Manual of Standardized Methodologies, Reporting, and Resources for Vulnerability Assessments in Northeast Florida

Second Edition (August 2024)

This manual was designed by the Northeast Florida Regional Council to complement the *Standardized Vulnerability Assessment: Scope of Work Guidance* from the Florida Department of Environmental Protection (FDEP). It provides additional recommendations on methodologies, reporting, and resources for Vulnerability Assessments in Northeast Florida (Baker, Clay, Duval, Flagler, Nassau, Putnam, and St. Johns Counties and their municipalities). These recommendations should be considered as best practices rather than mandated standardization. This manual also provides a robust set of resources for obtaining data, visualization tools, models, and other assessment tools. The first edition of this manual was one product of the FDEP Resilient Florida-funded grant 23RRE01: COORDINATING VULNERABILITY ASSESSMENTS AMONG NORTHEAST FLORIDA JURISDICTIONS. The purpose of the project was to standardize methodologies and reporting, improve communications, and compile a clearinghouse for regional approaches to Vulnerability Assessments.

The manual was developed using a 4-step process, which was similarly repeated for the second edition:

1) Compile and analyze existing vulnerability assessments inside the region—and outside the region, if applicable. Identify commonalities and discrepancies among vulnerability assessments already completed or underway to determine best practices. Create an inventory of existing vulnerability assessments and summarize their methodologies with the input of the Regional Resilience Collaborative; highlight commonalities and discrepancies; extract best practices that fit requirements within the FDEP guidebook.

2) Compile and assess existing models that may be used for exposure and sensitivity analyses. Compare and contrast features of existing models that may be used for exposure and sensitivity analyses. Access publicly available descriptions of existing models suggested by the Regional Resiliency Collaborative; create an inventory and summarize their features; assess the pros and cons of each model.

3) Hold meetings with all relevant staff from each jurisdiction to improve coordination. Allow all jurisdictions to provide input on how they are conducting their vulnerability assessments, any lessons learned, and recommendations for others as they move forward.

4) Develop regionally applicable methodologies and reporting. Synthesize information from previous tasks to develop an optional set of regionally applicable methodologies and reporting. Compile and analyze all information obtained with the input of the Regional

Resiliency Collaborative; identify commonalities and practices with useful results to standardize.

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Outline of Methodologies and Best Practices

Methodology

- Sea-Level Rise Projections
- Flooding
- Rainfall
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- Critical and Regionally Significant Assets
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- Spatial Estimate of Future Flood Risk
- Groundwater Impacts (if relevant)
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- Extreme Rainfall Model

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- In-Person Meetings
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Application

- Identify Strategies, Policies, and Resources
- Communicate with Government and Residents
- Implementation and Adaptation

Methodology

- Sea Level Rise Projections
    - The NOAA 2017 Intermediate High projections for 2040 and 2070 are commonly used to predict sea level rise. ACOE Intermediate/NOAA Intermediate Low and ACOE High scenarios for 2040 and 2060 have also been used, as has the U.S. Army Corps of Engineers Sea Level Change Curve Calculator. For this region, the Mayport Bar Pilots Dock NOAA tide gauge No. 8720218 is most often used as a point of reference.
    - Other tidal gauges have been used in Vulnerability Assessment (applicable to VA's funded by the FDEP) throughout the region, but they require express permission from the Florida Department of Environmental protection in order to be accepted as a grant deliverable if the assessment was funded through Resilient Florida program.
    - The Florida Department of Environmental Protection, under the Resilient Florida Program requires Vulnerability Assessments initiated after July 1, 2024 utilize the 2022 NOAA intermediate-low and intermediate sea level rise projections.
    - Sea Level Rise Projection years used in VAs vary based on location and data available. Years such as 2035, 2065, and 2100 were included in projections; however other cities used years away, such as 25, 50, and 100 to determine sea level rise scenarios. Other counts used community input and incremental approaches to decide on the future time frame for projections. Per HB1557, the planning horizon projections of sea level rise are based on when the vulnerability assessments is initiated. The projections are now:

Assessment Year	20-year horizon	50-year horizon
■ 2024	■ 2040	■ 2070
■ 2029	■ 2050	■ 2080
■ 2034	■ 2055	■ 2085
■ 2039	■ 2060	■ 2090
■ 2044	■ 2065	■ 2095
■ 2049	■ 2070	■ 2100

    - Location determined how to approach sea level rise projections. For example, Mayport used four critical segments on roadway A1A to highlight possible sea level rise scenarios.
    - Sea levels in Florida are rising faster than areas in other parts of the country. Additionally, sea levels in Florida are rising faster than they previously were. The

Florida Department of Environmental Protection states, "The rate of sea-level rise has increased from the 19th century to the 20th, and for the past 20 years the rate of global sea-level rise has been about 80% faster than the best estimate of the United Nations' Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report released in 2001…Recent estimates of melt-water contributions support a sea level in 2100 that is significantly higher than projected by the last IPCC,"
(https://floridadep.gov/sites/default/files/Climate%20Change%20and%20Sea-Level%20Rise%20in%20Florida_1.pdf).
The IPCC has since released 3 additional assessments, the most recent being the 6th released in March of 2023. The projections released in this assessment are even greater than identified in the previous assessments. As such, it is recommended to use additional sea level rise projections beyond only intermediate and intermediate-low, which are the minimum requirements for the Resilient Florida Program as of July 2024.

- Sea level rise has been shown to worsen and exacerbate the overall flood conditions and frequencies in multiple counties by a variety of tools, such as those from the Federal Transit Administration, as found in their FTA Resilience Guidebook, last updated May of 2024.
(https://www.transit.dot.gov/sites/fta.dot.gov/files/2024-05/TPE-FTA-Resilience-Guidebook-05-29-2024.pdf)
- It is recommended that all VAs go to at least 100 years for adequate sea level rise projections.

- Flooding
  - FEMA's Flood Insurance Rate Maps (FIRMs) can be used to highlight the possible impacts a 100- and 500-year flood could have on the community. The FIRMs are official flood maps used in the National Flood Insurance Program and mark the Special Flood Hazard Areas (SFHAs), the Base Flood Elevations (BFEs), and the risk premium zones applicable to the community.
    - 100- and 500-year flooding simply represent the percentage chance of a storm event happening in any given year. For example, there is a 1% chance in any year that a 100-year flood will happen. This does not preclude it from happening multiple times a year, it is just probability for estimating the chance of occurrence.
  - Tidal Flooding
    - Tidal flooding is also referred to as "high tide," "sunny day," or "nuisance" flooding. NOAA classifies it as "minor tidal" flooding.
    - Tidal flooding measures how much water levels exceed the average water levels for a specific location. It is expressed as water height above the mean higher high water (MHHW) tidal datum.

        - Tidal flooding data can be sourced from NOAA Flood Frequency data, NOAA's Digital Coast tool, or the NOAA Sea Level Rise Viewer. However, it may be necessary to use the information from the nearest local NOAA tide gauge(s) to determine tidal flooding. Information from the Sea Level Rise Viewer must be added onto this. Most of the VAs in the region have used the Mayport Bar Pilots Dock NOAA tide gauge No. 8720218. Other Vulnerability Assessments in the region have utilized the Trident Pier gauge, No. 8721604 for Flagler County, the Fernandina Beach gauge No. 8720030 for Nassau County or combinations thereof to ensure accurate tidal measurements.
        - Using alternative tidal gauges on Vulnerability Assessments in the region requires advance approval from the Florida Department of Environmental Protection (FDEP), if funded by the Resilient Florida Grant Program.
    - Compound Flooding
        - Compound flooding occurs when multiple different flood hazards occur at the same time. Some Vulnerability Assessments in the region have projected compound flooding by combining storm surge flood risk maps with rainfall induced inundation maps.
        - The Florida Department of Environmental Protection does not currently reference specific requirements, components, or methodology for conducting a compound flooding analysis. All Vulnerability Assessments funded through the Resilient Florida Grant Program require some level of compound flooding analysis. This document will be updated with guidance to supplement official requirements from the FDEP when they become available.
        - Extensive research and resources are being focused on the causes, effects, and mitigation of compound flooding. Duval County, coupled with DELTARES and The Water Institute are actively collecting data, and developing methodology in order to be able to generate real-time models for specific compound flood events along the Jacksonville coast and up the St. Johns River. Once this system is in place, getting other communities added will be a priority for the NEFRC, the more communities that join, the overall cost of the project will be reduced.
        - Compound flooding cannot be quantified simply by combining specific effects and adding the depths as the fluid dynamics of multiple concurrent storm events are not linear.
        - A consensus on a specific methodology on how to model and display compound flooding event does not yet have consensus and has not yet been codified. This manual will be updated as soon as there is a

scientifically backed codified methodology for compound flooding modeling from subject matter experts.

    - All of the VAs assess the impact of the 100- and 500-year flood or storm event, and some include the impacts that sea level rise could have on the significance of the flood. Depending on the funding source, the grant requirements could stipulate specific hazards that need to be modeled and assessed. For example, FDEP stipulates for new VA's after July 1, 2024 are required to utilize NOAA 2022 Intermediate and Intermediate Low SLR projections at minimum.
    - Inundation maps are highly recommended to assess how future storm surge maps - combined with rainfall maps - impact the 100 year-return period for the years projected, ultimately impacting the frequency of flooding.
- Rainfall
    - Rainfall has been projected using satellite data published by the European Commission Joint Research Center. Some VAs in the region also predicted upland rain induced flooding.
    - In areas with bodies of water and even those without bodies of water, the impact of rainfall on potential flooding should be assessed.
    - Florida International University's Sea Level Solutions Center has published a document containing extreme rainfall projections for the state of Florida. It can be found at: https://www.floridabuilding.org/fbc/publications/Research_2020-2021/FBC_FIU_Final_Report.pdf This document is the basis for determining change factors to apply to the NOAA Atlas 14 rainfall projections. Further analysis and modeling is needed to determine the full extent of the flooding depths that result form the rainfall.
    - Modeling
- Storm Surge Modeling
    - Storm surge is often modeled using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model with 2018 NOAA National Hurricane Center data. FEMA flood maps have also been used in storm surge modeling. Additionally, all of the Statewide Regional Evacuation Studies performed by the various Regional Planning Councils in Florida have used the Surge Inundation Modeler (SIM) created by FloodMaster. This combines the SLOSH model with DEM and a water source layer. It is important tot note that the SLOSH model does not extend to all parts of the region (for example inland non riverine). The model might need to be modified, additional models or methods may need to be applied.
    - Most VA modeling includes inundation from Category 1-5 Storm Surge Events.
- Property Data Set
    - VAs often look at property data to assess values, look at land use, and determine when a building underwent structural improvements. In applicable municipalities,

property data may be used to determine the presence of septic systems. Property data can be found from the relevant counties or municipalities.
    - FEMA's FIRMS have been used to map properties and their location relative to flood zones.
- Exposure
    - Exposure methodology is simply the measure of the depth of the water that a particular critical asset is exposed too. These hazards include high tide flooding, current and future storm surge, rainfall-induced flooding, and compound flooding
- Sensitivity
    - In addition to the exposure requirements of a FDEP vulnerability assessment, a sensitivity analysis is required for the entire critical asset inventory.
    - Sensitivity expands upon the exposure risks and measures the impact beyond water depth. Sensitivity in the context of a vulnerability assessment refers to the ability of the asset to "bounce back" after being exposed to a water hazard. The scale of the vulnerability can vary from little to no risk to complete loss of the asset.
    - The Florida Department of Environmental Protection does not yet have robust guidance on how a Sensitivity Analysis is to be conducted. Until the FDEP provides codified guidance on how the analysis should be conducted, solutions developed through collaborative efforts of subject matter experts should be utilized. This document will be updated with any formal guidance from FDEP on sensitivity.
    - Due to the fact that there is not standardized Sensitivity Analysis guidelines, municipalities and consultants have developed their own metrics on how sensitivity is assessed. As an example, a consultant in the region defined sensitivity and consequence for their analysis and scoring below.
        - Consequence was scored on a one to three scale:
            - One being "Low Consequence – which causes negligible or temporary effects, not costly and easily restored"
            - Two being "Moderate Consequence – moderate impacts that are costly but possible to restore"
            - Three Being "High Consequence – significant impacts that are very costly and likely irreversible"
        - Sensitivity is scored on a very similar zero to three scale
            - Zero scored as having "No impact on asset functionality"
            - One scored as "Short-term loos of functionality and/or minor damage
            - Two scored as "Significant loss of functionality but repairable/reversible"
            - Three scored as "Permanent loss of function"

        - Using these metrics coupled with risk of flood depths an asset can be scored on how sensitive it is the hazards identified in the Vulnerability Assessment
    - A sensitivity equation was developed based on collaboration funded through a Community Development Block Grant. Sensitivity can be modeled based on an accepted methodology from the following equation and variables affecting the equation.
        - Utilize a ¼ mile Hexagonal Grid. This is to ensure capture of specific assets, populations, and topography.
        - The equation is:
          Sensitive Area (Sensitivity) = Present Day Flooding + Social Vulnerability (SOVI) + Regional Drivers of Vulnerability (RDV) + Population + Natural Resource + Critical Assets
        - The variables in the above equation are derived by:
            - Present Day Flooding measured by total land area of flood hazard scored on a 1-5
            - Social Vulnerability Index scored on county and regional levels from the census track into a 1-5 score
            - Natural resources scored from 1-5 depending on the type of water feature.
            - Population counts are scaled differently between county and regional population levels in a 1-5 scoring methodology
            - Regional drivers of vulnerability are assessed through a Regional Risk Assessment.
                - There are three factors outside of the Social Vulnerability Index for sensitivity which are: disability, subsidized housing, and a lack of broadband access have been determined for the East Central region of Florida. Drivers of Regional Vulnerability for Northeast Florida are still being considered
                    - Candidates for the Northeast Florida Region under consideration presently are:
                      1. Loss of Biodiversity
                      2. Stormwater Infrastructure
                      3. Concentration of Septic Tanks
                      4. Presence of Prime Farmland Soils
                      5. Community Rating Scoring System
                        - 6. Percent of land with a tree canopy.
                        - 7. Recharge Areas

Data

- Critical and Regionally Significant Assets
    - Critical and regionally significant assets were mapped, as they are important to the community. They fell under four categories: transportation assets; critical infrastructure; community and emergency facilities; and natural, cultural, and historical resources. GIS layers for these assets can be found at the Florida Geographic Database Library.
    - There are many data sets available for different tasks, such as…
        - Property/parcel geo-referenced data (public, historic, natural resources, land use) - available through Florida Geospatial Open data or local water management districts.
        - Critical Facilities - available through the Florida Division of Emergency Management (FDEM) Critical Facilities Inventory, System FEMA/Dept. of Homeland Security, EPA's National Pollutant Discharge Elimination System (NPDES) Permit Program, FDEP's Public Water Supply (PWS) Wells, Tanks, and Plants, and local county/municipality data.
        - Flood Elevation Certificates - available through FDEM Elevation Certificates as well as local county/municipality data.
        - Roadway/Transportation Network data - available through layer, U.S. Department of Homeland Security Homeland Infrastructure, OpenStreetMap, and the Florida Department of Transportation (FDOT) Open Data Hub.
        - Building Footprints - available through Microsoft/Esri, Google, as well as local county and municipality property appraiser data.
- Topographic Data
    - LiDAR from municipalities, FEMA FIRMS, and a Digital Elevation Model (DEM) from the NOAA Sea Level Rise Viewer have been used by municipalities in the region to gather topographic data.
    - Statewide, regional, and local geodatabases for the Geographic Information Systems (GIS) have been developed as repositories for DEM's. The NEFRC hosts a wide range of the most up-to-date elevation data available for partner utilization.
- Flood Scenario-Related Data
    - The Mayport Bar Pilots Dock NOAA tide gauge No. 8720218 has been utilized for several of the Vulnerability Assessments in the region. Other tidal gauges can be utilized depending on the location and needs of the community (subject to DEP approval if funded through DEP grants)
    - NOAA updated seal level rise projections based on a February 2022 report which adjusted the 5 possible global sea level rise scenarios from their 2017 figures.
    - High tide flooding (sunny/nuisance) occurs when sea level rise combines with local factors to push water levels above the normal high tide mark. High tide

flooding can be projected using NOAA Flood Frequency data or the NOAA Sea Level Rise Viewer.
    - Storm surge projections were created using data from the NOAA National Hurricane Center.
    - SLOSH models have been developed for several VAs in the region.

Visualizations and Maps

- Critical Infrastructure and Roads
    - Maps have been used to visualize the impacts of hazards on evacuation routes and critical facilities. This allows municipalities to determine if the evacuation routes will be able to be utilized, as well as if critical facilities need to be retrofitted or moved.
- 100-Year Storm
    - This visualizes a 100-year storm event. The map utilizes a "bathtub model," where the higher water levels are just mapped to fill in areas of the City below the projected MHHW level.
- 500-Year Storm
    - This visualizes a 500-year storm event. The map utilizes a "bathtub model," where the higher water levels are just mapped to fill in areas of the City below the projected MHHW level.
- Storm Surge
    - Storm surge is often modeled using the SLOSH model from 2018 NOAA National Hurricane Center data. However, FEMA flood maps have also been used in storm surge modeling.
- Sea Level Rise Projections
    - Previously, the NOAA 2017 Intermediate High projections for 2040 and 2070 are commonly used to predict sea level rise. NOAA has released new projections as of February 2022.
    - New FDEP regulations for vulnerability assessments funded through the Resilient Florida Program require at least Intermediate Low and Intermediate planning horizons.
    - ACOE Intermediate/NOAA Intermediate Low and ACOE High scenarios for 2040 and 2060 have also been used, as has the U.S. Army Corps of Engineers Sea-Level Change Curve Calculator. For this region, the Mayport Bar Pilots Dock NOAA tide gauge No. 8720218 is most often used as a point of reference.
- Flooding Projections
    - NOAA Flood Frequency data and NOAA's Digital Coast tool are the most common sources for flood projections. Nuisance flooding and sunny day flooding are often included in VAs.

    - Flood scenario models are recommended to include a variety of maps such as base map, groundwater elevation, land elevation, surface water elevation, land use, impervious areas, storm surge (if applicable), sea level rise (if applicable), precipitation, and evapotranspiration.
- Land Use
    - Maps were created to compare current and future land uses in relation to the extent of flooding. This can be used to determine whether changes should be made to land use.
    - Land use data can be retrieved from the UF GeoPlan Center, which works with the FDOT to produce future land coverage for the entire state. Florida land use data is available up to the year 2070.
- Parcel Information
    - Parcel information can be used to identify the total cost of loss due to flooding by looking at property values. It has also been used to identify clusters of septic systems that are vulnerable to flooding. Parcel information can be used to determine whether changes should be made to land use to mitigate the effects of flooding.
- Sensitivity Analysis Maps
    - Per recent FDEP guidance, Sensitivity maps are required for all critical asset categories for all hazards utilized in the overall vulnerability assessment.

Models

- Sea Level Rise Modeling
    - The future forecasting horizons used to estimate sea level rise have varied over time due to new data and modeling becoming available. Historically, the most common ones were the NOAA 2017 Intermediate High Projections for 2040 and 2070. NOAA updated planning horizons in a 2022 technical report that provides projections out to the year 2150. The nearest NOAA tidal gauge that was used for most regional Vulnerability Assessments is the Mayport Bar Pilots Dock No. 8720218. Other tidal gauges such as The Trident (8721604) and Fernandina Beach (8720030) have been utilized depending on the municipality. It is important to note using alternative tidal gauges in Vulnerability Assessments requires express permission from the Florida Department of Environmetal Protection.
- Storm Surge Modeling
    - Most storm surge models used the Sea Lake and Overland Surges from Hurricanes (SLOSH) model.

- Spatial Estimate of Future Flood Risk
    - This model combines projected rainfall induced flooding with projected 100-year storm surge.
- Groundwater Impacts
    - These models look at the impacts of various hazards and stresses on the aquifer system. Groundwater impacts can be determined by combining sea level rise, storm surge, and flooding projections with historical groundwater levels. Conducting a literature review may also be helpful to find more information on saltwater intrusion to the aquifer system.
- FlynnMetrics Inundate
    - This model is being used for the Florida Multi-Regional Mitigation Assessment and Planning project and may be used for future VAs. One of its benefits is that it allows for 3D simulations, modeling the depth of flooding relative to building heights. This model also incorporates several variables that can affect flooding, such as rainfall and sea level rise.
- Extreme Future Rainfall
    - As part of a CDBD Multi-Regional Planning & Mitigation Assessment Grant, a model for future extreme rainfall was based on research from a collaborative effort from the Southwest Florida Water Management District and Florida International University. A coordinated effort by six Regional Planning Councils, stakeholders, subject matter experts, and other collaborators developed a model able to be utilized by a Geographic Information Systems to generate maps for extreme rainfall overlayed with building and vertical ground data. This model is built on four 100-year rain events utilizing a near and far term of 2040 & 2070 respectively for either 24- and 72-hour rain events with the CORDEX 83rd percentile model spread.

Public Engagement

- In-Person Meetings
    - In-person meetings are recommended to understand the purpose and scope of the VA and allow the public to provide input. Discussions allow the public to state their experiences with hazards they face in the area and identify locations that are vulnerable.
    - These meetings can come in several formats, Presentation, Charrette, Q&A. Depending on the data and information being presented, different formats should be utilized.

- General Maps
    - Providing maps at the meetings allows the public to identify areas of concern. They can mark maps; verify, validate, and correct indicated areas of flood risk and occurrence; and ask questions to clarify the methodology and findings. This can then inform what specific areas to prioritize in the VA.

Application

- Identify Strategies, Policies, and Resources
    - After completing their VA, several municipalities began to identify strategies, policies, and resources to address the vulnerabilities that were identified. The goal of the application process is to highlight areas that need extensive or immediate vulnerability reduction and use a combination of strategies to generate policies that best benefit the community as a whole.
- Communicate with Government and Residents
    - The results of the VA should be communicated with the government and residents so that they understand the vulnerabilities and the appropriate actions can be taken. Communication with the government and residents will likely look different, but public meetings are a good way to reach both groups. It is encouraged to use presentations and interactive activities to communicate knowledge and hold attention.
    - Municipalities have held outreach meetings to present the results of the vulnerability assessment, discuss proposed policies with the public, identify potential Adaptation Action Areas, and gather feedback to revise the proposed policy language accordingly. Additionally, one municipality held public hearings to adopt amendments to its Comprehensive Plan.
- Adaptation and Implementation
    - Once a vulnerability assessment is completed, it is strongly recommended that communities utilize the data to develop an adaptation plan to target assets for resilience measure consideration. This process will be a data-driven approach designed to target assets found to be most at-risk during the process and assets deemed to be part of targeted focus from stakeholders (i.e beaches, evacuation routes, etc.).
    - After developing a plan on how to adapt to the hazards identified in the vulnerability assessment. A concerted effort will need to be made to establish the best method of adapting to the hazards. This is the implementation phase where cost-benefit analysis needs to be undertaken to determine the best type of project

to protect the asset from the requisite hazard. The cost-benefit analysis needs to look at many factors, such as: cost (financial, environmental, human, etc.), feasibility (can/should it be engineered).

- Public participation in these measures should absolutely be considered for the development of adaptation and implementation projects. For example, public outreach on development of a hardened concrete seawall or a living natural shoreline would be something that it would be recommended to solicit input from stakeholders on.
- Development of an adaptation guidebook to supplement the FDEP developed guidebook is underway to help municipalities and other stakeholders make the best most informed decision on adaptation and implementation projects.

- Future Vulnerability Assessments and Updates
  - Vulnerability Assessments should be updated a minimum of every five years or sooner as deemed necessary by the municipality.
  - Planning Horizons have changed for future vulnerability assessments. No longer are the previous standard 2040/2070 horizons permitted based on current legislation for the Resilient Florida Program. The SLR planning horizions stipulated in the beginning of this document must be utilized for FDEP funded VA's
  - Data utilized in vulnerability assessments should be updated from vetted and trusted geodatabases at minimum annually, but ideally once every six months to ensure the most up to date information is being utilized for hazard assessment and analysis.

Vulnerability Assessment Reporting Template

I. Executive Summary
II. Introduction
  A. Overview of community
  B. Coastal resiliency planning efforts in Florida and/or the Region
  C. Information about the Vulnerability Assessment - why does the community need it?
  D. Scope of the Vulnerability Assessment - what does it address?
III. Methodology
  A. General Methodology
  B. Public Engagement Efforts (if applicable)
  C. Sea Level Rise Projections

D. Future Flood Risk
E. Storm Surge Modeling
F. Compound Flooding

IV. Future Conditions
A. Sea Level Rise Projections
B. Future Flood Risk Projections
C. Storm Surge Projections

V. Vulnerability Assessment
A. Overall Impact
B. Impact from Sea Level Rise
1. Value of Structures Affected
2. Critical Facilities Affected
C. Impact from Future Flood Risk
1. Value of Structures Affected
2. Critical Facilities Affected
D. Impact from Storm Surge
1. Value of Structures Affected
2. Critical Facilities Affected
E. Any extra scenarios/events that were assessed
1. Value of Structures Affected
2. Critical Facilities Affected

VI. Next Steps
A. Adaptation Planning
B. Policy Implications

VII. References

VIII. Appendix
A. Include materials provided to the public, if applicable
B. Include responses from the public, if applicable

Appropriate Resources and Data

Critical/Regionally Significant Assets Inventory	
Property/parcel geo-referenced data (public, historic, natural resources, land use)	Florida Geospatial Open Data, local water management districts – Florida Land Use, Cover, and Forms Classification System (FLUCCS), Florida Master Site File – Division of Historical Resources, locally sourced county and municipality data, Florida Department of Revenue (DOR) Land Use codes, Florida Division of Historical Resources data, Florida Natural Areas Inventory, Florida Geographic Data Library, FIU/UF, FBAR

Critical Facilities	Florida Division of Emergency Management (FDEM) Critical Facilities Inventory, USGS Geographic Names Information System, FEMA/Dept. of Homeland Security, locally sourced county and municipality data, EPA NPDES Permit Program, FDEP PWS, Florida Geographic Data Library
Flood Elevation Certificates	FDEM Elevation Certificates, locally sourced county and municipality data
Roadway/Transportation Network data	USGS The National Map transportation layer, U.S. Department of Homeland Security Homeland Infrastructure Foundation-Level Data, OpenStreetMap, Florida Department of Transportation (FDOT) Open Data Hub, NavTeq/HERE roads database, USDOT, Florida Geographic Data Library, FDEM, FWCC
Building Footprints	Microsoft/Esri, Google, locally sourced county and municipality property appraiser data
Topographic Data	
Survey data	FDEM Florida Elevation Certificates, locally sourced county and municipality data of Finished First Floor Elevations (FFEs) and roadway crests for selected critical assets
LiDAR, Digital Elevation Model (DEM) data	National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI) DEM, U.S. Interagency Elevation Inventory, USGS National Elevation Dataset, Florida Geospatial Open Data, local water management district GIS hubs, locally sourced county and municipality data The NOAA Sea Level Rise Viewer has a Digital Elevation Model shapefile that can be uploaded in ArcGIS.
Flood Scenario-Related Data	
Precipitation data	NOAA Atlas 14, local water management district, USGS, Florida Flood Hub (when available), European Commission Joint Research Center satellite data on water frequency, https://www.floridabuilding.org/fbc/publications/Research_2020-2021/FBC_FIU_Final_Report.pdf
Groundwater level data	FDEP, Generalized Well Information System (GWIS), one of the five Water Management Districts, potentiometric surface maps developed by the USGS
Sea level rise (SLR) projections	NOAA's 2020 intermediate and intermediate-low SLR projections for 2040 and 2070 at a minimum, and optionally, other projections available from NOAA Digital Coast website or the Florida Flood

	Hub, U.S. Army Corps of Engineers 2013 High Curve, ACOE Intermediate 2040 and 2060 scenarios
Tidal datums and tidal flooding	NOAA Tides and Currents website, NOAA Digital Coast SLR viewer, Florida Flood Hub, NOAA Flood Frequency data
Storm surge	Federal Emergency Management Agency (FEMA) flood depth grids and water surface elevation grids (which are non-regulatory products provided to local municipalities), National Hurricane Center's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model, USACE Coastal Hazards System South Atlantic Coastal Study (SACS), FEMA Stillwater elevation (SWEL) results, https://www.nhc.noaa.gov/nationalsurge/#data
Hydro stratigraphic Information (if applicable, with justification)	Each Water Management District maintains data related to the hydro stratigraphic units within its jurisdiction
River channel cross-section (if applicable)	See local river water management district for data.
Land use data	UF GeoPlan Center has collaborated with the FDOT to produce future land cover data for the entire state, which is updated annually as more data becomes available from various municipalities. Florida 2060 and Florida 2070 projects produced alternative land use scenarios based on varying degrees of potential urban area development in the state. Land use data are also maintained by the local water management districts, counties, and municipalities. Recently Southwest Florida Water Management District has started acquiring GIS shapefile defining the extent of the impervious areas alongside their LiDAR data. Municipalities should reach out to their respective water management district to see if similar impervious area extent data exists for their study area. The Florida Natural Areas Inventory (FNAI) tracks areas managed by federal, state, local, and private agencies for conservation. The map series includes inundation changes to the landscapes.
Evapotranspiration data	Grid-based ET data for the entire state can be obtained from the USGS
Natural Resources and Features	NOAA's CUSP dataset for shorelines, relevant water management district for surface waters, USFWS for wetlands
Additional Information	Census data, Florida Department of Health, Northeast Florida Regional Council, SSURGO database available from the USDA Natural Resources Conservation Services Web Soil Survey, relevant

	stormwater master plan, ArcNLET to assess groundwater and surface-water pollutants
Standardized Vulnerability Assessment: Scope of Work Guidance	https://floridadep.gov/sites/default/files/VA%20Scope%20FINAL%202_0.pdf This outlines all the requirements from the Florida DEP on completing a Vulnerability Assessment according to Florida Statute

Online Sea Level Rise Visualization Tools	
FDOT Sea Level Scenario Sketch Planning Tool	http://sls.geoplan.ufl.edu/ A planning tool for preliminary assessment of transportation infrastructure vulnerable to current and future flooding
NOAA Sea-Level Rise and Coastal Impacts Viewer	http://coast.noaa.gov/digitalcoast/tools/slr Mapping tool to visualize community-level impacts from coastal flooding or sea level rise (up to 10 feet above average high tides). Photo simulations of how future flooding might impact local landmarks are also provided, as well as data related to water depth, connectivity, flood frequency, socio-economic vulnerability, wetland loss and migration, and mapping confidence
Climate Central Surging Seas Viewer	http://sealevel.climatecentral.org/ Tool shows maps of areas with different amounts of sea level rise and flooding, down to neighborhood scale, matched with area timelines of risk. The tool also provides statistics of population, homes and land affected by city, county and state, plus links to factsheets, data downloads, action plans, embeddable widgets, and more
The Nature Conservancy Coastal Resilience Portal	https://maps.coastalresilience.org/ Coastal Resilience is a program led by The Nature Conservancy to examine nature's role in reducing coastal flood risk. This tool aids in assessing where to act in risk reduction, adaptation and conservation
Geospatial Assessment Tool for Operations and Response (GATOR)	https://geodata-floridadisaster.hub.arcgis.com/ A common operation picture/situational awareness, web-based map viewer for the Florida Division of Emergency Management and the State Emergency Response Team. GATOR is an interactive web-mapping tool

	for the display of geographic information to support emergency preparedness, operations, and response.
NOAA C-CAP Coastal Land Cover Atlas	https://www.coast.noaa.gov/digitalcoast/tools/lca.html Coastal land cover and land cover change information developed through NOAA's Coastal Change Analysis Program (C-CAP). The tool summarizes general change trends (such as forest losses or new development) and provides tables, maps, and reports to enhance communication and decision-making.
Resource Databases	
Adaptation Database for Planning Tool (ADAPT)	http://www.icleiusa.org/tools/adapt Tool designed to walk users through the process of assessing vulnerabilities, setting resiliency goals, and developing plans that integrate into existing hazard and comprehensive planning efforts.
Climate Adaptation Knowledge Exchange (CAKE)	http://www.cakex.org/ CAKE is a knowledge sharing platform that houses an extensive digital library of high-quality climate change adaptation case studies, tools, and resources, spanning all phases of the adaptation process (assessment, planning, implementation, evaluation, and monitoring).
Georgetown Climate Center	http://www.georgetownclimate.org/ GCC serves as a resource to state, federal, and local policymakers who are working to develop policies to reduce greenhouse gas pollution and become more resilient to the effects of climate change, providing legal, policy, and process support to inform policy development.
U.S. Climate Resilience Toolkit	http://toolkit.climate.gov/ The U.S. Climate Resilience Toolkit offers resources to help communities and businesses manage climate-related risks. It features a framework for assessing and reducing climate hazards, showcases resilience-building case studies, and provides over 500 digital tools for climate data and planning. The toolkit also offers tailored information for different U.S. regions and access to experts, reports, and training courses. It is designed to support the development of climate action plans and resilience strategies.

Deltares Open Software	https://oss.deltares.nl/ Deltares is an independent knowledge institute focused on innovative solutions for water and subsurface challenges. They aim to make deltas habitable, ensure global safety from flooding, create resilient and healthy water systems, support sustainable energy transitions, and develop resilient infrastructure. Deltares conducts research, offers consultancy, and collaborates on international projects to enhance societal impact. Their work includes a wide range of projects, research facilities, software, and data solutions. They also engage in public outreach through publications, events, and educational initiatives.

Add-Ins for GIS Programs and Other Models	
HAZUS-MH	https://www.fema.gov/hazus Hazus is a nationally applicable standardized methodology developed by the Federal Emergency Management Agency (FEMA). A downloadable software package called Hazus-MH (for Multi-Hazard) gives users access to FEMA's models for estimating potential losses from earthquakes, floods, and hurricanes.
SWMM-CAT	https://www.epa.gov/water-research/storm-water-management-model-swmm The Stormwater Management Model Climate Adjustment Tool is an EPA developed model for planning, analysis, and design related to stormwater runoff, combined and sanitary sewers, and other drainage systems. Evaluation of grey, green, and hybrid stormwater control systems is available with this tool.
SimCLIM	http://www.climsystems.com/simclim/ SimClim is a stand-alone and add-on for GIS modelling system that can be customized to examine risks from, and adaptations to, current climate variables and future climate change.
Sea Levels Affecting Marshes Model (SLAMM)	http://www.slammview.org/slammview2/ This model uses digital elevation data and other information to simulate potential impacts of long-term sea level rise on wetlands and shorelines. The Sea Level Affecting Marshes Model, or SLAMM, has been used in several geographies and applications across the nation since its development in the mid-1980s. Additional data related to dike locations

	or other protected areas, accretion rates, erosion rates, and other factors can be included within the model as optional/supplemental factors.
Community Viz	https://communityviz.com/ Tool for analysts and planners to generate complex, custom and highly accurate urban analytics, including scenarios, suitability analysis, build out potential, impact analysis and more.
NatureServe Vista	http://www.natureserve.org/conservationtools/natureserve-vista A tool that supports complex assessment and planning in any environment, anywhere that has data sufficient for your planning needs. The tool helps managers and planners assess impacts on a variety of natural, cultural, and development objectives, and create options for sites, and entire landscapes and seascapes. The tool also supports decision-making by providing quantitative reports and maps, and allows testing of "what-if" situations on the fly.
Open-Source Nonpoint Source Pollution and Erosion Comparison Tool (OpenNSPECT)	http://coast.noaa.gov/digitalcoast/tools/opennspect A screening tool helps assess changes in water quality resulting from different land use management and climate scenarios. The tool allows users to estimate nonpoint-source pollution and erosion processes within watersheds. Users can then compare pollutant and sediment loads based on different scenarios. Designed to be used in coastal and inland communities alike
Land Use Portfolio Model (by U.S.G.S.)	http://geography.wr.usgs.gov/science/lupm.htm A tool for modeling, mapping, and communicating risk designed to help public agencies and communities understand and reduce their vulnerability to, and risk of, natural hazards.
Integrated Valuation of Environmental Services and Tradeoffs (INVEST)	http://www.naturalcapitalproject.org/InVEST.html A tool used to map and value the goods and services from nature that sustain and fulfill human life
Sea Level Analysis Tool (SLAT)	https://climate.sec.usace.army.mil/slat/ The Sea Level Analysis Tool (SLAT) by the U.S. Army Corps of Engineers helps users evaluate potential sea level rise impacts. It allows the selection of specific locations via NOAA tide gauges, provides coastal water level data, scenario projections, and assesses critical

	thresholds for sea level rise. This tool aids in visualizing and planning for future coastal conditions by offering detailed, location-specific projections and analysis.
Coastal Adaptation to Sea-Level Rise Tool (COAST)	https://www.bluemarblegeo.com/products/COAST.php Developed at the University of Southern Maine with funding from the EPA, the COAST program predicts damages from varying amounts of sea level rise (SLR) and storms of various intensities and evaluates relative benefits and costs of response strategies.
Other Assessment Tools	
The Social Vulnerability Index (SoVI)	https://sc.edu/study/colleges_schools/artsandsciences/centers_and_institutes/hvri/data_and_resources/sovi/index.php The Social Vulnerability Index (SoVI®) measures the social vulnerability of U.S. counties to environmental hazards. The index is a comparative metric that facilitates the examination of the differences in social vulnerability among counties. SoVI® is a valuable tool for policy makers and practitioners because it graphically illustrates the geographic variation in social vulnerability.
Surging Seas: Risk Finder	https://riskfinder.climatecentral.org/ an interactive tool that helps users assess the risks of sea level rise and coastal flooding across the United States. It provides maps, data, and visualizations to explore local projections, economic and population impacts, and potential flooding scenarios.
NatureServe Climate Change Vulnerability Index (CCVI)	https://connect.natureserve.org/science/climatechange/ccvi The NatureServe Climate Change Vulnerability Index (CCVI) is a comprehensive tool designed to assess the vulnerability of species to climate change.
Community-based Risk Screening Tool (CRiSTAL)	https://www.iisd.org/cristaltool/ A project-planning tool that helps users design activities that support climate adaptation (i.e., adaptation to climate variability and change) at the community level.
FlynnMetrics Inundate Tool	http://www.flynnmetrics.com/2021/06/07/gis-3d-simulations/ The Inundate tool is a planning and spatial analysis framework for identification and delineation of areas potentially exposed to the impacts

	of extreme rainfall, at scales relevant for statewide, regional, and local agencies.

Source: https://floridadep.gov/sites/default/files/CRI_AAA_Planning_Guidebook_for_Florida%27s_Local_Government.pdf

Visualization Tools	
CanVis (NOAA)	This tool allows users to create photo-realistic simulations for visualizing the potential impacts from coastal development and sea level rise.
Climate Central's Surging Seas	This tool includes an interactive Risk Finder and Submergence Risk Map. The Risk Finder shows populations, infrastructure, and assets exposed to coastal flooding aggravated by different sea levels as determined by the user (i.e., 1 to 10 feet of rise). The Submergence Risk Map is a tool that depicts sea level rise scenarios.
FDOT Sea Level Scenario Sketch Planning Tool	This tool allows for visualization of potentially inundated areas due to sea level rise, identification of transportation facilities potentially at risk from sea level rise inundation, report creation to summarize and prioritize impacted infrastructure, and the ability to create custom inundation surfaces.
The Nature Conservancy Coastal Resilience Mapping Portal	This tool provides users with access to interactive tools to visualize future flood risks from sea level rise and storm surge.
NOAA Sea Level Rise Viewer	This tool is an online viewer that allows users to visualize potential impacts from sea level rise.
NOAA Sea Level Trends	This tool illustrates regional trends in sea level with arrows representing the direction and magnitude of change. This can be used to determine areas which have experienced the highest rates of change and may be most vulnerable to future sea level rise.
Social Vulnerability Index (SoVI)	This tool measures the social vulnerability of U.S. counties and census tracts to environmental hazards, including sea level rise.
USGS National Assessment of Coastal	This tool maps the Coastal Vulnerability Index (CVI) data layer, which expresses the relative vulnerability of the coast to physical

Vulnerability to Sea Level Rise: Coastal Vulnerability Index (CVI)	changes due to sea level rise, geomorphology, and shoreline erosion rates.
USGS Digital Shoreline Analysis System (DSAS)	This tool can be used to measure coastal erosion and accretion, which can help users determine the areas that have experienced the highest rates of change and may be most vulnerable to sea level rise.
Modeling Tools	
ADvanced CIRCulation Model (ADCIRC)	ADCIRC is a tool commonly used for predicting storm surge and flooding, modeling tides and wind-driven circulation, studying larval transport, conducting nearshore marine operations, and assessing dredging feasibility and material disposal. https://adcirc.org/
The Integrated Hydrologic Model	This model depicts how climate and anthropogenic factors influence different hydrologic responses in a system. https://www.integratedhydrologicmodel.org/
Hazus-MH (FEMA)	This tool is a risk assessment methodology for analyzing potential losses. Although it is not specifically designed for sea level rise planning applications, many communities have used it to assess potential losses due to sea level rise. https://www.fema.gov/flood-maps/products-tools/hazus
Integrated Valuation of Environmental Services and Tradeoffs (InVEST) (Nature Capital Project)	InVEST is a family of free and open-source tools used to map and value goods and services from nature that are essential for sustaining and fulfilling human life. The Coastal Vulnerability uses the characteristics of coastal landscapes to compare their exposure to erosion and flooding in severe weather. When overlaid with data on coastal population density, the model's outputs can be used to identify where humans face higher risks of damage from storm waves and surge. https://naturalcapitalproject.stanford.edu/invest/coastal-vulnerability
NatureServe Climate Change Vulnerability Index (CCVI)	This is an online web-based tool that identifies ecosystems and plant and animal species that are particularly vulnerable to the effects of climate change and can help assess the relative vulnerability of species of interest occurring on the coast that may be impacted by sea level rise. https://explorer.natureserve.org/
NOAA Wave Exposure Model (WEMo)	A free and easy-to-use numerical wave exposure model (WEMo) that uses linear wave theory to calculate actual wave height and derived wave

	energy while taking into consideration wind generation and local water depth characteristics such as shoaling and dissipation from breaking waves. WEMo also provides predictions of seafloor sediment movement. https://coastalscience.noaa.gov/science-areas/climate-change/wemo/
StormWise Software Formerly: Interconnected Channel and Pond Routing (ICPR) Model	Focuses on modeling hydraulically interconnected and interdependent pond systems. Over time, the modeling has developed to include channel and pipe flow, groundwater, and interactions of surface water modeling. The modeling consists of 3 main building blocks, nodes, links, and basins. Nodes use inflow, outflow, and storage characteristics to calculate elevation. Water is connected from node to node via pathways such as pipes and channels. The three types of mapping flows that this module can generate include 1D surface flow, 2 D overland flow, and 2D groundwater. https://streamline.tech/stormwise
Sea Levels Affecting Marshes Model (SLAMM) (Warren Pinnacle Consulting, Inc.)	The Sea Level Affecting Marshes Model (SLAMM) simulates how wetlands and shorelines change with long-term sea level rise. It predicts wetland distributions under rising sea levels and presents results in tables and graphs. The latest versions include a Roads module to check how often roads flood and an uncertainty analysis module to assess the impact of uncertain input data on predictions. https://warrenpinnacle.com/prof/SLAMM/index.html
Simulator of Climate Change Risks and Adaptation Initiatives (SimCLIM) (CLIMsystems Ltd.)	The Simulator of Climate Change Risks and Adaptation Initiatives (SimClim) software examines future climate scenarios, including sea-level rise from climate change and local land movements. It rapidly generates place-based sea-level scenarios and includes models focused on coastal erosion and flooding. SimClim integrates data to simulate bio-physical and socio-economic impacts of climate variations, supporting decision-making and climate-proofing http://www.climsystems.com/site/home/
Sea Level Analysis Tool (SLAT)	The Sea Level Analysis Tool (SLAT) is a user-friendly web application that enables users to visualize observed sea level data, compare observations to projected sea level change, and estimate when tidal and extreme water levels will intersect with elevation thresholds related to local infrastructure (e.g., roads, power generating facilities, dunes). https://climate.sec.usace.army.mil/slat/

Decision Support Tools	
Beach-fx (USACE)	This tool is a comprehensive analytical framework for evaluating the physical performance and economic benefits and costs of shore protection projects, including sea level rise adaptation projects.

Coastal Adaptation to Sea Level Rise Tool (COAST)	This software helps users answer questions addressing the costs and benefits of actions and strategies to avoid damages to assets from sea level rise through 3D visualizations.
CommunityViz (Placeways LLC)	This tool provides a means for visualizing and communicating possible future land use change scenarios driven by sea level rise.
NatureServe Vista	This tool enables users to create, analyze, implement, and monitor land use and resource management scenarios that achieve conservation goals.
NOAA Inundation Analysis Tool	This is an online tool that can be used to create scenarios of increased sea level rise. The output may be used to compare how many high tides and total hours of inundation would have been experienced during a selected time period assuming a given amount of sea level rise versus the historical data.
U.S. DOT Vulnerability Assessment Scoring Tool (VAST)	This tool is intended for state DOTs, MPOs, and other agencies interested in assessing how components of their transportation system may be vulnerable to climate stressors, including sea level rise.
Source	https://floridadep.gov/sites/default/files/AdaptationPlanningGuidebook.pdf