using all available data at the time of the publication. Property and crop damage should be considered a broad estimate.

Table 4.14 – NCEI Reported Flood Events in Orange County – January 1996 to February 2022

Location	Date	Event Type	Injuries/Deaths	Damages
Winter Park	07/21/2001	Flash Flood	0/0	$0
West Portion	09/05/2004	Flash Flood	0/0	$0
Eatonville	10/1/2016	Flash Flood	0/0	$10,000
Orlando	07/14/1999	Flood	0/0	$0
Orlando	07/21/2002	Flood	0/0	$0
Zellwood Eure Bro Airport	10/7/2016	Flood	0/0	$0
Walt Disney World	9/10/2017	Flood	0/0	$0
Westwood	8/19/2018	Flood	0/0	$1,000
Orlando	07/31/2001	Heavy Rain	0/0	$20,000,000
Winter Garden	06/12/2003	Heavy Rain	0/0	$0
Winter Park	09/27/2005	Heavy Rain	0/0	$0
Plymouth	06/25/2007	Heavy Rain	0/0	$0
Union Park	10/08/2011	Heavy Rain	0/0	$0
Union Park	06/04/2013	Heavy Rain	0/0	$0
Fairvilla	09/23/2014	Heavy Rain	0/0	$0
Orlando	11/25/2014	Heavy Rain	0/0	$0
(Orl)Orlando Exec Airport	8/14/2019	Heavy Rain	0/0	$0
(Mco)Orlando Intl Airport	6/22/2020	Heavy Rain	0/0	$0
Golden Rod	7/20/2021	Heavy Rain	0/0	$0

Source: NCEI Storm Events Database
Note: Losses reflect totals for all impacted areas.

The following provides additional details on flood events within the NCEI database and additional events reported by South Florida Water Management District.

September 5, 2004 – Hurricane Frances caused 8-10 inches of rain to fall across north and west Orange County, flooding homes and roads.

June 25, 2007 – Nearly 1.7 inches of rain fell in 20 minutes at Plymouth.

June 4, 2013 – Tropical Storm Andrea produced heavy rain across Central Florida over a three-day period. Maximum totals in Orange County reached 5-6 inches.

September 23, 2014 – Thunderstorms brought 3-6 inches of rain in less than two hours. Totals for the 24-hour period reached 6-12 inches. Many roads flooded and became impassable, and homes were isolated and damaged from floodwaters. The most impact areas included Winter Park, Azalea Park, and Maitland.

November 11, 2014 – Two days of heavy rain and thunderstorms caused flooding across Orange County. Rainfall totals reached 3-9 inches, with highest totals across northern parts of the county. Flooding made several roadways impassable.

August 14, 2019 – Numerous slow-moving thunderstorms produced several inches of rain. Orange County Fire Rescue reported that several motorists were stranded in several feet of standing water at Ensenada Drive and El Prado Avenue. Additionally, at the intersection of State Road 50 and Maguire Boulevard near Orlando Executive Airport several stalled vehicles with 1 to 2 feet of water covering the roadway was reported.

June 22, 2020 – Heavy thunderstorms produced between 4.5 to 5.5 inches of rain in the Lake Nona area causing localized flooding. Orange County Fire Rescue reported that all six lanes of Narcoossee Road at Eagle Creek Sanctuary Boulevard in Lake Nona were closed due to high standing water. Six vehicles were stranded in the water.

July 20, 2021 – Numerous private weather stations in Orange County recorded between 3 and 5 inches of rain, in less than 2 hours, mainly around Goldenrod.

Probability of Future Occurrence

Likely – By definition, there is a 1-percent annual chance of a flood event equaling or exceeding the mapped floodplain boundaries and flood depth shown in this hazard profile. However, Orange County can be expected to experience a variety of more and less severe events with varying frequencies. In the 26-year period from 1996 to 2022 there have been 19 flood-related events recorded in NCEI, which equates to a 73 percent annual chance of flooding. Given observed and projected climate change impacts, discussed below, flooding may become even more likely in coming years.

Climate Change and Future Conditions

Given that Orange County's largest flood risks stem from heavy rains, increases in the intensity of rain events, hurricanes, and tropical storms driven by climate change will likely affect the County. According to a 2009 report by the SFWMD titled *Climate Change and Water Management in South Florida*, average annual rainfall may increase or decrease slightly in the future but more frequent intense rainfall events are likely to occur with longer dry periods in between. NOAA's National Centers for Environmental Information 2022 State Climate Summary for Florida supports this projection. Observed annual precipitation data from 1900 to 2020 shows no clear trend in overall precipitation; however, data on the observed number of 4-inch extreme precipitation events indicates that extreme rainfall has been near or above average since 1995.

Heavy rainfall poses a threat to homes, businesses, and water control structures. Per the SFWMD report, if flooding were to reach new extremes, the water management system already in place may not be adequate to provide the necessary levels of flood protection. Flooding could also further degrade water quality due to increased runoff, the loss of positive pressure in sewer systems, damage to septic systems, and pollutants washed into water bodies.

Vulnerability Assessment

High – A significant amount of property in unincorporated Orange County is exposed to flood risk. People are at risk living or working in flood-prone areas and traveling through flood prone roadways. Flooding may also impact infrastructure and environmental assets in the county.

Flood damage is directly related to the depth of flooding by the application of a depth damage curve. In applying the curve, a specific depth of water translates to a specific percentage of damage to the structure, which translates to the same percentage of the structure's replacement value. Table 4.15 provides the depth damage factors that were used to calculate flood losses for Orange County. These depth damage factors are based on the default depth damage curve in Hazus.

Table 4.15 – Depth Damage Percentages

Depth(ft)	Percent Damaged (%)						
	Agricultural	Commercial	Education	Government	Industrial	Religious	Residential
0	0	1	0	0	1	0	13
1	6	9	5	5	10	10	23
2	11	14	7	8	12	11	32
3	15	16	9	13	15	11	40
4	19	18	9	14	19	12	47
5	25	20	10	14	22	12	53
6	30	23	11	15	26	13	59
7	35	26	13	17	30	14	63
8	41	30	15	19	35	14	67
9	46	34	17	22	39	15	71
10	51	38	20	26	42	17	73
11	57	42	24	31	48	19	75
12	63	47	28	37	50	24	77
13	70	51	33	44	51	30	79
14	75	55	39	51	53	38	80
15	79	58	45	59	54	45	81
16	82	61	52	65	55	52	81
17	84	64	59	70	55	58	82
18	87	67	64	74	56	64	82
19	89	69	69	79	56	69	83
20	90	71	74	83	57	74	83
21	92	74	79	87	57	78	83
22	93	76	84	91	57	82	84
23	95	78	89	95	58	85	84
24	96	80	94	98	58	88	84

Source: Hazus

Content value estimations are based on FEMA Hazus methodologies of estimating value as a percent of improved structure values by property type. Table 4.16 shows the breakdown of the various property types and their estimated content replacement value percentages.