City of
Satellite Beach

Resiliency Analysis and Solutions Implementation Project

2024

Prepared by the East Central Florida Regional Planning Council for the City of Satellite Beach and the Florida Department of Environmental Protection Resilient Florida Grant Program—Agreement Number: 22PLN03.

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Executive Summary

In 2022, the City of Satellite Beach received a grant award as part of the Florida Department of Environmental Protection's (FDEP) Resilient Florida Grant Program to complete a vulnerability assessment under the standardized requirements under s. 380.093, F.S. This vulnerability assessment includes an inventory of critical assets, including regionally significant assets, that are essential for critical government and business functions, national security, public health and safety, the economy, flood and storm protection, water quality management, and wildlife habitat management—as well as the vulnerability and risk to each asset.

The impacts of tidal flooding, current and future storm surge, rainfall-induced flooding, and compound flooding were identified using sea level rise projection data should include NOAA's most recent intermediate-high and intermediate-low projections for 2040 and 2070. Storm surge projections used were equal to or exceed the current 100-year return period (1% annual chance) flood event. Higher frequency storm events were also analyzed, where applicable to understand the exposure of a critical asset across various flood levels. Flood exposure and sensitivity were identified during each event scenario to create a baseline for adaptive measures in the future.

With this in mind, resilience strategies should guide decision-making in order to resolve real-world local problems—and should be directly responsive to local land use and development patterns, capital improvement plans (CIPs), and the vulnerabilities uncovered in the assessment. Since summarizing flood hazard findings into responsive resilience strategies is an important component of risk reduction and resilience building—adaptive measures were developed to help the city protect assets and reduce vulnerabilities.

Acronyms & Abbreviations

AAA Adaptation Action Area

CHHA Coastal High Hazard Area

CIP Capital Improvement Plan

CPA Community Planning Act

CRS Community Rating System

CCVI Climate Change Vulnerability Index

CVI Coastal Vulnerability Index

DEM Digital Elevation Model

DCIA Directly Connected Impervious Area

DSAS Digital Shoreline Analysis System

EAR Evaluation and Appraisal Review

ECFRPC East Central Florida Regional Planning Council

EPA United States Environmental Protection Agency

FDEP Florida Department of Environmental Protection

FDOT Florida Department of Transportation

FEMA Federal Emergency Management Agency

FDEM Florida Division of Emergency Management

FFE First Floor Elevations

FIRM Flood Insurance Rate Map

FS Florida Statute

GI Green Infrastructure

GIS Geographic Information Systems

IFAS University of Florida Institute of Food and Agricultural Sciences

IPCC Intergovernmental Panel on Climate Change

LID Low Impact Development

LMS Local Mitigation Strategy

NHM National Hydrologic Model

NFIP National Flood Insurance Program

NOAA National Oceanic and Atmospheric Administration

MHHW Mean Higher High Water

SCTPO Space Coast Transportation Planning Organization

SFHA Special Flood Hazard Area

SLOSH Sea, Lake, and Overland Surges from Hurricanes

SLR Sea Level Rise

TDR Transfer of Development Rights

TIA Total Impervious Area

USACE United States Army Corps of Engineers

USGS United States Geological Survey

VA Vulnerability Assessment

Definitions

- **25-Year/24-Hour Rainfall Event:** A rainfall event that statistically represents that there is a 4% chance that an event of that magnitude may occur in any given year.
- **100-Year/24-Hour Rainfall Event:** A rainfall event that statistically represents that there is a 1% chance that an event of that magnitude may occur in any given year. For example, a coastal flood event that has a 1% chance of occurring in any given year (the “100-year event”) has a 26% chance of occurring within a 30-year period, and sea level rise further increases the chance over that 30-year period).
- **500-Year/24-Hour Rainfall Event:** A rainfall event that statistically represents that there is a 0.2% chance that an event of that magnitude may occur in any given year.
- **Acute shocks:** Sudden and sharp events that threaten or disrupt a community (i.e. hurricanes, floods, etc.).
- **Adaptation:** Adjustment in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptive Measures: A strategy, project, plan or policy, that aims to increase resilience to acute shocks or chronic stresses.
- **Base Flood Elevation (BFE):** The elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year. The BFE is shown on the Flood Insurance Rate Map (FIRM) for zones AE, AH, A1–A30, AR, AR/A, AR/AE, AR/A1– A30, AR/AH, AR/AO, V1–V30 and VE.
- **Coastal Communities:** Communities adjacent to the sea or coastal lagoon systems.
- **Coastal High Hazard Area:** Special Flood Hazard Areas (SFHAs) along the coasts that have additional hazards due to wind and wave action. These areas are identified on Flood Insurance Rate Maps (FIRMs) as zones V, V1-V30 and VE.
- **Critical Asset:** as defined in s. 380.093, F.S.
- **Coastal Flooding:** Flooding in coastal communities caused by either sea level rise, storm intensification or both.
- **Exceedance:** The likelihood that in the future, a SLR scenario will be exceeded.
- **Exposure:** Assets that may be exposed and adversely impacted by flooding.
- **Flood Level:** The elevation of water on dry surfaces caused by an event.
- **Mean Higher High Water (MHHW):** The average of the high tide water heights over each tidal day.
- **Regionally Significant Assets:** Critical assets that support the needs of communities spanning multiple geopolitical jurisdictions, including, but not limited to, water resource facilities, regional medical centers, emergency operations centers, regional utilities, major transportation hubs and corridors, airports, and seaports.
- **Resilience:** The ability to bounce forward; absorb, recover and get better in the face of short-term shocks like hurricanes or infrastructure failures and term stressors long like affordable housing, aging infrastructure, shifting economic trends and climate change.
- **Sea Level Rise (SLR):** The increasing water level of the oceans over time.

- **Special Flood Hazard Area (SFHA):** An area having special flood, mudflow or flood-related erosion hazards and shown on a Flood Hazard Boundary Map (FHBM) or a Flood Insurance Rate Map (FIRM) Zone A, AO, A1-A30, AE, A99, AH, AR, AR/A, AR/AE, AR/AH, AR/AO, AR/A1-A30, V1-V30, VE or V. The SFHA is the area where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies.
- **Storm Surge:** The abnormal rise of water generated by a storm, over and above the predicted astronomical tides.
- **Tidal Flooding:** When sea level rise combines with local factors to push water levels above the normal high tide mark.
- **Vulnerability:** The predisposition for an asset to be adversely impacted.
- **Water Level (Depth):** The elevation of water on or off land.

Introduction & Background

Resilient Florida Grant Program

Recognizing that Florida is particularly vulnerable to water-based hazards, the state acknowledges that the increasing frequency of rain events, storm/severe weather systems and sea level rise poses economic, social, public health and environmental challenges to residents and visitors alike.

In early 2021, the Florida Senate established CS/CS/SB 1954: Statewide Flooding and Sea Level Rise Resilience. Then, in 2022 the state Senate followed with CS/SB 1940 (CS/HB 7053; later substituted) to develop additional criteria for standardized vulnerability assessments in order to prepare for the adverse impacts from flooding as a result of increased frequency of rainfall and storm surge events, more frequent and severe weather, and sea level rise.

As defined in 380.093, F.S., vulnerability assessments administered under the Resilient Florida Grant Program must include an exposure analysis and a sensitivity analysis. An exposure analysis should identify the depth of water caused by various flooding and, if appropriate, sea-level rise. The data should include: tidal flooding; current and future storm surge; rain-fall induced flooding; and compound flooding or a combination of tidal, storm surge, and rainfall-induced flooding (where applicable). Scenarios should include analysis performed in North American Vertical Datum of 1988 (NAVD88), at least two local sea-level rise scenarios (2017 NOAA Intermediate-Low and Intermediate-High sea-level rise projections) for at least two planning horizons for the year 2040 and 2070.

The sensitivity analysis builds on the exposure analysis but measures the impact of flooding on critical assets. The analysis provides an inventory of the critical assets and evaluates the impact of flooding on assets based on each flood scenario the assigned risk-level based on the inundation of land. The sensitivity analysis also identifies community characteristics such as affected populations, structures, and economic impacts. The most comprehensive approach will evaluate both critical assets as well as community characteristics.

- ► **Two SLR Scenarios (2017 NOAA):**
  Intermediate-low & Intermediate-high for planning horizons 2040 & 2070.

A Regional Approach

The East Central Florida Regional Resiliency Action Plan (ECFRRAP)

In 2018, through extensive stakeholder input with Brevard and Volusia Counties, the East Central Florida Regional Planning Council adopted two scenarios for planning for sea level rise. According to the East Central Florida Regional Resiliency Action Plan (ECFRRAP)—"no one projection rate curve should be used for planning purposes across all projects and programs. Instead, a range of rise should be considered based upon the vulnerability, allowable risk, and project service life and the forecast project "in-service" date of a facility or development. The range should include a minimum rise of 5.15 feet by 2100 (2013 USACE High) with an upper range of 8.48 feet by 2100 (2017 NOAA High). Short-term planning should consider impacts out to 2040 (20-year planning horizon), medium-term planning should consider impacts out to 2070 (50-year planning horizon), and long-term planning should extend out to 2100 (80-year planning horizon). Adaptation plans of the community should also be taken into consideration when planning, engineering and constructing infrastructure relative to sea level rise and flooding to ensure consistency with community development plans (ECFRRAP, 2018)."

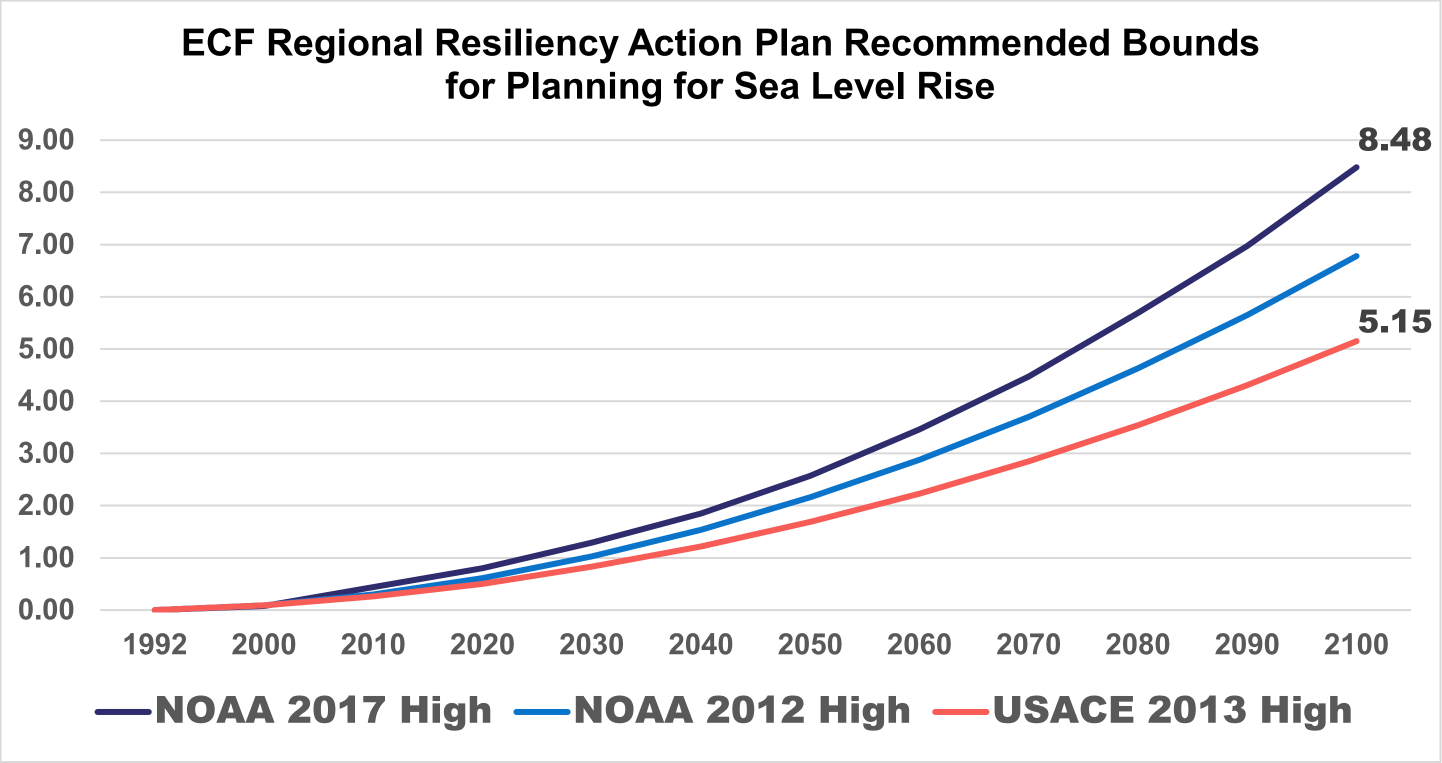

Figure 1. Recommended range for sea level rise planning and includes the projected rise in sea level by decade based on the *ECFRRAP*.

ECFRPC Sea Level Rise Curve Descriptions

8.48 feet (by 2100)

UPPER BOUND DESCRIPTION

The sea level rise estimates associated with the NOAA 2017 high rate curve are recommended as the upper bound of the planning scenario. These data are recommended for assessment and adaptation, mitigation and minimization planning of those facilities that have little risk tolerance and long functional life span, as well as new/proposed (re)development or significant intensification on previously minimally developed land that may be on future fringes of vulnerable areas. The upper bound of sea level rise planning should consider the local estimate for the forecasted year of facility life expectancy based on in-service date. USACE guidance requires a 100-year potential service life of large infrastructure projects. These projects along with new community development projects should include an approved adaptation strategy prior to construction consistent with the community's adaptation plan. It is recommended that facilities necessitating an upper bound of sea level rise planning are recommended to plan for a minimum rise in sea level of 1.85 feet by 2040, 4.47 feet by 2070 and 8.48 feet by 2100.

5.15 feet (by 2100)

LOWER BOUND DESCRIPTION

The recommended minimal or lower bound of planning level for consideration is the USACE 2013 High Rate Curve or a minimum planning of 5.15 feet of rise by 2100 (1.22 ft. by 2040 and 2.85 ft. by 2070). This minimal planning level would be recommended for facilities that are less vulnerable, have a greater risk tolerance to flooding, are of little impact in terms of the health, safety and welfare of the community, facilities with a short time-frame of functionality or facilities that are easily relocated or planned for relocation. Using the USACE 2013 High Rate Curve as a minimum ensures that CRS activities applying even this lower bound are eligible for CRS credits under the 2017 CRS manual.

While the statute curves will be used for assessing critical assets for implementation funding, curves that exceed the statute minimums can be used for planning purposes. For Brevard and Volusia Counties, it is recommended that the ECFRPC curves be used for planning purposes as these have been previously adopted.

The East Central Florida Regional Resilience Collaborative (ECFR2C) Framework (GHGs + SLR)

Higher global temperatures increase the chances of higher sea level rise. NOAA's Technical Report NOS 01 notes that "increasing the amount of greenhouse gases (GHGs) in the atmosphere will trap more heat. The amount of GHGs in the atmosphere determines the "forcing" of climate change and its effects, such as changes in temperature and sea level rise. Various forcing scenarios describe possible GHG emissions pathways, which range from quick emissions reduction to unmitigated future emissions" (Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01).

The report goes on to say that "by 2050, the expected relative sea level (RSL) will cause tide and storm surge heights to increase and will lead to a shift in U.S. coastal flood regimes, with major and moderate high tide flood events occurring as frequently as moderate and minor high tide flood events occur today. Without additional risk-reduction measures, U.S. coastal infrastructure, communities, and ecosystems will face significant consequences"[1]. The report draws on new science from the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report to provide updated trajectories and exceedance probabilities based on different levels of global warming.

To accompany the already established unified sea level rise curves, alignment with NOAA's Technical Report and literature, it is important to note that the ECFR2C completed the region's first GHG emissions inventory and established a 54.3% science-based emissions reduction target from baseline 2019 by 2030. The inventory was verified by CDP in 2022 while the region moves toward developing an integrated Climate Action Plan (RiCAP) that will describe strategies to accomplish the target. The RiCAP will unite three strategy sections to include high impact actions, climate informed mitigation, climate informed conservation weaving health and equity principles throughout.

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[1] Source: *Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*. NOAA Technical Report NOS 01.

Resilience and Regional Transportation Systems

Space Coast Transportation Planning Organization (SCTPO) and the Transportation Resiliency Master Plan

Transportation resiliency is vital to our complex network of infrastructure, communications, economy, tourist industry, unique environment, and more. The *Transportation Resiliency Master Plan* (RMP), completed in October 2022, analyzed the vulnerability of our roadways to hurricane winds and storm surge, sea level rise, coastal erosion, wildfire and smoke, and flooding. It also considered the importance of the roadway because of its access to critical destinations, such as the airport and community assets, such as a fire department, as well as what communities are most at risk. Following the analysis, the master plan considered potential next steps and completed a funding sources analysis to consider how [to] fund making our roadway networks more vulnerable (SCTPO).

For the purposes of this report, the flood, sea level rise, shoreline erosion, and storm surge executive summaries will be referenced. For flooding, the RMP identified a baseline for flooding using the 100-year floodplain. Within Brevard County, 56% of the roads are impacted. In Satellite Beach specifically, 11% of the roads are impacted by a 100-year flood. For sea level rise, the RMP used the NOAA High curve for 2100. For this scenario, 29% of the roads are impacted, though it is worth noting that this is primarily on the barrier island. As a result, Satellite Beach can expect 73% of its roadways to be impacted. For storm surge, the RMP identified impacts from a Category 3 hurricane. Brevard County as a whole may experience impacts to 27% of the roads. In Satellite Beach, the impacts from a Category 3 hurricane could result in impacts to 52% of the roads. And finally, for shoreline erosion, the RMP identified a 200-foot buffer from the Indian River Lagoon, the Banana River, and the Atlantic Ocean. In this scenario, 20% of Brevard roads are impacted and 4% of Satellite Beach's roads are impacted.

Evacuation Routes and Zones

Florida coastal counties are susceptible to storm surge from tropical storms and hurricanes. For most coastal Florida counties, evacuation zones have been designated. Florida Statute 380.093 includes requirements for assessing transportation assets (in this case major roadways) and evacuation routes. State Road (SR) A1A, the main roadway for Satellite Beach is in Evacuation Zone A. Generally, Zone A is most vulnerable and most likely to be evacuated first as it is susceptible to storm surge.

Adaptation Planning for Local Communities

Risks + Financial Factors

Generally, adaptation can be defined in many ways. When it comes to planning for water-based hazards, adaptation means assessing the impacts of climate change and developing goals and processes for implementing mitigative actions. Communities should view adaptation (and resilience planning) as an investment that may save money in the long term. Actions taken to reduce risk may lead to a reduction in storm-related business interruption across a variety of important coastal industries such as the tourism, recreation, seaports and ocean transportation, marine, and fishing/living resources industries.

The impacts of sea level rise and climate change—such as flooding from the ocean and extreme precipitation—will increasingly impact a community's finances. For example, as sea level rise encroaches into neighborhoods and business districts, property values may go down, emergency service costs will increase, and business disruption costs will escalate. These consequences will both reduce revenue as home owners abandon properties or sales taxes go down in areas prone to increased flood and increase costs as communities deal with the aftermath.

Financial factors like these are weighed by bond rating agencies, and when they become substantial, the cost to borrow money increases. As a result, a downgrade in the bond rating could force communities to pay more to borrow money for projects like building, maintaining, and rebuilding facilities and infrastructure including even the type of measures needed to adapt to sea level rise. The resulting increased cost of borrowing may then be passed on to residents and businesses as communities struggle to cope. Developing an adaptation plan is a step in the right direction to identify the areas at greatest risk and identify a tangible process for addressing the impacts (Florida Adaptation Planning Guidebook, 2018).

In addition to this vulnerability assessment, the City will review its comprehensive plan and land development codes to ensure consistency with the Peril of Flood requirements in Section 163.3178(2)(f), F.S. Policies will include examples of strategies, principles, and related engineering solutions that reduce flood risk in coastal areas when resulting from high-tide events, storm surge, flash floods, stormwater runoff, and the related impacts of sea-level rise. Best practice development/redevelopment strategies will also be considered to include site development techniques and construction techniques that reduce losses due to flooding consistent with, or more stringent than, the flood-resistant construction requirements in the Florida Building Code. The overall goal is to reduce the risks associate with flooding and sea level rise.

City of Satellite Beach Resilience Initiatives

The depth and scope of a vulnerability assessment can vary significantly and will depend on community goals, the availability of data and information, resources to conduct the assessment, and individual interests of the jurisdiction and its residents. For the City of Satellite Beach, this means working continuously on sustainability efforts. Located on a barrier island—between the Atlantic Ocean and the Indian River Lagoon—the City is vulnerable to sea level rise, coastal erosion, flooding and storm surge.

In 2015, the City completed its first vulnerability assessment. This initial analysis examined flooding via the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and measured inundation for a 100-year storm. The analysis also examined storm surge for category 1 through 5 hurricanes, and sea level rise based on the Florida Department of Transportation (FDOT) Sea Level Rise Sketch Tool developed by the University of Florida (UF) GeoPlan Center using the Army Corps of Engineers (USACE) low, intermediate, and high projections for years 2040, 2070 and 2100 (relative to NAVD88 from Mean Higher High Water (MHHW).

However, as climate change exacerbates water-based hazards, the City will update their vulnerability assessment to include new data and projections via the Resilient Florida Grant program. In order to more accurately predict the impact of flooding, this updated assessment will provide insight to citizens, stakeholders, and policymakers. Under the requirements of s. 380.093, F.S.—and through updated methodologies, this vulnerability assessment will provide analysis and subsequent policy recommendations for City implementation and land use planning. This includes a review of the City’s Comprehensive Plan and the land development codes for compliance with the Peril of Flood statute (s. 163.3178, F.S.).

Image 2. State of Florida with marker to indicate Satellite Beach's general location.

Methodology

Data Collection

For each vulnerability assessment, the ECFRPC works with local and regional partners to identify assets, and provide quality control to ensure a robust dataset. Additional data includes the Florida Department of Emergency Management (FDEM) statewide critical facilities database, various other agency datasets provided by the Federal Emergency Management Agency (FEMA), and local governments (city and county). Regionally significant assets—which span multiple geopolitical jurisdictions—were also identified and include, but are not limited to, water resource facilities, regional medical centers, emergency operations centers, regional utilities, major transportation hubs and corridors, airports, and seaports. To identify regional assets, the ECFRPC used the jurisdictional county for which a city is located, or a neighboring county which may impact the overall analysis. Utilizing GIS, a standard database was developed and populated with asset data for consistency across the east central Florida region. In the process of researching background data, certain datasets listed as “critical assets” defined in section 380.093 were unavailable, or not provided do to the sensitivity of the information. This includes (but is not limited to) critical infrastructure such as potable/drinking water facilities, water utility conveyance systems, electric production, and supply facilities. Thus, some of this information is not publicly available, will not be included, and may limit the vulnerability assessment’s extent.

Critical Assets (as defined in F.S 380.093)

- Transportation assets and evacuation routes, including airports, bridges, bus terminals, ports, major roadways, marinas, rail facilities, and railroad bridges.
- Critical infrastructure, including wastewater treatment facilities and lift stations, stormwater treatment facilities and pump stations, drinking water facilities, water utility conveyance systems, electric production and supply facilities, solid and hazardous waste facilities, military installations, communications facilities, and disaster debris management sites.
- Critical community and emergency facilities, including schools, colleges, universities, community centers, correctional facilities, disaster recovery centers, emergency medical service facilities, emergency operation centers, fire stations, health care facilities, hospitals, law enforcement facilities, local government facilities, logistical staging areas, affordable public housing, risk shelter inventory, and state government facilities.
- Natural, cultural, and historical resources, including conservation lands, parks, shorelines, surface waters, wetlands, and historical and cultural assets.

Regionally Significant Assets

Regionally significant assets mean critical assets that support the needs of communities spanning multiple geopolitical jurisdictions, including, but not limited to, water resource facilities, regional medical centers, emergency operations centers, regional utilities, major transportation hubs and corridors, airports, and seaports (380.093 F.S.).

Section 380.093 F.S. Requirements

A vulnerability assessment conducted pursuant to s. 380.093, F.S. must encompass the entire county or municipality; include all critical assets owned or maintained by the grant applicant. Regionally significant assets must also be identified and include an exposure and sensitivity analysis. The following further explains the approach to the exposure and sensitivity analysis.

Exposure Analysis

The exposure analysis is performed to identify the depth of water-based hazards such as flooding and sea level rise. The analysis includes sea level rise and high tide flooding; current and future storm surge; and rainfall-induced flooding and compound flooding (if applicable). Data using the 2017 NOAA Intermediate-Low and Intermediate-High sea-level rise projections was used and includes two planning horizons for the years 2040 and 2070 (2100 was also included for SLR + storm surge). According to the 2022 Global and Regional Sea Level Rise Scenarios for the United States technical report by NOAA, the range includes a minimum rise of 1.75 (0.5m) feet by 2100 with an upper range of 6.08 (1.85m) feet by 2100 for the Contiguous United States. Additionally, the ECFRRAP scenarios were also used as these were adopted by Brevard and Volusia through previous planning documents. They include a minimum rise of 5.15 feet by 2100 (2013 USACE High) with an upper range of 8.48 feet by 2100 (2017 NOAA High).

Sensitivity Analysis (and Social Vulnerability)

The purpose of this analysis is to measure the impact of flooding on critical assets—and the surrounding community's dependence on those assets. The analysis includes an evaluation of the impact of flood severity on each asset type at each flood scenario and assigns a risk level based on percentages of land area inundated and number of critical assets affected. By applying the data from the inventory of critical assets and the exposure analysis, a community's sensitivity and social vulnerabilities will be measured. This is important because according to the Florida Adaptation Planning Guidebook (2018), "sensitivity can [also] be defined as the responsiveness of a system to hazard impacts"—and "provides an inventory of community assets, such as populations, structures, and economic functions, and quantifies and measures the impacts of sea level rise on those assets." Thus, the sensitivity analysis is an opportunity to identify not only critical assets, but the ability for people with fewer resources who are affected by flooding or sea level rise to access "community lifelines".

By utilizing a definition of risk as a function of hazard threat area (the spatial extent of past hazards and modeled future hazards, vulnerabilities (social and population), and severity of impacts—a method designed to empirically assess complex geospatial representations of threats and impact—the ECFRPC analyzed the impact of flooding on critical assets and the community. This is important because recognizing assets as community lifelines is vital to response, local government continuity of operations, economic functions, and health and safety. Social vulnerability is described as the ability to prepare for, respond to, and rebound from hazards (Cutter & Emrich, 2006). Since socially vulnerable populations often have fewer resources and take longer to recover from disasters—understanding where these populations are located, in relation to critical assets will allow decision-makers and emergency management responders to better understand where and how social vulnerabilities manifest in a community. Ultimately, the goal is to determine how flood hazards affect a community's ability to prepare for, recover from, and adapt.

As part of the sensitivity analysis, the ECFRPC employed a Social Vulnerability Index (SoVI) developed by Dr. Christopher Emrich (University of Central Florida). The Social Vulnerability Index predates a similar index created and supported by the CDC/ATSDR Social Vulnerability Index (CDC/ATSDR SVI) which utilizes 15 variables to ascertain community level social vulnerability. The UCF SoVI index leverages 29 socioeconomic variables derived from the U.S. Census Bureau's five-year American Community Survey (ACS) estimates[2], to more comprehensively identify the various ways in which social vulnerability manifests across the landscape. Here, Principal Component Analysis—a standard data reduction approach—converts the 29 input variables (Table 1) into a set of nine factors (Table 2) for the AOI. Resulting SoVi scores are then classified (low, medium, or high) based on standard deviations from the mean score and represent the main drivers of social vulnerability in the AOI. Here, a SoVI run for each county focuses only on the social indicators specific to that county (rather than the region) result in slightly different driving factors of social vulnerability in Volusia specifically. These factor descriptions highlight the socio-economics and demographic characteristics driving the SoVI in each county.

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[2] The input variables can be processed using the SoVI methods originally established at the University of South Carolina's Hazards & Vulnerability Research Institute (HVRI) by Dr. Susan Cutter.

Social Vulnerability Index Input Variables		
Variable	Description	Pillar
1	Percent Civilian Unemployment	Employment Structure
2	Percent Employment in Extractive Industries	Employment Structure
3	Percent Employment in Service Industry	Employment Structure
4	Percent Female Participation in Labor Force	Employment Structure
5	Percent Renters	Housing
6	Percent Mobile Homes	Housing
7	Percent Unoccupied Housing Units	Housing
8	Percent Population under 5 years or 65 and over*	Population structure
9	Percent of Children Living in 2-parent families	Population structure
10	Median Age	Population structure
11	Percent Female*	Population structure
12	Percent Female Headed Households*	Population structure
13	People per Unit	Population structure
14	Percent Asian*	Race/Ethnicity
15	Percent Black*	Race/Ethnicity
16	Percent Hispanic*	Race/Ethnicity
17	Percent Native American*	Race/Ethnicity
18	Percent Poverty	Socioeconomic Status
19	Percent Households Earning over $200,000 annually	Socioeconomic Status
20	Per Capita Income	Socioeconomic Status
21	Percent with Less than 12th Grade Education	Socioeconomic Status
22	Median Housing Value	Socioeconomic Status
23	Median Gross Rent	Socioeconomic Status
24	Percent of households spending more than 40% of their income on rent or mortgage	Socioeconomic Status
25	Percent Households Receiving Social Security Benefits*	Special Needs
26	Percent Speaking English as a Second Language with Limited English Proficiency	Special Needs
27	Nursing Home Residents Per Capita	Special Needs
28	Percent of population without health insurance	Special Needs
29	Percent of Housing Units with No Car	Special Needs

Table 1. *Indicates a characteristic tied to a protected class under The Civil Rights Act of 1991 (Pub. L. 102-166).[3]

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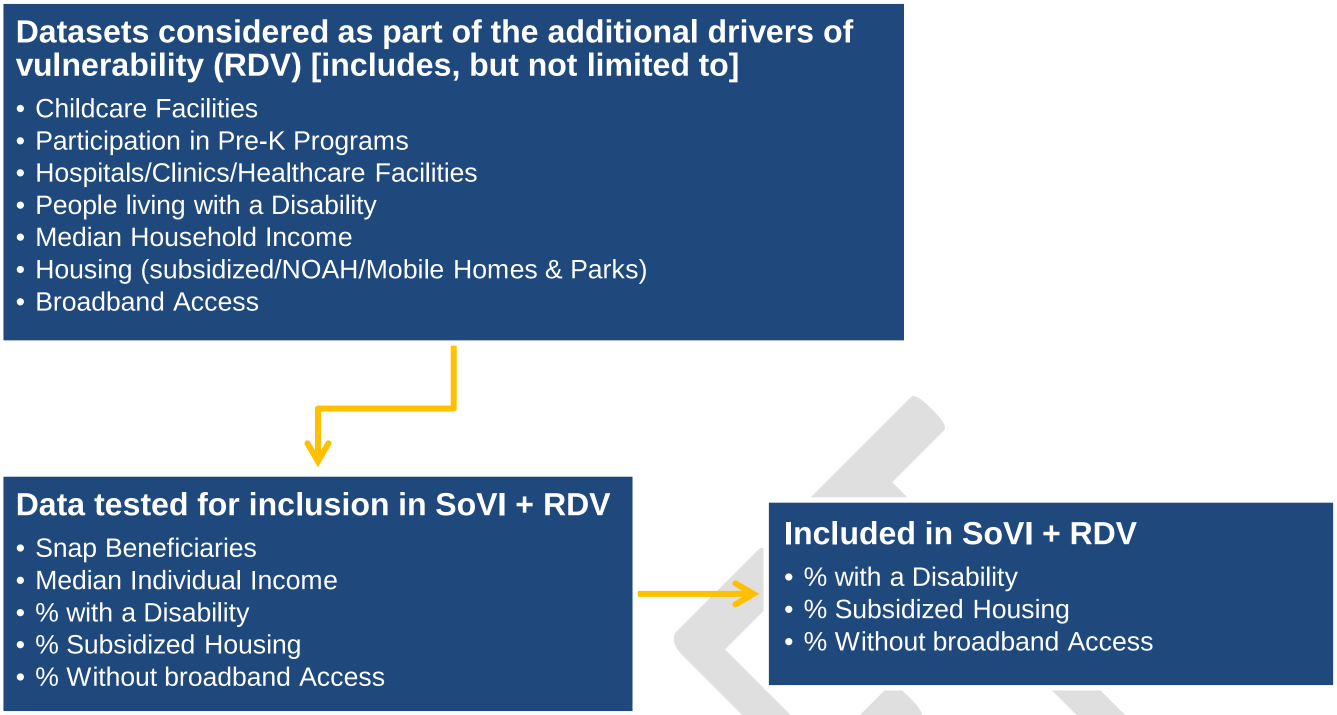
[3] In addition to considering protected class individuals in the SoVI analysis, PRDOH will also consider during implementation how assistance impacts beneficiaries that are classified as a protected class and shall consider HUD resources on racially and ethnically concentrated areas of poverty as published here: https://hudgis-hud.opendata.arcgis.com/datasets/56de4edea8264fe5a344da9811ef5d6e_0?geometry=-68.905%2C17.630%2C-64.845%2C18.544

Table 2. Brevard County Social Vulnerability Factor Descriptions

Vulnerability Influence		SoVi Social Vulnerability Index Factor Descriptions
Factor 1	▲	Age
Factor 2	▲	Social Status and Household Type
Factor 3	▲	Housing Tenure and Housing Cost Burden
Factor 4	▼	Wealth
Factor 5	▲	Race and Access Barrier
Factor 6	▲	Gendered Employment and Gender
Factor 7	▲	Employment Type and Employment
Factor 8	▲	Race and Housing Availability

Here, the second column shows the specific component influence on SoVI, describing if these variables increases (red up arrow) or attenuate (blue down arrow) social vulnerability. Volusia County has two components (Wealth and Race/Wealth) driving down vulnerability where the remainder of components drive up SoVI. The third column describes (in general terms) the variables most heavily influencing each component. These descriptions are generated based on only the top 2 (two) most influential variables and should only be used to gain a general understanding of how the component is defined. Together, these components describe social vulnerability across the area of interest—however it is important to recognize that SoVI manifests differently for every specific place—and in this case every census tract—across space. Factors driving social vulnerability in one place may not be the same as those driving social vulnerability in neighboring census tracts.

Three additional (regional specific) drivers of vulnerability have also been added and include datasets identified by the R2C Risk & Vulnerability Advisory Committee. These were selected from nearly twenty (20) additional variables (Figure 2) identified by the R2C for inclusion as Regional Drivers of Vulnerability (RDV) because they: (1) were measurable across the AOI at the census tract level; (2) did not correlate with any current SoVI indicators; and (3) were not part of an offshoot heat-related mitigation planning effort.



Datasets considered as part of the additional drivers of vulnerability (RDV) [includes, but not limited to]

- Childcare Facilities
- Participation in Pre-K Programs
- Hospitals/Clinics/Healthcare Facilities
- People living with a Disability
- Median Household Income
- Housing (subsidized/NOAH/Mobile Homes & Parks)
- Broadband Access

Data tested for inclusion in SoVI + RDV

- Snap Beneficiaries
- Median Individual Income
- % with a Disability
- % Subsidized Housing
- % Without broadband Access

Included in SoVI + RDV

- % with a Disability
- % Subsidized Housing
- % Without broadband Access

Figure 2. Additional Drivers of Regional Vulnerability *(does not include complete list of initial drivers).*

For the sensitivity analysis, a hexagonal grid (hex grid) is used to classify sensitivity by 0.25-square mile for the entire AOI. Hexagons and other regularly shaped features enable users and readers to normalize geography more easily for thematic mapping rather than be constrained to using irregular shaped polygons created from a political process (for example, county boundaries, census tracts, zip codes, flood plain boundaries, hurricane wind fields, tornado tracks, etc.). This is useful because of the massive disparity in some of these shapes (Esri, 2015) and the inability for people to understand and account for differences at various scales and from different input types. Utilizing a hex grid and applying different drivers for sensitivity and exposure, a standardized methodology of rating sensitivity from the regional level and the county level is applied.

Utilizing the equation below, each hexagon in the study area will be used as a bin to store and display information pertaining to each concept (flooding, SoVI, RDV, etc.) in a and measurable and easily understandable manner.

Sensitive Area (Sensitivity) *f* Present Day Flooding + SoVI + RDV + Population + Natural Attributes + Critical Assets

Present Day Flooding

Both the ECFRPC and Resilient Florida statute SLR projections, as well as the 100- and 500-year flood zones were utilized in determining each hex grid’s percent area exposed to flooding. Both the combined FEMA Flood Zones and storm surge up through category 3 was utilized to for sensitivity. Storm surge categories 4 and 5 are represented with a Yes (Y) or No (N) if the asset is exposed/sensitive to SLR + storm surge. Additional risks were considered by using the Florida Hydrography file and the RPC Lagoon File, to determine the total land versus water area of each hexagon. Next, a separate analysis was run to determine the percent land covered by each flood hazard. By doing this, the area of present-day flooding can be quantified in both the study area and each 0.25-mile hexagon. In the analysis the scores are as follows: 0% = 1 (Low), 1% - 24% = 2 (Medium Low), 25% - 50% = 3 (Medium), 51% - 75% = 4 (Medium High), and > 75% = 5 (High). To avoid counting flooding twice, the highest score for both flood hazards was used to determine sensitivity.

Social Vulnerability

Each census tracts' SoVI score was classified into five categories based on standard deviation from the mean where (Low = 1, Medium Low = 2, Medium = 3, Medium High = 4, High = 5). These were joined spatially into the respected hexagon. If a hexagon crosses multiple census tracts, the highest SoVI class will be noted and applied.

SoVI Score Standard Deviation	5-Class Rank
< -0.5	Low (1)
>= -1.0 and < -1.5	Medium Low (2)
>= -0.5 and < 0.5	Medium (3)
>= 0.5 and < 1.0	Medium High (4)
>1.0	High (5)

Table 3. SoVI Score classification method.

Regional Drivers of Vulnerability (RDV)

Building on the outcomes of a draft Regional Risk Assessment, additional Regional Drivers of Vulnerability (RDV) were included to determine social vulnerability. The three factors outside of SoVI for sensitivity are: disability, subsided housing, and lack of broadband access. Each of these factors were scored at both the regional and county extent, combined, and then standardized (1-5) using a Min/Max Standardization[4] method to receive a 1-5 score.

Population

Where SoVI identifies marginalized populations with less capacity to prepare for, respond to, and rebound from disasters, population density allows decision makers to understand not only the underlying infrastructure but the populations that those assets serve. To determine the population in each hexagon, census blocks via TIGER data was utilized. From there, the summarize within tool was used to count the population in each hexagon and then a score was generated for both the regional and county extent.

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[4] Min/max standardization method ((x-minx)/(max x – minx)*4)+1.

Natural Attributes

Because Florida is home to a unique variety of different and everchanging landscapes, each one provides a different risk when it comes to flooding. Starting at the baseline for land (without water), a score of 1 was assigned to quantify risks. The next features that were examined to determine sensitivity were lakes and wetlands (a score of 2), as both these features pose a risk to flooding during rain events. A score of 3 was assigned to each hexagon that touched a river system, since river systems pose a greater risk of flooding. A score of 4 was given to any hexagon touching the coast line or the lagoon system. And finally, a score of 5 was used for all areas along the coastline and lagoon marked critically eroded via the FDEP.

Scores for each facet of susceptibility were then summed and standardized (1-5) added using a Min Max standardization, resulting in a score (1-5) for each hex grid representing susceptibility (low – high). Each piece of critical infrastructure will receive its inundation depth from a Category 1 storm. This depth will then be quantified and combined with the resulting score from SoVI + Population + Present Day Flooding + Critical Asset to determine the present-day risk of each critical asset.

Sea Level Rise and High Tide Flooding Analysis and Methodology

The following provides a detailed description of analyses utilized to produce spatialized assessments of regular high tide flooding in Brevard County, Florida, in the years 2020 (contemporary), 2040 and 2070. These assessments were developed based upon analysis of historical measurements at the Trident Pier tide gauge (NOAA 2023), which were extrapolated across four different sea-level rise (SLR) projection scenarios: 1) NOAA (2017) Intermediate-Low; 2) NOAA (2017) Intermediate-High; 3) USACE (2013) High; and 4) NOAA (2017) High.

Use of the 2017 NOAA (2017) Intermediate-Low and NOAA (2017) Intermediate-High projection scenarios follows the direct statewide guidance provided by Florida Statute 380.093 for conduct of the “comprehensive statewide flood vulnerability and sea level rise data set and assessment.” Use of the USACE (2013) High and NOAA (2017) High projection scenarios follows the minimum and maximum regional guidance for SLR vulnerability assessments as recommended through the East Central Florida Regional Resiliency Action Plan (ECFRPC 2017). A summary of these four assessed SLR curves at the assessed time step increments is provided as Table 1.

	2020	2040	2070
NOAA (2017) Intermediate Low	0.37	0.73	1.29
USACE (2017) High	0.50	1.22	2.85
NOAA (2017) Intermediate High	0.66	1.48	3.35
NOAA (2017) High	0.80	1.85	4.47

Table 1. Sea-Level Rise Projections for Trident Pier Tide Gauge, as feet above 1992 mean sea level (MSL).

Tide Gauge Assessment

The tide gauge data analysis for this assessment is based solely on the NOAA (2023a) Trident Pier tide gauge. Trident Pier is located in Brevard County at Port Canaveral, with an establishment date of October 13, 1994, and is the closest NOAA tide gauge to all coastal areas located within Brevard County. The nearest NOAA gauge to Trident Pier is approximately 125 miles to the south at Lake Worth Pier, near West Palm Beach.

The 1992 MSL at Trident Pier is defined by NOAA as 0.95 feet below the North American Vertical Datum of 1988 (NAVD88). The 1992 MSL at Lake Worth Pier is defined by NOAA as 0.97 feet below NAVD88, which is 0.02 feet lower than the MSL set for Trident Pier. Our sole use of Trident Pier—i.e., without use of interpolation between Trident Pier and Lake Worth Pier—is therefore in compliance with standards set by Florida Statute 380.093 (3)(d)3.d., which states that “(l)ocal sea level data may be taken from one such (tide) gauge if the gauge has a higher mean sea level” than the two nearest tide gauges to the community of interest.

Tidal Flooding Thresholds

NOAA has established thresholds for “Minor”, “Moderate”, and “Major” tidal flooding heights at most U.S. tide gauges (Sweet et al. 2021). These tidal flooding heights are defined by NOAA as relative to the 1992 mean higher high water (MHHW) datum. A summary of these flood heights, relative to MSL, NAVD88, and MHHW at Trident Pier in shown in Table 2.

	MSL	NAVD88	MHHW
Minor	3.81	2.86	1.76
Moderate	4.77	3.82	2.72
Major	6.02	5.07	3.96

Table 2. NOAA Tidal Flooding Thresholds for Trident Pier Tide Gauge, as feet above the given datum.

Trident Pier Tide Gauge Assessment and Projections

To develop an historical assessment and future projections of tidal flood behavior at Trident Pier tide gauge, we first downloaded the full record of daily high tide event heights recorded since the tide gauge was first installed. Because Trident Pier has semidiurnal behavior (i.e., usually shows two high and low tides each day), we further filtered the high tide events to only include the highest tide recorded on each day within the record. Consistent with Florida Statute 380.093 (3)(d)2.a., this filtering standardizes the unit of flood event analysis as “tidal flood days.”

Historical Tidal Flooding Events

By applying the thresholds shown in Table 2, we calculated annualized tidal flooding days recorded at Trident Pier over the period of November 1, 1994 – October 31, 2021. A visualization of these results, shown in Figure 2, indicates the generally increasing trend of minor tidal flooding events at Trident Pier over the historical gauge record. The increased occurrence of minor tidal flooding events is consistent with an observed trend of rising sea levels at Trident Pier and other tide gauges throughout Florida and most other areas of the world.

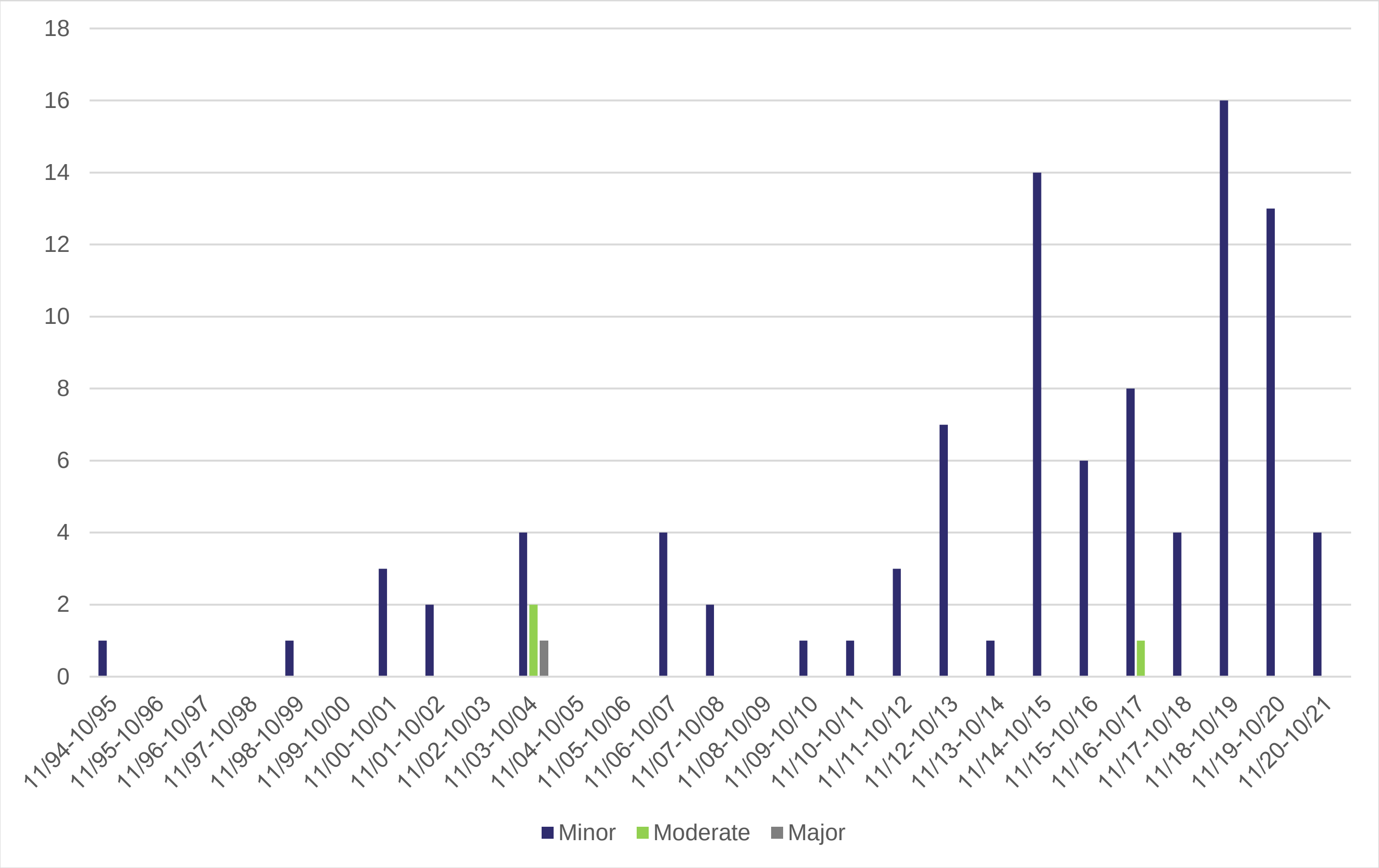

Figure 3. Annualized Tidal Flooding Events at Trident Pier, November 1994–October 2021.

Projections of Future Tidal Flooding with Sea-Level Rise

NOAA utilizes the 19-year “Metonic cycle” as the standard basis for determining and re-evaluating tidal datums, as defined through the National Tidal Datum Epoch. The Metonic cycle essentially rounds up the 18.61-year nodal tidal cycle, in which highly predictable changes in the declination of the moon across the time period are known to drive natural variations in tidal amplitude across the globe (e.g., Peng et al. 2019).

When conducting projections of future sea level conditions, it is crucial to account for the known astronomical variations through the entirety of the 19-year tidal cycle. For this reason, we developed our projections of future tidal flooding at the Trident Pier tide gauge through use of daily high tide data for a 19-year reference period covering November 1, 2002, through October 31, 2021, which corresponds to a full Metonic cycle.

Another crucial consideration for using historical tide gauge data as the basis for making future SLR projections is to normalize the secular trend associated with historical sea-level rise that occurred between 1992 and 2020. Failure to remove this secular trend when using the tide gauge to project impacts forward introduces some element of double-counting, which can lead to overestimates of future flood risk.

This normalization was performed by first calculating a daily SLR projection, as feet relative to 1992 MSL, for each SLR scenario through a modification of Equation 2 from USACE (2013):

$$E(t) = at + bt^2$$

Where, t is days from January 1, 1992;

a is a constant representing the historical trend of SLR, as feet per day;

b is a rate constant calculated for each SLR scenario, as feet per days squared;

and $E(t)$ is eustatic sea-level rise as feet

For the background historical trend of SLR, we utilized the published value of 0.76 ft/100 years as calculated for the Daytona Beach Shores tide gauge (Evans et al. 2019), resulting in a constant value of 0.0000208 for “a” across all scenarios. Values for “b” were then solved for each sea-level rise projection scenario based on the given SLR value for the projection being reached at December 31, 2070 ($t = 28854$). Values for “b” for each projection scenario are summarized in Table 3.

Projection Scenario	Calculated Rate Constant “b”
NOAA (2017) Intermediate-Low	8.593e-10
USACE (2013) High	3.397e-9
NOAA (2017) Intermediate-High	2.781e-9
NOAA (2017) High	4.777e-9

Table 3. Daily Rate Constant b by Sea-Level Rise Projection Scenario.

Over the 19-year reference period, we used the daily calculated E(t) for each projection scenario to normalize all observed daily high tides to a standard baseline condition (January 1, 1992, or t=0). This is accomplished through the following equation:

$$T_{\text{norm-SLRS}} = T_t - E(t)_{\text{SLRS}}$$

Where T_t is the observed highest high tide on day t, as feet above NAVD88 at Trident Pier;

$E(t)_{\text{SLRS}}$ is the calculated SLR projection at day t, as feet, under the given sea-level rise scenario projection (SLRS);

$T(t)_{\text{norm-SLRS}}$ is tide height at day t, as feet above NAVD88, normalized to the MSL condition of

t=0 under the given sea-level rise scenario projection (SLRS)

After the full set of $T(t)_{\text{norm-SLRS}}$ values were calculated for the 19-year reference period, we then used these normalized historical tide values as the basis for creating a simulation of future tide heights across all days spanning a projection period of November 1, 2021, through December 31, 2100. The normalized data from the 19-year reference period were simply “looped” such that the entirety of the 79-year projection period is covered by the reference period data. For example, the simulated use of the normalized data for October 31, 2021, on the projection date of October 31, 2040, is followed by the normalized data for November 1, 2002, on the projection date of November 1, 2040.

To obtain future daily tide height projections in the projection period from the daily normalized tide heights, we applied this equation for each SLR scenario projection:

$$T(t)_{\text{proj-SLRS}} = T_{\text{norm-SLRS-ref-}t} + E(t)_{\text{SLRS}}$$

Where $T_{\text{norm-SLRS-ref-}t}$ is the normalized reference tide height, as feet above NAVD88 and as assigned at day t, for the given sea-level rise scenario (SLRS);

$E(t)_{\text{SLRS}}$ is the calculated SLR projection at day t, as feet, under the given sea-level rise scenario projection (SLRS);

$T(t)_{\text{proj-SLRS}}$ is the projected daily tide height, as feet above NAVD88, as adjusted to the given sea-level rise scenario projection

Importantly, we do recognize that this future tide height projection exercise is not based upon specific astronomical tide predictions tied to each date. Instead, the method uses actual tide height data from the gauge record as a proxy for projecting how future tidal behavior will be affected by sea-level rise at an aggregate level over time. The advantage of utilizing actual tide data in this way is that effects of wind speed, direction, and other environmental condition—none of which can be predicted at a daily basis far into the future in the way that lunar movement and associated astronomical tides can be – are inherently incorporated into the long-term tide gauge record. As such, this method provides a robust, data-driven basis for projecting how tide height behavior at Trident Pier would be affected by different rates of sea-level rise, as well as developing aggregated statistical assessments about this behavior. However, we do caution that the projected tide heights absolutely should not be interpreted as in any way making specific predictions about expected tide behavior on any listed days within the projection period, and that such specific predictions are in not in any way an implied or intended use of this analysis.

Tide Height Exceedance Analysis

After calculating a full suite of projected daily tide heights for each SLR scenario, we then conducted an annualized daily tide height percentile analysis centered around the years 2040 (assessment period from 2030-2049) and 2070 (assessment period from 2060-2079). We assessed annualized tide heights at the percentile levels of 99.75% (level exceeded ~1 day per year), 99% (level exceeded ~4 days per year), 98% (level exceeded ~7 days per year), 95% (level exceeded ~18 days per year), 90% (level exceeded ~36 days per year), 75% (level exceeded ~91 days per year), and 50% (level exceeded ~182 days per year). A summary of the calculated percentile values for each SLR scenario in projection year 2040 is provided in Table 4. Similar percentile values in projection year 2070 are provided in Table 5.

	NOAA (2017) Intermediate Low	USACE (2013) High	NOAA (2017) Intermediate High	NOAA (2017) High
99.75%	3.55 (2.45)	4.08 (2.98)	4.30 (3.20)	4.80 (3.70)
99.00%	3.31 (2.21)	3.83 (2.73)	4.02 (2.92)	4.49 (3.39)
98.00%	3.13 (2.03)	3.67 (2.57)	3.86 (2.76)	4.32 (3.22)
95.00%	2.83 (1.73)	3.37 (2.27)	3.56 (2.46)	3.99 (2.89)
90.00%	2.55 (1.45)	3.07 (1.97)	3.25 (2.15)	3.66 (2.56)
75.00%	2.12 (1.12)	2.62 (1.52)	2.78 (1.68)	3.17 (2.07)
50.00%	1.65 (0.55)	2.14 (1.04)	2.31 (1.31)	2.67 (1.57)

Table 4. Percentile Analysis for High Tide Heights at Trident Pier by Sea-Level Scenario in 2040, as feet above NAVD88 and MHHW (in parentheses).

	NOAA (2017) Intermediate Low	USACE (2013) High	NOAA (2017) Intermediate High	NOAA (2017) High
99.75%	4.30 (3.20)	5.92 (4.82)	6.47 (5.37)	7.70 (6.60)
99.00%	4.05 (2.95)	5.66 (4.56)	6.18 (5.08)	7.37 (6.27)
98.00%	3.82 (2.72)	5.42 (4.32)	5.94 (4.84)	7.14 (6.04)
95.00%	3.52 (2.42)	5.08 (3.98)	5.59 (4.49)	6.80 (5.70)
90.00%	3.27 (2.17)	4.81 (3.71)	5.31 (4.21)	6.47 (5.37)
75.00%	2.84 (1.74)	4.37 (3.27)	4.86 (3.76)	5.98 (4.88)
50.00%	2.36 (1.26)	3.87 (2.77)	4.35 (3.25)	5.42 (4.32)

Table 5. Percentile Analysis for High Tide Heights at Trident Pier by Sea-Level Scenario in 2070, as feet above NAVD88 and MHHW (in parentheses),

Digital Elevation Model (DEM) & VDatum Adjustment

The digital elevation model (DEM) we used for this project is a LIDAR-based grid provided by the East Central Florida Regional Planning Council with vertical elevations in feet, as referenced to NAVD88. To develop map visualizations of tidal flood heights across all oceanic and estuarine areas of Brevard County, we utilized the NOAA (2023b) VDatum (v4.5.1) tool and ArcGIS to develop an interpolated adjustment of NAVD88 to MHHW. The VDatum tool is specifically designed to allow for seamless conversions into more directly comparable reference systems, and this adjustment from NAVD88 to MHHW provides a basis for more accurate visualizations of tide heights throughout the entirety Brevard County relative to both the Trident Pier tide gauge and NAVD88. The Indian River Lagoon system in Brevard County shows particularly wide spatial variations in tidal amplitude relative to Trident Pier and in mean sea level relative to NAVD88, making a VDatum conversion into MHHW desirable as a means of applying a consistent “regular” high water datum reference across otherwise quite hydrologically divergent systems.

Tidal Flood Days Visualization

To develop the tidal flood days visualizations, we used ArcGIS 10.5 to select all cells from the DEM with VDatum adjusted values lower than the 99.75% MHHW thresholds noted for all scenarios in Table 4 & Table 5. A hydrologic connectivity filter was then utilized to remove all cells from the selections that were not directly connected to an ocean or estuary through other selected cells. Elevation values in each remaining cell were then reclassified into a projected tidal flood days per year using the values summarized in Table 6.

Percentile	Days Exceeded Per Year
99.75%	1
99.00% - 99.74%	1 - 3
98.00% - 98.99%	3 - 7
95.00% - 97.99%	7 - 18
90.00% - 94.99%	18 - 36
75.00% - 89.99%	36 - 91
50.00% - 74.99%	91 - 183
<50%	>183

Table 6. Conversion of tidal flood height percentile values into days exceeded per year.

Annual Tidal Flood Depth Visualization

To develop the tidal flood depth visualizations, we used the hydrologically connected selections from the MHHW-based DEM at the 99.75% tidal flood height thresholds for all projection scenarios, as listed in Table 4 and Table 5. We then used the Raster Math function in ArcGIS 10.5 to subtract the MHHW-based DEM values from the 99.75% tide height thresholds for each projection scenario. The difference between the 99.75% tide height projection and the DEM-based elevation is the projected flood depth at each selected cell.

Additional Considerations

The other closest other Atlantic tide gauge (besides Trident Pier) to much of Volusia is the Mayport gauge near Jacksonville. From a regional planning/policy perspective, Trident Pier was used for Volusia, since Volusia and Brevard are both in the ECFRPC's service zone. Using another tide gauge from outside the service area would, likely add confusion, without gaining much (if any) different geophysical information. Furthermore, Trident Pier includes tidal flooding thresholds (relative to MHHW) that are almost the same as they are for Mayport. And the future forecasts that NOAA has developed for Trident Pier and Mayport are also similar. In fact, NOAA projects that Trident Pier will have just a bit more tidal flooding than Mayport in 2030 (7-15 days for Trident Pier; 5-10 days for Mayport) and 2050 (25-65 days for Trident Pier; 20-65 days for Mayport). As a result, the analysis would likely produce similar result if the tide gauge at Mayport were assessed in a similar way to the Trident Pier.

Coastal Erosion and SLR

Critically Eroded Beaches and Florida's Strategic Beach Management Plan

In 1986, pursuant to Sections 161.101 and 161.161, Florida Statutes (F.S.), FDEP was charged with the responsibility to identify those beaches of the state which are critically eroding and to develop and maintain a comprehensive long-term management plan for their restoration. The long-term management plan has several components that the department implements including the Critically Eroded Beaches Report and the Strategic Beach Management Plan.

The department, pursuant to rule 62B-36.002(5), Florida Administrative Code (F.A.C.), defines "critically eroded shoreline" as, "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 shorelines 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" (FAC R 62B-36.006).

The critical erosion report provides an inventory of Florida's erosion areas on the 825 miles of sandy beaches fronting the Atlantic Ocean, Straits of Florida, Gulf of Mexico and the roughly 66 coastal barrier tidal inlets. This report is periodically updated to include additions and deletions. When planning for future initiatives beyond the date of this report's publication, readers may wish to visit the department's webpage to ensure use of the most up-to-date information. And while many of the designated critically eroded beaches have been restored through the placement of beach and dune fill material [—nearshore sand supply is diminishing and moving/replacing sand is expensive] (FDEP, 2022).

Long-term holistic beach management will require policies that direct populations away from shorelines, high coastal hazard areas, coastal barrier islands—any place susceptible to flooding, sea level rise or erosion. First, armoring activities such as permanent structures have exacerbated erosion and resulted in loss of the beach and its ecosystems. Next, inlets cause erosion because of sand that builds up in the channel. Florida statute s. 161.142, recognizes "that inlets interrupt or alter the natural drift of beach-quality sand resources, which often results in these sand resources being deposited in nearshore areas or in the inlet channel, or in the inland waterway adjacent to the inlet, instead of providing natural nourishment to the adjacent eroding beaches" (F.S. 161.142). Additionally, as seen with Hurricanes Ian and Nicole—tropical storms and extreme weather also cause rapid loss of sand on Florida's beaches. And finally, SLR will contribute to erosion. Because Florida's topography and beaches are relatively flat, increased sea levels will cause waters to migrate inward, contributing to shoreline recession.

Coastal Construction Control Line (CCCL)

CCCLs are established in 25 of Florida’s coastal counties with sandy beaches, and may be re-established if a county’s shoreline conditions change dramatically due to historic erosion or hurricanes and other large storms. The CCCL location is based on coastal engineering models, survey and bathymetric data and scientific principles that determine the upland or landward extent of the damaging effects of a 100-year storm event.

However, it is worth noting that there are problems with the CCCL. According to Ruppert (2008), “while Florida’s current CCCL permitting program has increased the safety of new structures built in the coastal zone, it fails to adequately protect the ability of the beach to migrate, fails to account for SLR, and encourages increased development due to beach nourishment. These failings have resulted in increased development subject to both immediate coastal hazards and the long-term problems of SLR” (Ruppert, 2008). Though there is a lack of uniformity on how CCCLs are managed county-by-county, FDEP’s Critically Eroded Beaches data and the CCCL will be used in this report as a baseline for erosion to indicate additional risk caused by SLR and storm surge (Image 4).

Coastal High Hazard Zone

Section 163.3177(6)6., F.S., requires that local governments limit public expenditures that subsidize development in Coastal High Hazard Areas, and Section 163.3177(6)(a)10.a., F.S., requires that local governments designate Coastal High Hazard Areas on their future land use map series. Many local comprehensive plans and land use codes have objectives and policies which limit or restrict residential density, the type of development allowed, establish special building requirements, and that limit the use of public funds within the Coastal High Hazard Area. The statute lists provisions that a coastal management element must include to comply with state coastal high-high hazard area protections. The element must ensure that: 1) the adopted level of service for an out-of-county hurricane evacuation is maintained for a category 5 storm event as measured on the Saffir-Simpson scale, or 2) a 12-hour evacuation time to shelter is maintained for a category 5 storm event as measured on the Saffir-Simpson scale and shelter space reasonably expected to accommodate the residents of the development contemplated by a proposed comprehensive plan amendment is available.

Hurricane Nicole Before and After (November 2022)

Image 3. Satellite Beach—Before Hurricane Nicole, 2022.

Image 4. Satellite Beach—Erosion after Hurricane Nicole, 2022.

Image 5. Satellite Beach Coastline with Homes—Before Hurricane Nicole, 2022.

Image 6. Satellite Beach Coastline with Homes—Erosion after Hurricane Nicole, 2022.

Exposure Analysis Findings

Transportation

The City of Satellite Beach is bound by two major corridors. State Road (SR) 404, also known as Pineda Causeway and S. Tropical Trail SR 513. Within the city limits, there are several roads that are owned/maintained by the city that currently experience or will experience impacts from flooding or sea level rise. They include: Shearwater Parkway, South Patrick Drive, Cassia Boulevard, and Desoto Parkway. Additionally, SR A1A, a major north-south corridor will be impacted by flooding or SLR.

Critical Infrastructure

Most of the infrastructure in the city was installed prior to current design standards and does not meet the level of service required today. The City's stormwater conveyance system has been updated when/where applicable, but many pipes are smaller and are being impacted by rainy day flooding, higher tides, and age.

Critical Community and Emergency Facilities

Generally, the city owns/maintains key community facilities such as city hall, the Civic Center, and Public Works. Emergency/law enforcement facilities include the new Fire Station and Police Station. There are also public schools within the city's boundaries that serve the city as well as neighboring cities. They include Surfside Elementary School and Satellite Beach High School. Emergency medical services and emergency management facilities are generally located outside the city's boundaries, but within Brevard County.

Natural, Cultural, and Historical Resources

Natural and cultural resources within the city consist of a number of outdoor recreational facilities. They include: Satellite Beach Skate Park, Samsons Island, Satellite Beach Dog Park and Pelican Beach Conservation Area. The city has also worked to purchase 40% of the shoreline along the Atlantic Ocean for preservation and conservation.

Sensitivity Analysis Findings

Social vulnerability describes an area’s capacity to prepare for, respond to, and rebound from disaster events (Cutter & Emrich, 2006), and has a long conceptual and theoretical history in social and disaster science fields (Birkmann, 2013). Socially vulnerable populations have fewer resources to aid in preparation for disasters, often bear the brunt of disaster impacts, and take longer to bounce back from disaster events. Empirical measures of social vulnerability enable decision makers and emergency managers to understand where vulnerable populations reside and how that vulnerability manifests across a landscape. Augmenting these variables with additionally local social vulnerabilities, such as disabled, homeless, or lack of broadband can provide additional insights on area specific vulnerabilities.

Driven by the R2C Risk & Vulnerability Advisory Committee, additional drivers of vulnerability were incorporated in the baseline SoVI for each county in the region and the region on the whole. These drivers include: disabled populations; lack of broadband access; and subsidized housing. This is important because FEMA recognizes the importance of “community lifelines” and the connection to critical infrastructure. As climate change exacerbates hazards, people may experience severity of consequence, which assesses single hazards and the frequency of events, and relates those vulnerabilities to an individual’s or place’s level of risk. Under a framework that aligns the FEMA community lifelines with the R2C’s risk assessment—the sensitivity analysis will consider not only the critical assets required by statute, but will build on the exposure analysis to include socioeconomic factors that may make certain populations more vulnerable and less able to prepare for, respond to, and rebound from chronic shocks and stressors related to flooding and sea level rise.

Image 7. FEMA Community Lifelines graphic (source: FEMA).

Using a weighted methodology, the sensitivity analysis considered each water-based hazard and social vulnerability to determine a baseline—and added additional factors such as critical erosion to determine an asset’s level of exposure and risk. As factors become more severe, risks increase thus determining sensitivity. For example: **SoVi + RDV + Population + Flooding + Natural Attributes (Vulnerable Landscapes) = Sensitive Areas (Sensitivity Analysis).**

Conclusion & Recommendations

According to the *Florida Adaptation Planning Guidebook,* adaptation and implementation strategies are important components of adaptation planning in the face of sea level rise, flooding and climate change. This framework provides an opportunity for how a city responds to the findings of the vulnerability assessment. Adaptation strategies should assess and identify the impacts that are likely to affect planning activities, sustainable or resilient development goals, and actions that best minimize losses to both the natural and built environment. Ultimately, the goal is to ensure that communities understand their baseline risks; are educated on the actions required; have the tools to take action; and have a plan of action in response to flood hazards.

And because, Florida is susceptible to many types of hazards, prioritizing adaptation or planning needs is key. Within this assessment, prioritization will be guided by the sensitivity analysis and may include strategies that are categorized as short-term or long-term; or on a scale that includes: protection; accommodation; retreat; or avoidance[5]. This will also help prioritize funding and projects eligible for Resilient Florida's implantation grants. The importance here, is that proper planning can accelerate and leverage both state and Federal disaster assistance resources.

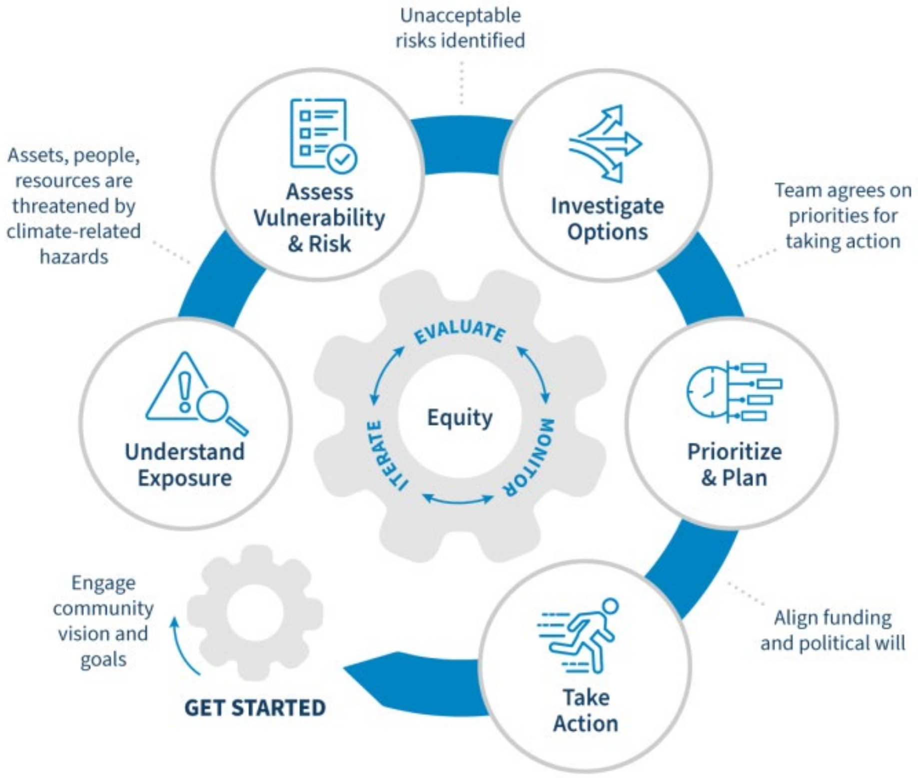

Image 8. Steps to Resilience—framework from the U.S. Climate Resilience Toolkit.

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[5] *Adaptation Planning Guidebook*: Identify Adaptation Strategies, p. 38.

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