

DEP AGREEMENT NO. 22PLN66
MONROE COUNTY VULNERABILITY ASSESSMENT UPDATE & COMPLIANCE

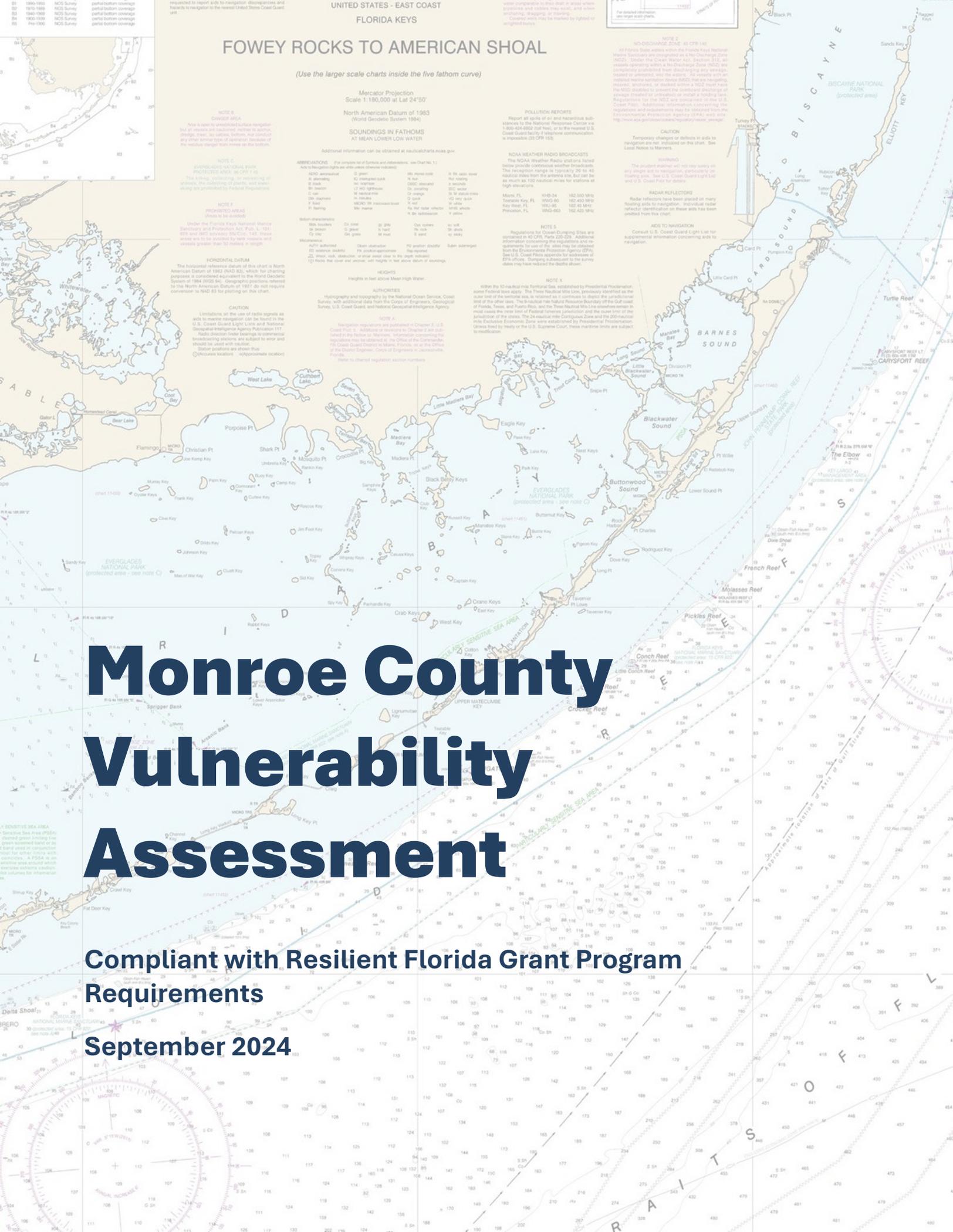
Monroe County

Final Project Report



September 2024

This report is funded in part through a grant agreement from the Florida Department of Environmental Protection. The views, statements, findings, conclusions, and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the State of Florida or any of its subagencies.



FOWEY ROCKS TO AMERICAN SHOAL

(Use the larger scale charts inside the five fathom curve)

Mercator Projection
Scale 1:180,000 at Lat 24°50'

North American Datum of 1983
(World Geodetic System 1984)

SOUNDINGS IN FATHOMS
AT MEAN LOWER LOW WATER

Additional information can be obtained at nauticalcharts.navy.mil.gov

ABBREVIATIONS The symbols for lights and obstructions, see Chart No. 1

NOTE 1: NO-DISCHARGE ZONE 40 CFR 140

NOTE 2: POLLUTION REPORTS

NOTE 3: NOAA WEATHER RADIO BROADCASTS

NOTE 4: HORIZONTAL DATUM

NOTE 5: CAUTION

NOTE 6: RADAR REFLECTORS

NOTE 7: AIS TO NAVIGATION

NOTE 8: HEIGHTS

NOTE 9: AUTHORITIES

NOTE 10: NAVIGATOR REGULATIONS

NOTE 11: WATER TO CHANNEL REGULATION SECTION NUMBERS

NOTE 1: NO-DISCHARGE ZONE 40 CFR 140
All Florida State waters within the Florida Keys National Marine Sanctuary are designated as a No-Discharge Zone (NDZ). Under the Clean Water Act, Section 312, all vessels operating within the NDZ are prohibited from discharging any sewage, oil, or other pollutants into the water. The NDZ is established to protect the sensitive marine environment of the sanctuary. Vessels are required to use onboard sewage treatment systems or pump-out stations. For more information, visit <http://www.fishwildlife.com/governance/ndz.htm>.

NOTE 2: POLLUTION REPORTS
Report all spills of oil and hazardous substances to the National Response Center via 1-800-424-6802, or by fax to the nearest U.S. Coast Guard facility if telephone communication is impossible (202) 267-1633.

NOTE 3: NOAA WEATHER RADIO BROADCASTS
The NOAA Weather Radio stations listed below provide continuous weather broadcasts. The reception range is typically 20 to 40 nautical miles from the antenna site, but can be as much as 100 nautical miles for stations at high elevations.

NOTE 4: HORIZONTAL DATUM
The horizontal reference datum of this chart is North American Datum of 1983 (NAD 83), which for charting purposes is considered equivalent to the World Geodetic System of 1984 (WGS 84). Geographic positions related to the North American Datum of 1983 do not require conversion to WGS 84 for plotting on the chart.

NOTE 5: CAUTION
Temporary changes or defects in aids to navigation are not indicated on this chart. See Local Notices to Mariners.

NOTE 6: RADAR REFLECTORS
Radar reflectors have been placed on many floating aids to navigation. Individual radar reflector identification on these aids has been omitted from this chart.

NOTE 7: AIS TO NAVIGATION
Consult the Coast Guard Light List for supplemental information concerning aids to navigation.

NOTE 8: HEIGHTS
Within the 10-nautical-mile territorial sea, established by Presidential Proclamation, some Federal laws apply. The Three-Nautical Mile Line, previously identified as the outer limit of the territorial sea, is retained to report the jurisdictional limit of the other laws. The 10-nautical-mile natural Resource Boundary of the Gulf coast of Florida, Texas, and Louisiana is also retained to report the jurisdictional limit of the other laws. The jurisdictional limit of the Federal Fishery Jurisdiction and the outer limit of the jurisdiction of the States. The jurisdictional limit of the Exclusive Economic Zone and the 200-nautical-mile Exclusive Economic Zone were established by Presidential Proclamation. These laws apply to the U.S. Supreme Court. These maritime laws are subject to modification.

NOTE 9: AUTHORITIES
Hydrography and topography by the National Ocean Service, Coast Survey, with additional data from the Corps of Engineers, Geological Survey, U.S. Coast Guard, and National Oceanic and Atmospheric Administration.

NOTE 10: NAVIGATOR REGULATIONS
Regulations and notices published in Chapter 2 of the U.S. Coast Pilot 1. Additional regulations or notices to Chapter 2 are published in the Florida or Maritime Information concerning the regulations may be obtained at the Office of the Commandant, U.S. Coast Guard District in Miami, Florida, or at the Office of the District Engineer, Corps of Engineers in Jacksonville, Florida.

NOTE 11: WATER TO CHANNEL REGULATION SECTION NUMBERS
Water to channel regulation section numbers.

Monroe County Vulnerability Assessment

Compliant with Resilient Florida Grant Program Requirements

September 2024



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A detailed nautical chart of a coastal region, likely the Gulf of Mexico, showing islands, reefs, and depth soundings. The title 'GLOSSARY AND ACRONYMS' is overlaid in large, bold, dark blue letters.

GLOSSARY AND ACRONYMS

Adaptation (to climate change) - The process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. Adaptive capacity is the ability to make these adjustments.

Assets - People, resources, ecosystems, infrastructure, and the services they provide. Assets are the tangible and intangible things people or communities' value.

Bathtub method / model - The projected sea level rise at a point in time is added to the current water elevation and overlaid on the existing topography to identify inundated areas.

CISA - Cybersecurity and Infrastructure Security Agency

Climate Change - The increasing changes in the measures of climate over a long period of time - including precipitation, temperature, and wind patterns.

CRS - Community Rating System, a FEMA program that encourages communities to prepare for flooding events by awarding FEMA flood insurance premium discounts for completing floodplain management and other flood mitigation activities.

DEP or FDEP - Florida Department of Environmental Protection

Exposure - The presence of people, assets, and ecosystems in places where they could be adversely affected by hazards.

FEMA - Federal Emergency Management Agency.

Global warming - The rise in global temperatures due mainly to the increasing concentrations of greenhouse gases in the atmosphere.

Hazard - An event or condition that may cause injury, illness, or death to people or damage to assets.

Hazard mitigation - When used by the Federal Emergency Management Agency (FEMA), the effort to reduce loss of life and property by lessening the impact of near future disasters.

IPCC AR5 RCP 8.5 Scenario - This condition is known as a representative concentration pathway for the concentration and trajectory of greenhouse gases was developed and intended by members of the Intergovernmental Panel on Climate Change (IPCC) to be a “very high baseline emission scenario” representing the 90th percentile of the volume of emissions that could occur in various future years if society does not make efforts to reduce greenhouse gas emissions. It is a “business as usual” scenario.

Impacts - Effects on natural and human systems that result from hazards. Evaluating potential impacts is a critical step in assessing vulnerability.

IRPF - Infrastructure Resilience Planning Framework

King tide - A non-scientific term describing an especially high tide caused by alignment of the gravitational pull between the sun and moon. A King Tide usually occurs three to four times a year.

Mitigation (of climate change) - A human intervention to reduce emissions or enhance the sinks of greenhouse gases.

NIH - NOAA Intermediate-High Sea Level Projection.

NIL - NOAA Intermediate-Low Sea Level Projection.

NOAA - National Oceanographic and Atmospheric Administration.

Projections - The 2019 Unified Sea Level Rise Projections published by the Southeast Florida Regional Climate Change Compact. Potential future climate conditions calculated by computer-based models of the earth system. Projections are based on sets of assumptions about the future scenarios that may or may not be realized.

Relative sea level rise - The way the height of the ocean rises or falls relative to the land at a particular location.

Resilience - The capacity of a community, business, or natural environment to prevent, withstand, respond to, and recover from a disruption.

Risk - The potential total cost if something of value is damaged or lost, considered together with the likelihood of that loss occurring. Risk is often evaluated as the probability of a hazard occurring multiplied by the consequences that would result if it did happen.

Scenarios - A set of assumptions about the future regarding the level of mitigation efforts and other physical processes that have a level of uncertainty.

Sea level rise (absolute sea level rise) - The height of the ocean surface above the center of the earth, without regard whether nearby land is rising or falling.

Sensitivity - The degree to which a system, population, or resource is or might be affected by hazards.

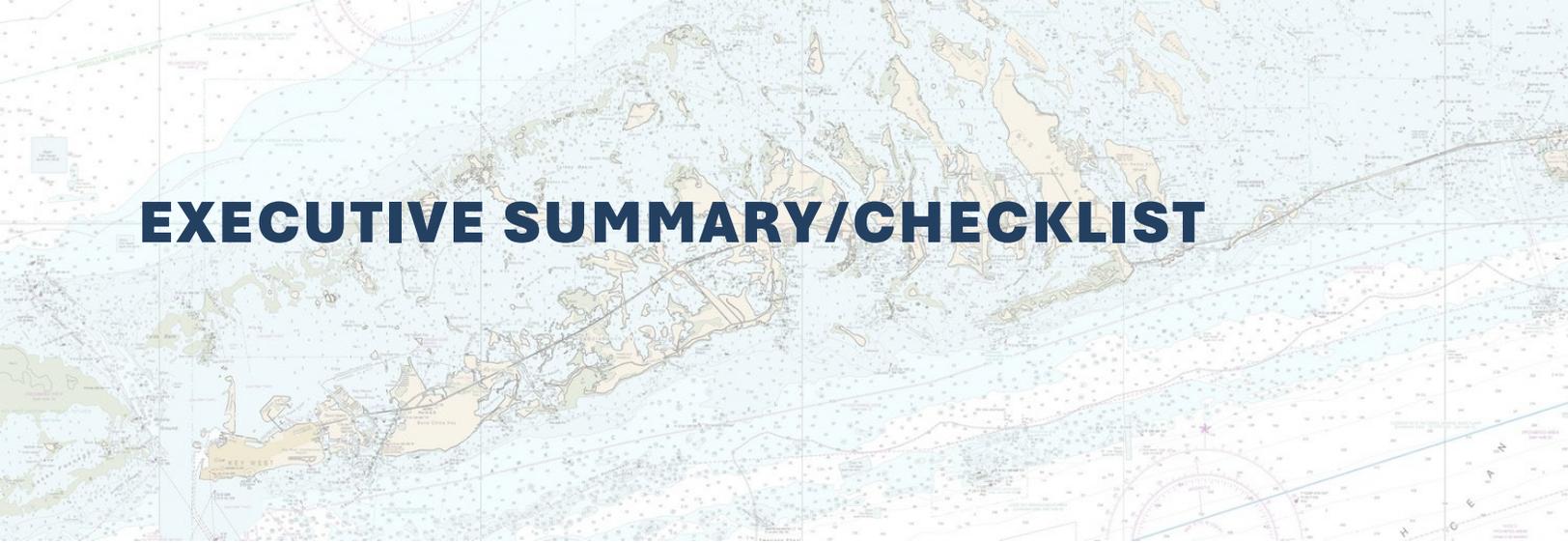
SLR - Sea level rise.

Uncertainty - A state of incomplete knowledge. Uncertainty about future climate arises from the complexity of the climate system and the ability of models to represent it, as well as the inability to predict the decisions that society will make.

Vulnerable populations - Vulnerable groups of people include those with low income, some communities of color, immigrant groups (including those with limited English proficiency), indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities and persons with pre-existing or chronic medical conditions.

Vulnerability - The propensity or predisposition of assets to be adversely affected by hazards. Vulnerability encompasses the degree of exposure, sensitivity, potential impacts, and adaptive capacity.

Vulnerability assessment - A process for identifying who or what is impacted by climate change, which considers a combination of exposure, sensitivity, and adaptive capacity.



EXECUTIVE SUMMARY/CHECKLIST

This section serves as both an Executive Summary of the full Vulnerability Assessment Report, as well as an outline corresponding to the items in the Resilient Florida Grant Program Vulnerability Assessment Compliance Checklist Certification document distributed by the Florida Department of Environmental Protection (DEP). Headings and subheadings of sections in bold and / or italics with alphabetic letters in parentheses indicate the item identified in the DEP Checklist.

Final Vulnerability Assessment Report (a)

The complete Vulnerability Assessment Report can be found after this Executive Summary.

Results

The main takeaways of the Vulnerability Assessment:

- **Flood Risk:** Monroe County faces significantly elevated flood risks due to sea-level rise, particularly in low-lying areas. This risk is projected to increase over time, with substantial impacts expected by 2040, 2070, and 2100.
- **Critical Asset Vulnerability:** Essential infrastructure, including stormwater management systems, transportation networks, and emergency services, faces considerable disruption risks from flooding.
- **Economic and Social Impacts:** The local economy and vulnerable populations are at high risk due to current and future flood threats, potentially affecting tourism, property values, and community well-being.
- **Adaptation Urgency:** Implementation of robust adaptation strategies is crucial for Monroe County to enhance its resilience against climate-related challenges.

Conclusions and Recommendations

In conjunction with this vulnerability assessment, the Monroe County should consider the following recommendations to improve its climate resilience:

- **Infrastructure Resilience:** Elevate and flood-proof critical infrastructure, particularly in identified hot spots.
- **Natural Defenses:** Restore and enhance coastal ecosystems to serve as natural buffers against flooding.
- **Policy and Planning:** Update building codes, land use regulations, and emergency response plans to reflect increased flood risks.
- **Community Engagement:** Develop comprehensive education and outreach programs to increase public awareness and preparedness.
- **Adaptive Management:** Implement a flexible, long-term adaptation strategy that can be adjusted as conditions change and new data becomes available.

This Vulnerability Assessment provides Monroe County with a robust foundation for developing targeted resilience strategies. By addressing the identified risks and implementing the recommended actions, the county can work towards enhancing its overall resilience to climate-related challenges, ensuring the long-term safety, economic stability, and environmental health of its communities.

Electronic Mapping Data

Geospatial data (b)

Per FDEP requirements, a list of assets is included in the report. See Appendix A for a complete list of the data types/layers/sources.

GIS metadata (c)

GIS information supplied to FDEP contains the required metadata.

Critical assets impacted by flooding and sea level rise (d)

The GIS analysis underpinning this Vulnerability Assessment incorporates layers including critical municipal and regionally significant assets. Critical assets generally are those owned and maintained by the county or are essential for the functioning of the county. It should be noted that some critical assets may not be owned or

maintained by the county, for instance, health care or certain utility assets. Regionally significant assets are those that may not be owned by the county but are no less critical to its functionality. These may be Federal, state or municipal assets.

Data summary for county assets

The following sources of data were collected and evaluated for the project:

1. **Transportation Assets and Evacuation Routes:** airports, bridges, bus terminals, bus routes, boat ramps, major roadways, evacuation routes, port facilities, marinas, rail facilities, and railroad bridges.
2. **Critical Infrastructure:** wastewater conveyance structures and lift stations, potable water conveyance structures, stormwater drainage infrastructure and stormwater ponds, electric production and supply facilities, military installations, post offices, communications facilities, and disaster debris management sites.
3. **Critical Community and Emergency Facilities:** childcare facilities, schools, colleges, universities, assisted housing, community centers, emergency medical service facilities, fire stations, emergency management services, health care facilities, hospitals, law enforcement facilities, risk shelters, local government facilities, and state government facilities.
4. **Natural, Cultural, and Historical Resources:** This category is dedicated to preserving and protecting natural areas and cultural/historical sites, including historic buildings and cemeteries, places of worship, and other historical and cultural assets, city, county and state parks, shorelines, surface waters, wetlands, and other terrestrial and aquatic natural areas.
5. **Supplementary Information:** This category includes additional data not explicitly required by Subsection 380.093, F.S., but valuable for a detailed vulnerability assessment. It encompasses FEMA's flood insurance study, the revised FEMA October 2019 Bay County Flood Insurance Study (FIS) ("2019 Bay County FIS"), flood zones, frequently flooded areas, soils, impervious surface areas, seawalls, land cover, land use, and property values.

Regionally significant assets

Multiple asset types listed above would be considered regionally significant assets; they are due special attention. Given their specific mention in the statutory language which refers to critical assets that support the needs of communities spanning multiple geopolitical jurisdictions and, in this case, include:

- Ports
- Rail facilities
- Airports

- Evacuation routes
- Electric power transmission lines
- Drainage assets (including those maintained by water management district)
- Stormwater ponds
- Drinking water facilities
- Emergency medical service facilities
- Risk shelter inventory

Asset layers were compiled initially in a baseline asset inventory. This baseline asset inventory was reviewed multiple times without the data compilation process. During this exchange, the importance and relevance to resilience was discussed and a critical asset inventory was established. This serves as a foundation that is further analyzed in the vulnerability assessment. A more prioritized map series was produced which focused on the highest priority assets within the community and can be found in the Critical Asset Inventory.

Areas Prioritized in the Analysis

Figure 1 – Flooding Hot Spot Map



The analysis reviewed approximately 88,790 assets contained within the limits of Monroe County. The project team identified 25 flooding “hot spots” based on the intensity of projected flooding caused by rainfall events and future sea level rise and

the concentration of assets identified by Monroe County. which were then prioritized based on level of flood impacts. In addition, items of immediate need within the hot spots were also highlighted. Specifically:

- 164 assets were prioritized as level 1 or level 2, the highest levels, based upon criticality and threat (representing the top 1-10% most vulnerable).
- 106 assets were prioritized as level 3 (representing the 10-25% most vulnerable).
- 1,697 assets were prioritized as level 4 or level 5 (representing the 25-50% most vulnerable).
- 86,823 assets were not prioritized (the least vulnerable 50%).

The hot spot maps can be found in the Sensitivity Analysis Map Series (Appendix E.3).

Areas of Immediate Need

Based on the generated hot spots and collaboration with Monroe County staff, the project team has prepared a list of areas that were identified as areas of immediate need and listed assets at risk in each hot spot. These assets could translate to overall adaptation priorities for the county, but they should be further investigated at the engineering level for feasibility, design, cost and overall ability to alleviate current or future flooding risk.

Table 1 - Summary of Flood Impact and Asset Frequency

Hot Spot Description	Flood Impact Summary	Asset Prioritization Summary
Hot Spot 1: Card Sound Bridge	Majority of assets impacted by 2040 rainfall projections.	Low density of prioritized assets. Identified as a road improvement project by Monroe County.
Hot Spot 2: Big Coppitt Key	Area projected to be impacted by 2040 sea level rise and high tide flooding projections.	No prioritized assets. Site was specifically called out by Monroe County for road improvements.
Hot Spot 3: Stillwright Point	Area projected to be impacted by present day rainfall projections.	No prioritized assets. Site was specifically called out by Monroe County for road improvements.

Hot Spot Description	Flood Impact Summary	Asset Prioritization Summary
Hot Spot 4: Key West International Airport	Majority of assets impacted by 2100 sea level rise and high tide flooding.	Moderate density of prioritized assets.
Hot Spot 5: Sugarloaf Key	Majority of assets impacted by present day rainfall and high tide flooding.	Low density of prioritized assets. Identified as a road improvement project by Monroe County.
Hot Spot 6: Pigeon Key	Area projected to be impacted by present day high tide flooding projections.	No prioritized assets. Site was specifically called out by Monroe County.
Hot Spot 7: Summerland	Majority of assets impacted by 2100 sea level rise and high tide flooding projections.	High density of prioritized assets. Encompasses road improvement projects.
Hot Spot 8: Stock Island	Majority of assets impacted by 2040 storm surge projections.	High density of prioritized assets. Contains road improvement projects.
Hot Spot 9: Cudjoe Key	Majority of assets impacted by 2070 storm surge projections.	Moderate density of prioritized assets. Contains road improvement projects.
Hot Spot 10: Long Key	Majority of assets impacted by 2040 rainfall projections.	Moderate density of prioritized assets.
Hot Spot 11: Big Pine Overseas Hwy Area	Majority of assets impacted by 2100 surge projections.	High density of prioritized assets.
Hot Spot 12: Key West Flagler Ave	Area projected to be impacted by 2040 storm surge projections.	No prioritized assets. Site was specifically called out by Monroe County for road improvements.
Hot Spot 13: Duck Key	Majority of assets impacted by 2070 surge projections.	High density of prioritized assets. Contains road improvement projects.

Hot Spot Description	Flood Impact Summary	Asset Prioritization Summary
Hot Spot 14: The Avenues, Big Pine Key	Majority of assets impacted by 2040 sea level and high tide flooding projections.	Moderate density of prioritized assets.
Hot Spot 15: Conch Key	Majority of assets impacted by present day rainfall projections.	High density of prioritized assets. Contains road improvement projects
Hot Spot 16: North, Key Largo	Majority of assets impacted by 2040 sea level rise projections.	High density of prioritized assets. Contains road improvement projects.
Hot Spot 17: Marathon Airport	Majority of assets impacted by 2040 surge projections.	High density of prioritized assets.
Hot Spot 18: North, Big Pine Key	Majority of assets impacted by 2070 sea level rise and high tide flooding projections.	Low density of prioritized assets. Contains road improvement projects.
Hot Spot 19: Middle, Key Largo	Majority of assets impacted by 2070 surge projections.	High frequency of prioritized assets. Contains road improvement projects.
Hot Spot 20: Twin Lakes, Key Largo	Majority of assets impacted by 2040 surge projections.	Moderate frequency of prioritized assets. Contains road improvement projects.
Hot Spot 21: Orange Blossom/Harry Harris Park, Tavernier Key	Majority of assets impacted by present day rainfall projections.	Low frequency of prioritized assets. Contains road improvement projects.
Hot Spot 22: Ocean Reef, Key Largo	Majority of assets impacted by 2100 sea level rise and high tide flooding projections.	Moderate frequency of prioritized assets.

Hot Spot Description	Flood Impact Summary	Asset Prioritization Summary
Hot Spot 23: Winston Waterways, Key Largo	Majority of assets impacted by 2070 sea level rise and high tide flooding projections.	High frequency of prioritized roadways. Contains road improvement projects.
Hot Spot 24: Emergency Medical & Hospital Area, Tavernier Key	Majority of assets impacted by 2040 rainfall projections.	Moderate frequency of prioritized assets. Contains road improvement projects.
Hot Spot 25: Elementary/Middle School, Key Largo	Majority of assets impacted by 2070 surge projections.	Low frequency of prioritized assets.

Peril of Flood Compliance Plan amendments (e)

The Monroe County Comprehensive Plan already complies with paragraph 163.3178(2)(f), Florida Statutes, pertaining to Peril of Flood; therefore, Peril of Flood amendments are not included within this Vulnerability Assessment.

Tidal Flooding

In the context of planning for future tidal flooding events, the Vulnerability Assessment Report for Monroe County incorporates detailed modeling techniques to predict how rising sea levels and high tide events will impact the area over several planning horizons. This modeling is particularly important given the county's vulnerability to climate change-induced phenomena, specifically flooding. The assessment uses the North American Vertical Datum of 1988 (NAVD 88) as a benchmark for all elevations, ensuring accuracy and consistency in projection data.

Key to this analysis are the flooding scenarios evaluated, included in each of the following sections of this executive summary, which consider combinations of sea level rise and high tide flooding, alongside projections of the number of days tidal flooding is expected to occur. The scenarios are based on NOAA's Intermediate-Low (NIL) and Intermediate-High (NIH) Sea Level Rise Projections from 2017, which were the required scenarios at the initiation of this Vulnerability Assessment. These projections provide a framework for understanding the range of possible future conditions, enabling the county to prepare for a variety of outcomes.

The analysis employs geospatial temporal modeling techniques, leveraging tools such as ArcGIS Pro and the VDATUM tool for datum conversion, to assist with simulating tidal flooding scenarios. This methodology employs the National Oceanic and Atmospheric Administration's (NOAA) mapping sea level rise inundation methodology, ensuring the assessment accurately captures the complexities of tidal flooding under various future scenarios.

Figure 2 - Sample Tidal Flooding Scenario Map (Key Largo)

NIH 2070 SLR Projection and High Tide Flooding



This methodology also includes a representation of the analysis depicting a geographical display of the number of tidal flood days expected for each scenario and planning horizon in the map series entitled “Days of Tidal Flooding” in the Exposure Map series, supplemental to the two-foot mean higher high-water threshold established by FDEP. This combination offers a nuanced view of the days each year that are expected to experience tidal flooding, contributing to a more comprehensive understanding of the temporal dynamics of flood risk.

Figure 3 - Approximate Number of Days of Tidal Flooding (NIH 2070) (Key Largo)

Days of Tidal Flooding = SLR Projection and High Tide Flooding



This scenario incorporates the FDEP's requirement to add two feet to the MHHW mark, enhancing predictions for future tidal flooding by accounting for increased sea levels and high tide events. This conservative approach aids in planning for more frequent and severe flooding, underscoring the need for robust coastal defenses like seawalls and natural barriers.

Building on the previous analysis, this section projects the number of days expected to experience tidal flooding, emphasizing its impact on daily life and the economy. It highlights the importance of comprehensive flood risk management strategies to mitigate these effects, aiming to ensure Monroe County's resilience and sustainable development amidst rising sea levels and changing climate conditions.

The scenarios of Sea Level Rise + High Tide Flooding and Days of Tidal Flooding together guide Monroe County's flood resilience strategy. They highlight expected changes along coastlines and low-lying areas, steering the conversation towards adapting urban plans, emergency readiness, and strengthening community resilience. Integrating these insights into Monroe County's long-term planning enables proactive responses to sea level rise and tidal flooding challenges, aiming for a resilient future for the community.

Storm Surge Flooding

This analysis leverages FEMA's storm surge data and the HAZUS-MH software, adjusting historical data monumented within the most recent effective Flood Insurance Study (FIS) from 2005 based on future sea level rise projections. It offers a detailed planning grade understanding of future storm surge impacts by integrating these projections with existing FEMA FIS data.

Depth of current and future storm surge flooding

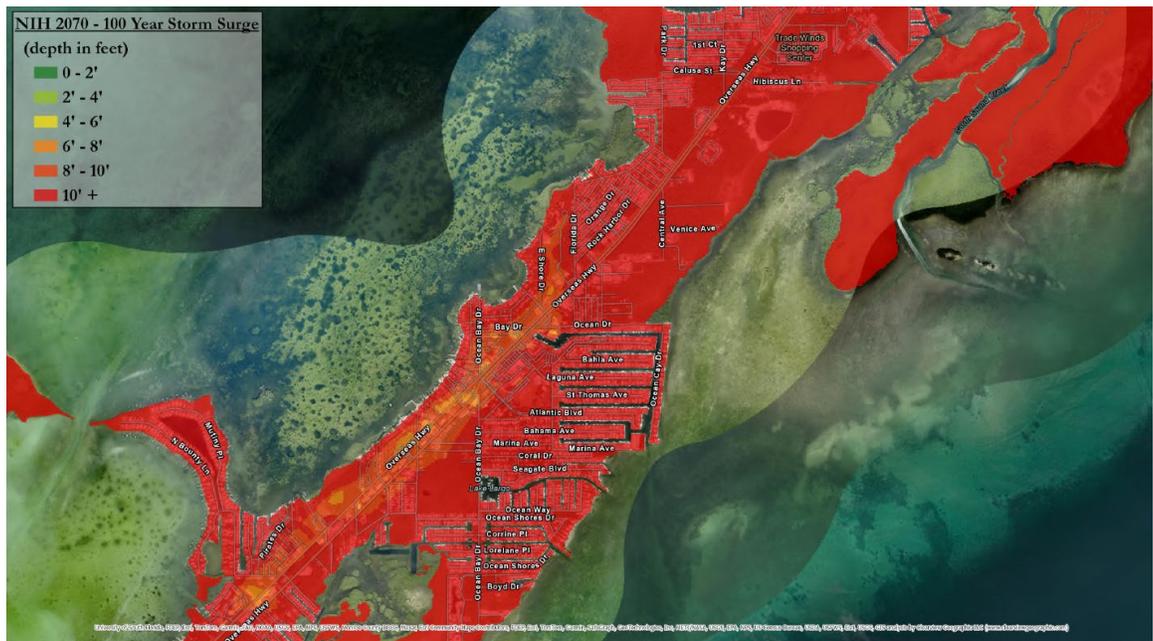
(h)

Using FEMA's comprehensive storm surge data in conjunction with HAZUS-MH software, historical storm surge events were adjusted to align with projected sea level increases for 2040, 2070, and 2100 planning horizons. This process enabled the prediction of storm surge depths across different timelines, providing a granular view of how storm surge flooding may evolve. The outcomes reveal significant increases in storm surge depths, underscoring the urgent need for adaptive infrastructure and planning measures to mitigate the impacts on vulnerable coastal communities.

Initial storm surge event equals or exceeds current 100-year flood event (i)

The initial storm surge event analyzed in this assessment equals or exceeds the magnitude of the current 100-year flood event as required by statute. This comparison highlights a stark increase in the severity and frequency of storm surge events, likely attributable to ongoing climatic changes and sea level rise. This implies that an event previously considered to be a once-in-a-century occurrence may now happen more frequently, requiring a reevaluation of flood risk assessments and flood zone designations. This finding is critical for updating building codes, insurance rates, and disaster preparedness plans to better reflect the heightened risk of significant storm surge flooding in the future. All storm surge maps can be found in the Exposure Map series.

Figure 4 - NIH 2070 SLR + 100-Year Storm Surge (Key Largo)



The 100-year and 500-year storm surge scenarios are critical to understanding Monroe County's flood risks, with the former having a 1% annual chance of occurrence and the latter a 0.2% chance. These scenarios, crucial for urban and infrastructure resilience planning, consider the compounded impacts of climate change on storm surge risks using FEMA data and HAZUS-MH software, adjusted for future sea level rise. They provide a foundation for developing flood defenses, revising building codes, and crafting evacuation strategies. This comprehensive risk assessment aids Monroe County in proactive planning against storm surge flooding, ensuring a holistic approach by integrating with tidal flooding and sea level rise projections. It is a strategic effort to bolster the county's resilience, protect its community, and maintain infrastructure integrity in the face of climate change.

Rainfall-induced Flooding (k)

Pursuant to the requirements of Section 380.093(3), F.S., this Vulnerability Assessment employs a spatiotemporal analysis, leveraging existing modeling results and developing new simulations to assess flood risk accurately. Use of the Hydrologic Engineering Center's River Analysis System (HEC-RAS) tool allows for detailed rainfall simulation and runoff computation. The integration of NOAA's Atlas 14 precipitation data and the South Florida Water Management District's future rainfall change factors facilitates a comprehensive evaluation of potential future scenarios of rainfall-induced flooding. This methodological approach ensures that the assessment adheres to legislative requirements while providing a robust

framework for predicting flood elevations under various conditions. All rainfall maps can be found in the Exposure Map series.

The rainfall-induced flooding section outlines scenarios ranging from the more frequent 25-year events to the rare but devastating 1,000-year event, alongside adjusted projections that consider anticipated changes in sea level rise. Each scenario represents a distinct level of flood risk based on the probability and intensity of rainfall over a 24-hour period, thereby providing a comprehensive spectrum of potential flood hazards.

Future boundary conditions (l)

To account for the evolving nature of flood risk due to climate change, the future boundary conditions for this analysis have been adjusted via overlays and change coefficient multipliers. These modifications incorporate elements of sea level rise and high tide conditions to the extent practicable, ensuring that the assessment reflects the most accurate and relevant scenarios for evaluating future flood risks. By doing so, the study aligns its predictions with the latest climate science, providing a more realistic projection of flood elevations and areas at risk.

The assessment adjusts the 25-year and 100-year 24-hour scenarios to reflect the impact of climate change on rainfall patterns, offering a forward-looking analysis of flood risks. By incorporating projections of increased rainfall intensity and frequency, these scenarios provide a clearer picture of potential future flood hazards. This comprehensive approach enables Monroe County to adapt its infrastructure and policies to the realities of a changing climate, ensuring informed decision-making in flood mitigation and resilience planning. This effort is vital for maintaining community well-being and sustainable development amidst the challenges posed by more frequent and intense rainfall events.

Depth of rainfall-induced flooding (m)

The analysis delves into the projected depths of rainfall-induced flooding for significant storm events, specifically the 25-year, 50-year, 100-year, 500-year, and 1000-year storms. By examining these scenarios, the study identifies critical areas that are likely to experience substantial flooding, thus presenting a clear picture of the potential impact on infrastructure and communities. The depth of flooding is quantified through detailed maps and tables, offering valuable insights into the spatial distribution of flood risks.

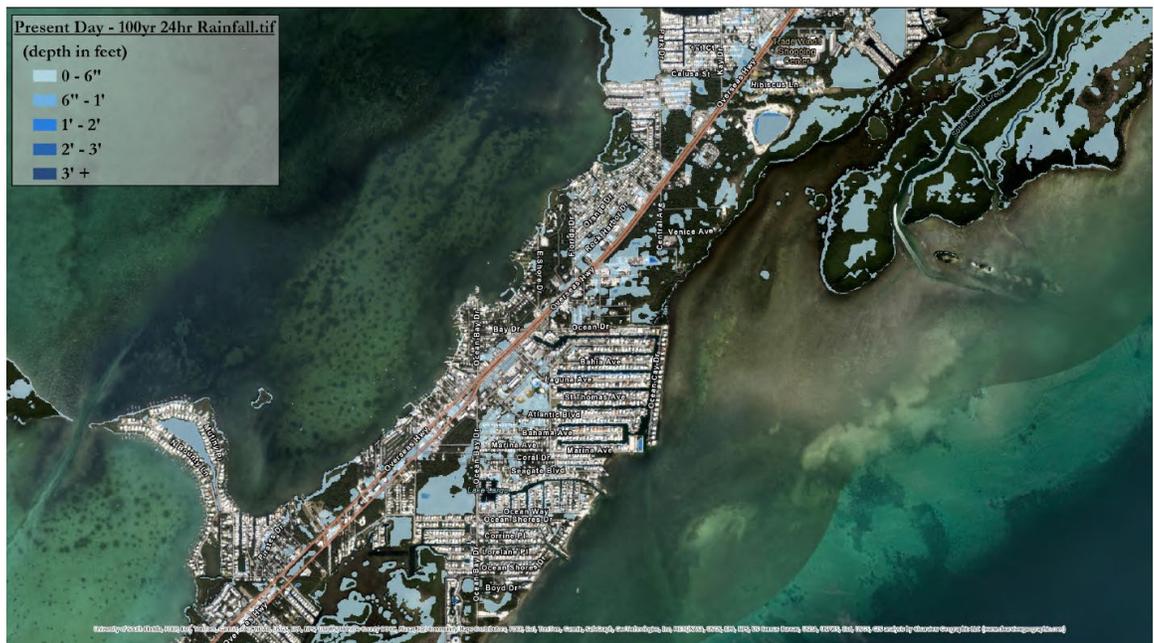
The study presents its findings through a series of maps and tables that visualize the depth and extent of rainfall-induced flooding for all storm scenarios within the exposure series. These mapped visual aids facilitate a better understanding of the

spatial distribution of flood risks, enabling stakeholders to identify high-risk areas and prioritize mitigation efforts accordingly.

100-year storm

This scenario predicts the extent and depth of flooding likely to occur with a 1% chance of throughout any given year providing a baseline for flood risk management and urban planning. This concept is widely used in flood risk management and planning to design standards for infrastructure resilience, such as levees, dams, and floodplains.

Figure 5 - Present Day - 100-Year 24-Hour Rainfall (Key Largo)



The 100-year 24-hour scenario, modeling a severe storm with a 1% annual occurrence chance, is essential for guiding flood risk management and urban development strategies. It informs the creation of flood mitigation infrastructure, land use regulations, and insurance policies, pinpointing areas for strategic investments to lower flood risks and methods to bolster community resilience.

500-year storm

An assessment of the more extreme but less frequent 500-year storm event gives insights into the potential for catastrophic flooding, informing long-term resilience strategies. It signifies a storm that has a 0.2% chance of occurring in any given year.

This statistical measure is used to describe the severity and likelihood of extreme weather events, helping in the planning and construction of infrastructure designed to withstand such rare but potentially devastating storms.

Figure 6 - Present Day - 500-Year 24-Hour Rainfall (Key Largo)



The 500-year 24-hour scenario, modeling an extreme rainfall event with a 0.2% annual chance, is vital for assessing the maximum flood risk potential, identifying areas and infrastructure at risk of severe flooding. This scenario underscores the need for extensive planning and advanced mitigation efforts to prepare for and reduce the impacts of such catastrophic events.

Higher frequency storm analyzed for exposure of a critical asset (j)

In addition to the standard 100-year and 500-year storm scenarios, the analysis also includes a detailed examination of higher frequency storms to assess the exposure of critical infrastructure and assets. This focused analysis helps in identifying vulnerabilities and planning for protective measures to safeguard essential services and facilities against the impact of more frequent, higher-intensity flooding events. Further exploring a range of storm events, including the 25-year, 50-year, 100-year, 500-year, 1,000-year storms, provides a more comprehensive overview of flood risks over a spectrum of probabilities meeting and exceeding the statutory requirements

for Vulnerability Assessments. This detailed assessment, summarized in accompanying tables, aids in the development of a nuanced flood risk management strategy that addresses both common and severe flooding scenarios.

The rainfall scenarios ranging from 25-year to 1,000-year events provide a comprehensive array of flood risk assessments essential for Monroe County's flood management and urban planning. The 25-year scenario, with a 4% annual chance, highlights moderate flooding risks, emphasizing the need for improved drainage and community preparedness. Progressing in severity, the 50-year scenario (2% chance) evaluates the adequacy of flood defenses and critical infrastructure resilience. The 100-year scenario is a key benchmark in flood risk management, guiding urban development, flood mitigation, and land development with a 1% annual occurrence chance. It calls for strategic investments to enhance community resilience. The 500-year scenario, reflecting a 0.2% chance of extreme rainfall, and the 1000-year scenario, with a 0.1% chance, both underscore the importance of comprehensive planning and robust mitigation to address the highest levels of flood risk and potential catastrophic impacts. Collectively, these scenarios underscore the necessity of a forward-looking approach to urban planning, emergency management, and resilience building against increasing flood risks.

Compound/Combined Flooding (n)

This segment addresses the compound effects of tidal, storm surge, and rainfall-induced flooding under various scenarios primarily focused on the 100-year and 500-year storm surge events plus 25-year and 100-year rainfall events with the compounding effect of sea level rise. It involves overlaying depth grids from various scenarios, acknowledging the resource and time constraints of the project. Combined flooding maps can be found in the Exposure Map series.

Figure 7 – Present Day SLR + 100-Year Surge + 25-Year 24-Hour Rainfall (Key Largo)



Through the comprehensive analysis of these compounded scenarios, the report underscores the importance of integrating multidimensional flood risk assessments into urban planning and infrastructure development. Such detailed projections facilitate the strategic implementation of adaptation and mitigation strategies, ensuring that communities are better prepared and more resilient to the increasingly complex and severe flooding challenges posed by climate change.

Scenario Development Specifications

North American Vertical Datum of 1988 (o)

All elevations referenced in and analyzed for this Vulnerability Assessment are expressed in North American Vertical Datum of 1988 (NAVD 88) values. Any exceptions are limited and are specifically noted in the Vulnerability Assessment and further appendices.

Local Sea Level Rise Scenarios (p)

The sea-level rise scenarios included in the Vulnerability Assessment include the 2017 NOAA Intermediate-Low (NIL) Sea Level Rise Projection and the 2017 NOAA Intermediate-High (NIH) Sea Level Rise Projection. These scenarios were the required scenarios when this Vulnerability Assessment was initiated prior to July 1,

2024. Legislation adopted by the Florida Legislature in 2024 shifts these required scenarios to the 2022 NOAA Intermediate Low and Intermediate scenarios. These new scenarios will apply to Vulnerability Assessments initiated after July 1, 2024; and as such, the county should consider this in future updates to this Vulnerability Assessment. It should be noted that for near-term scenarios the NOAA 2022 scenarios align for 2040. But for the 2070 and 2100 scenarios, the NOAA 2017 scenarios are higher and thus more conservative for planning purposes.

The benefit of evaluating a range of conditions is that the county can determine the tolerance for risk for any adaptation strategy decision and act upon data from this analysis that reflects a wider range of conditions. For assets, adaptation projects and policy decisions where there is a higher criticality for that decision, the higher end of the projections and output should be considered. Where there is a lower tolerance for flood impact, the lower end of the projections could be considered. The range provides options needed for more place-based and flood impact decision-making.

Planning horizons (q)

The planning horizons for this assessment coincide with NOAA's forecasting years: 2040, 2070 and 2100. While Section 380.093(3), F.S., only requires the 2040 and 2070 planning scenarios currently, this Vulnerability Assessment also includes the 2100 condition.

Sea level data selection (r)(s)

According to statute, vulnerability assessments must include local sea level data that has been interpolated between the two closest National Oceanic and Atmospheric Administration tide gauges or use the sea level data from whichever of those two nearest gauges reports a higher mean sea level.

For Monroe County, this Vulnerability Analysis uses NOAA's VDATUM software to interpolate between the two closest tide gauges, Vaca Key (8723970) and Key West (8724580). This interpolation is integrated directly into the exposure analysis methodology by converting the original North American Vertical Datum of 1988 (NAVD88) elevations from the Digital Elevation Model (DEM) to the localized vertical tidal datums. By aligning the DEM elevations with data from local tide gauges, this conversion ensures accurate and consistent comparisons, correctly reflecting local sea level elevations and allowing precise data manipulations.

A nautical chart showing coastal features, depth soundings, and navigational markers. The title 'VULNERABILITY ASSESSMENT REPORT' is overlaid in large, bold, dark blue letters.

VULNERABILITY ASSESSMENT REPORT

Introduction and Background

This Monroe County Vulnerability Assessment (2024) represents the latest in a series of steps taken by Monroe County to build its resilience to the impacts of climate change, most notably sea level rise, precipitation and combined flooding impacts.

This current Vulnerability Assessment is funded through the Resilient Florida program, established by the Statewide Flooding and Sea Level Rise Resilience Act (SB 1954/HB 7019) approved by the Legislature in April 2021 and Governor DeSantis in May 2021, now Section 380.093, F.S. Among many other provisions, the legislation established the Resilient Florida Grant Program to provide funding to local governments for resilience planning grants and creation of the process to establish the annual Statewide Flooding and Sea Level Rise Resilience Plan appropriating annual funding for resilient infrastructure upgrades. State funding is predicated on local governments identifying assets at risk via vulnerability assessments conducted according to requirements detailed in the legislation and providing prioritized lists of proposed projects to the state. DEP is also charged with creating a statewide vulnerability assessment based on the local assessments.

In addition to serving as an update to, and expansion of, the initial Vulnerability Assessment completed in June 2021, this document specifically complies with the criteria established by the State of Florida in 2021 for eligibility for the resiliency infrastructure grants annually evaluated and ranked for appropriations in the Statewide Flooding and Sea Level Rise Resilience Plan. Those requirements, detailed in subsection 380.093(3), F.S., name the “components, scenarios, data, and information” that must be included for a vulnerability assessment to be considered complete.

Even more importantly, however, this Vulnerability Assessment assists Monroe County in protecting its residents, infrastructure, properties, natural landscapes, and way of life from the threats of sea level rise and extreme flooding.

Monroe County knows that the need for climate adaptation and mitigation planning does not exist in a vacuum, but rather stems from evidence of increasing sea levels and damaging rain and storm events, recognition of serious future risks, and the stark damage flooding is already causing in the region. Faced with these realities, the county and its regional partners are pursuing an aggressive and overarching planning strategy to address underlying climate change threats.

Public Participation and Engagement

Community resilience is the capacity of governments, individuals, organizations, institutions, and businesses to plan for, respond to, withstand, and bounce back from acute and chronic stressors related to climate change impacts, including sea level rise, flooding, and more intense storms. To successfully build long-term community resilience, stakeholders must be consulted and invited to shape planning processes and decisions about adaptation measures and infrastructure investments. Otherwise, these policies will lack the broad-based public support needed to sustain them over the long term and through political or economic challenges.

To ensure public input into this Vulnerability Assessment, Monroe County held a two-part virtual meeting series online on August 28 and September 10. In addition, the County scheduled three in-person open houses for September 16-18, 2024, with meetings taking place in Big Pine Key, Marathon, and Key Largo, covering the Lower, Middle, and Upper Keys, respectively.

Resilience Initiatives in Monroe County

County Efforts

Monroe County has been engaged in resiliency, climate, and sustainability planning since 2010 when it first hired a staff person to head the County's sustainability and climate initiatives. That effort was concurrent with the award of American Reinvestment and Recovery Act (ARRA) funds and was one catalyst in undertaking these broader planning and infrastructure initiatives. This led to the County's first sustainability and resiliency planning document known as GreenKeys.

The County has amended provisions of its Comprehensive Plan and integrated sea level rise policy initiatives into the Plan and its Code of Ordinances. The County also produced its first Vulnerability Assessment in 2015 in conjunction with the

GreenKeys Planning process. The County also produced a credited CRS Watershed Management Plan in 2019 and was awarded 120 points for that effort. This WMP was one of the first in the Country to incorporate the new guidance related to sea level rise into the effort evaluating the NOAA Intermediate High 2100 condition. The County undertook numerous other policy initiatives, such as a specific state-mandated update of its Coastal and Conservation Element of the Comprehensive Plan to comply with new state guidelines. The County updated its Vulnerability Assessment work in 2021 and is currently proceeding with a further Vulnerability Assessment update to ensure it meets the requirements of the state's Resilient Florida program guidelines, enacting into law in 2021.

The County also initiated a planning effort in 2020 to conduct a Roads Vulnerability Analysis and Capital Plan. This extensive engineering-based effort has been based on updated and highly accurate mobile LiDAR previously collected by the County and evaluates the vulnerability and criticality of the County's roadways. The Plan includes conceptual engineering design, cost estimates, and a timetable in five-year increments to undertake road elevation, stormwater, and tidewater adaptation projects. The County and municipalities have engaged in extensive coordination to expand that planning process across the entirety of the Keys including the municipalities. The County has recently launched a Natural Resources Adaptation planning process to determine the cost-benefit and natural resources adaptation priorities in the County. Finally, the County has begun implementing several road elevation/adaptation and shoreline projects according to state and federal grants and appropriations received.

Florida Department of Transportation (FDOT)

FDOT has developed a statewide Resilience Action Plan (RAP), as required by Section 339.157, F.S. As a major state roadway, the Overseas Highway, US-1, is included within the plan's purview. The plan seeks to enhance infrastructure and operational resilience, design retrofits and construction of highway facilities, and strengthen partnerships to address multijurisdictional needs. The RAP assesses potential impacts of storms, flooding, and sea level rise on the State Highway System, and identifies strategies to improve the resiliency of Transportation facilities. FDOT recently initiated development of the Statewide Resilience Improvement Plan (RIP), which will build on the prior statewide RAP analysis and could potentially secure additional federal funding identified by the plan.

The current RAP includes a priority project list, which categorizes short term projects in line with FDOT's five-year work program and long-term projects based on their respective needs and cost-feasible long-range plans. The priority project list also identifies geographic areas that may be subject to water-related hazards.

Florida Keys Aqueduct Authority

The Florida Keys Aqueduct Authority (FKAA) has provided information to Monroe County as well. Data regarding critical facilities has been incorporated into baseline asset maps referenced later within this document. Although the County does not own or manage FKAA assets, they are still considered “regionally significant” and will be evaluated under the scenarios required by Section 380.093, F.S. and incorporated into the Critical Asset Inventory.

FEMA Community Rating System

Since its creation in 1968, the National Flood Insurance Program (NFIP) has provided federally-backed flood insurance in communities that enact and enforce floodplain regulations. By requiring communities to plan for and protect against a 1%-average-annual-chance flood event (also known as a 100-year flood event), the NFIP encourages the regulation of development in flood areas.

The Federal Emergency Management Agency (FEMA) oversees the NFIP and administers its Community Rating System, a voluntary program that offers NFIP insurance rate reductions for property owners in communities that exceed the minimum NFIP participation requirements through certain additional floodplain management and conservation activities. Local governments are classified according to their total CRS scores. Table 2 below shows CRS participation in Florida and the percentage reduction in flood insurance rates associated with each rating class.

Table 2 - CRS Participation in Florida

CRS Class	Number of Florida Communities	NFIP Discount
9	17	5%
8	40	10%
7	53	15%
6	72	20%
5	58	25%
4	1	30%
3	4	35%

With 3,592 points, Monroe County is currently ranked Class 3 in the program, having achieved this level in 2022, jumping directly from Class 5. This provides residents of unincorporated Monroe County in a Special Flood Hazard Area (SFHA)—

approximately 96 percent of policyholders—with a 35% premium discount. Residents outside of the SFHA receive a 10% discount.

Discounted flood insurance provides a powerful incentive for communities to take steps that will reduce flood damage to existing buildings and manage development in certain unmapped areas, encouraging the restoration and preservation of the natural functions of floodplains.

CRS provides both incentives and tools to further the goals of providing flood insurance to property owners, reducing flood loss, and saving taxpayers' money. With the county participating in the program, property owners can receive discounted flood insurance premium rates; with effective floodplain management, the community becomes more resilient.

These rate reductions are due, in part, to the county's initiatives that help to implement three basic CRS goals:

1. Reduce flood damage to insurable property. The CRS program encourages communities to reduce the exposure of existing buildings (and their contents) to flood damage, especially properties that have flooded multiple times. Standards exceeding the minimum criteria of the NFIP may be needed to protect buildings and contents from flood hazards. The CRS encourages communities to map and provide data on their flood hazards and employ such data in their regulatory programs.
2. Strengthen and support the insurance aspects of the NFIP. Communities are awarded CRS points for activities that support accurate risk rating of flood insurance premiums, through mapping and information programs that help assess individual property risk and reduce repetitive flood losses. Local governments can receive additional points for informing residents of their flood risk and inducing them to purchase and maintain flood insurance policies.
3. Encourage a comprehensive approach to floodplain management. The CRS program encourages communities to use all available tools to implement comprehensive local floodplain management programs, which can address concerns beyond the protection of insurable property. The CRS program recognizes local efforts that protect lives; advance public health, safety, and welfare; minimize damage and disruption to infrastructure and critical facilities; preserve and restore the natural functions and resources of floodplains and coastal areas; and ensure that new development does not shift adverse impacts to other parts of the watershed or other properties. Understanding the physical and biological processes that form and alter floodplains and watersheds allows communities to appropriately address flooding, erosion, habitat loss, water quality, and special flood-related

hazards. The “comprehensive approach” envisioned by the CRS program includes planning, public information, regulations, financial support, open space protection, public works activities, emergency management, and other appropriate techniques.

CRS Requirements and Creditable Activities

In recognition of the fact that “floodplains and watersheds change over time” due to “many natural and manmade changes,” the CRS Manual introduced a series of credit options for “community efforts to anticipate” future flood risk in relation to climate change. Because sea level rise is expected to be an increasingly critical issue for floodplain management, many of the credit options and assessment criteria for coastal communities specifically refer to studies of sea level rise impacts on future hydrologic conditions and local drainage systems.

These options are summarized in section 116.c of the CRS Manual as:

1. Credit is provided in Section 322.c for communities that provide information about areas (not mapped on the Flood Insurance Rate Map (FIRM) that are predicted to be susceptible to flooding in the future because of climate change or sea level rise.
2. To achieve CRS Class 1, a community must receive credit for using regulatory flood elevations in the V and coastal A Zones that reflect future conditions, including sea level rise.
3. Credit is provided in Section 342.d when prospective buyers of a property are advised of the potential for flooding due to climate changes and/or sea level rise.
4. Credit is provided in Section 412.d when the community’s regulatory map is based on future-conditions hydrology, including sea level rise.
5. Credit is provided in Section 432.k when a community accounts for sea level rise in managing its coastal A Zones.
6. Credit is provided in Section 452.b for a coastal community whose watershed master plan addresses the impact of sea level rise.
7. Credit is provided in Section 512.a, Steps 4 and 5, for flood hazard assessment and problem analyses that address areas likely to flood and flood problems that are likely to get worse in the future, including (1) changes in floodplain development and demographics, (2) development in the watershed, and (3) climate change or sea level rise.

There are 19 creditable CRS activities organized under four categories as reflected in Table 3. Each of the 19 activities has one or more elements. The CRS Manual assigns credit points based on the extent to which each activity advances the goals of the

CRS, which are 1) to reduce and avoid flood damage to insurable property, 2) to strengthen and support the insurance aspects of the NFIP, and 3) to foster comprehensive floodplain management. As of its 2020 CRS submittal, the county participated in 15 activities within all four categories.

From its current 3,592 points, reaching Class 2 would require earning an additional 408 points (4,000 points total). Class 5 would require an additional 908 points (4,500 points total). CRS Class 2 or Class 1 status would win an additional 5% or 10% premium discount, respectively, for qualified NFIP policyholders within the Special Flood Hazard Area.

Monroe County’s current Class 3 rating was achieved under the guidelines of the 2017 CRS Coordinator’s Manual that was in effect when the county was evaluated in 2020. In January 2021, FEMA released an Addendum to the 2017 CRS Coordinator’s Manual, which set forth new prerequisites for participation in the CRS program. The county’s activities will be reevaluated during its next CRS cycle verification under the most current CRS program rules.

Table 3 – Monroe County CRS Activities

CRS Activity Number	CRS Activity	Points Earned by Monroe County in Activity
310	Elevation Certificates	38
320	Map Information	70
330	Outreach Projects	350
340	Hazard Disclosure	22
350	Flood Protection Information	95
360	Flood Protection Assistance	40
370	Flood Insurance Promotion	90
410	Flood Hazard Mapping	0
420	Open Space Preservation	880
430	Higher Regulatory Standards	421
440	Flood Data Maintenance	158
450	Stormwater Management	326
510	Floodplain Management Planning	497
520	Acquisition and Relocation	0
530	Flood Protection	160
540	Drainage System Maintenance	80

<u>CRS Activity Number</u>	<u>CRS Activity</u>	<u>Points Earned by Monroe County in Activity</u>
610	Flood Warning and Response	365
620	Levee Safety	0
630	Dam Safety	0

Good floodplain management decisions acknowledge and how floodplains might look over time. This includes many factors such as rising sea levels. The CRS Manual incorporates acknowledgement of—and credit for—community efforts to anticipate future flood risk and climate resilience and to take actions to mitigate adverse impacts. Monroe County is in a good position to better align participation in the CRS program with outcomes from this Vulnerability Assessment and further integrate more advanced modeling planned for the near term.

Current Context

Climate Change and Sea Level Rise

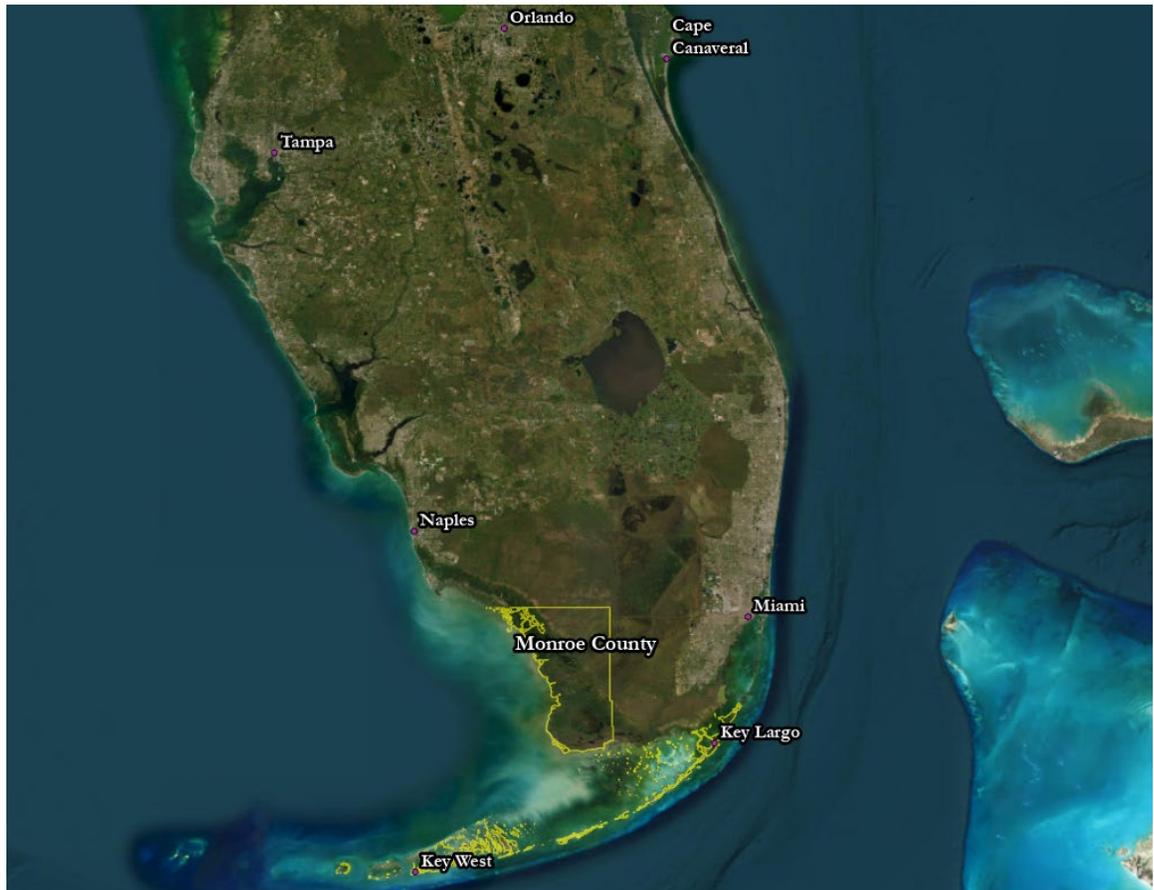
Globally, climate change presents a monumental challenge, characterized by rising temperatures, shifting weather patterns, and increased frequency of extreme weather events. In the context of Monroe County, these global trends manifest in specific regional impacts that directly affect the county's environmental and socioeconomic fabric. Monroe County faces unique challenges due to its geographical location, with climate change exacerbating existing environmental vulnerabilities. The assessment specifically focuses on understanding these local implications, including how shifts in climate patterns are influencing the county's natural ecosystems, urban infrastructure, and socio-economic dynamics.

In the case of Monroe County, climate change presents a multifaceted set of challenges that demand careful examination and proactive response. Characterized by rising global temperatures, altered weather patterns, and a heightened frequency of extreme events, these changes have direct and indirect effects on Monroe County, impacting various aspects of the region's environment, economy, and society.

One notable consequence is the increase in sea levels, which is primarily driven by the thermal expansion of seawater and the melting of polar ice caps and glaciers. As sea levels continue to rise, Monroe County's coastal areas face escalating risks, including erosion, more frequent and severe flooding, and compromised infrastructure. These impacts are compounded by the county's low-lying topography and its reliance on a robust coastal economy, making it particularly vulnerable to sea-level rise.

Sea-level rise is a critical concern for coastal communities in Monroe County, posing significant risks to its infrastructure, ecosystems, and communities. Monroe County's geographical location between the Gulf of Mexico and the Atlantic Ocean makes it highly susceptible to the effects of sea-level rise. The county's coastline, characterized by its shorelines and vital economic assets, is under threat as sea levels encroach further inland. Coastal erosion and compromising drainage system operations are two consequences of these impacts likely to increase in the future.

Figure 8 - Regional Context of Monroe County



Furthermore, the increased frequency and intensity of storms, including hurricanes and tropical cyclones, pose a substantial risk to Monroe County. Rising sea levels exacerbate the storm surge effect, magnifying the potential for devastating inundation during these events.

Additionally, the economic vitality of Monroe County, with its reliance on tourism, fisheries, and maritime industries, is intricately linked to its coastal assets. As sea levels rise and coastal vulnerabilities grow, these sectors face increasing uncertainty and disruption.

Physical Descriptors of Area

Geographical Setting and Characteristics

Monroe County's geographical characteristics render it particularly susceptible to climate change impacts. These characteristics include:

- **Coastal Location:** Monroe County's location between the Gulf of Mexico and Atlantic Ocean makes it highly susceptible to a range of coastal hazards. This includes the threat of sea-level rise, which can lead to temporary or permanent inundation of coastal areas, and storm surges from tropical storms and hurricanes. Additionally, by increasing the base water level, sea level rise elevates the risk of flooding during daily and seasonal high tides.

Figure 9 - Vicinity Map of Monroe County



- **Elevation and Topography:** While some parts of the county feature relatively flat terrain, others exhibit slightly elevated landscapes. These topographical differences greatly influence flood risk and drainage patterns. Low-lying areas

with minimal elevation are at greater risk of flooding, while elevated regions may experience comparatively lower flood risk. Within the county's boundaries, low-lying areas are predominantly situated along the coastline and adjacent to water bodies such as canals and estuaries. Due to their lower elevation, these regions face a heightened risk of inundation during extreme weather events.

Figure 10 - Elevation (Upper Keys)

Lower elevations in purple, higher elevations in red

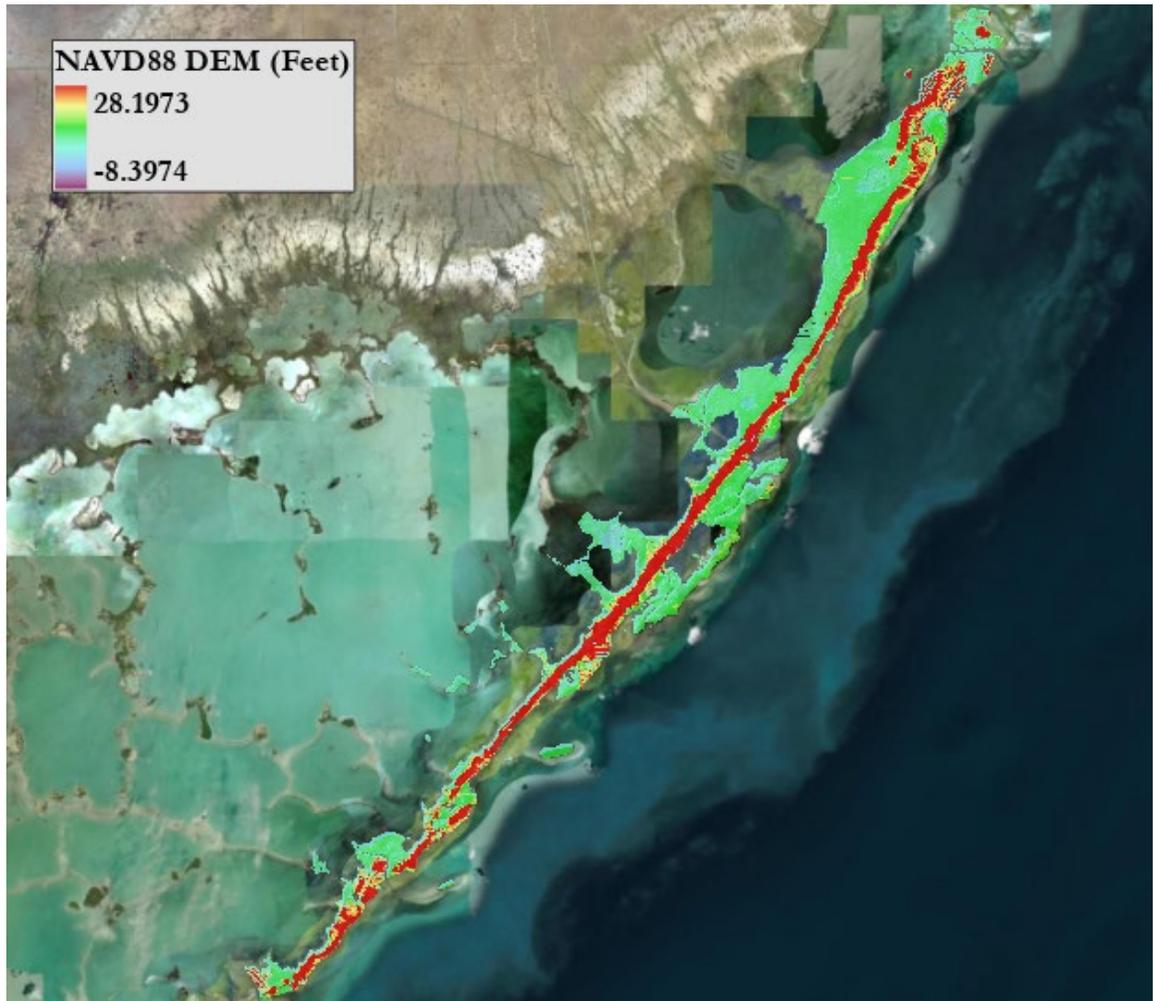
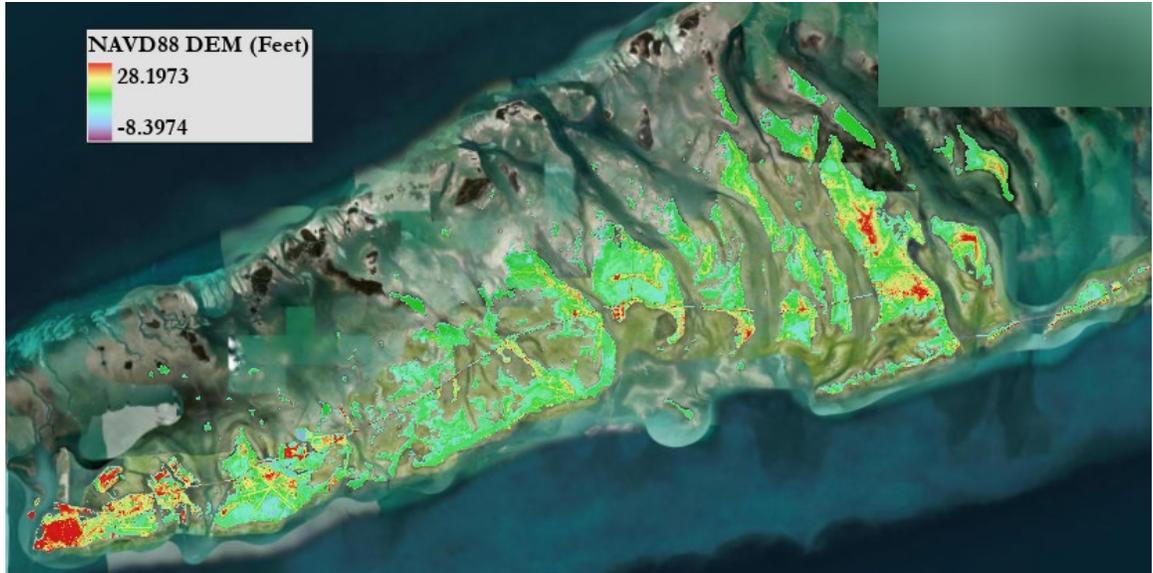


Figure 11 - Elevation (Lower Keys)

Lower elevations in purple, higher elevations in red



Demographic Overview

Understanding the demographic characteristics of Monroe County is crucial for evaluating the county population's vulnerability in the face of climate change. This comprehensive analysis provides insights into the population dynamics, growth trends, socioeconomic factors, and the application of tools like the Social Vulnerability Index and the Location Affordability Index, offering a multifaceted understanding of the challenges and potential solutions for climate resilience.

Population Dynamics and Distribution

Monroe County's diverse population spans urban and suburban areas with distribution patterns critical for assessing flood related impacts. The concentration of populations in different areas varies between day and night, influencing the risk exposure during flood-related events. During the day, the urban core experiences high population densities as people converge on workplaces, schools, and commercial areas. At night, the population disperses into residential neighborhoods, where concentrations are lower. These patterns are depicted in Figures 12-15, using color coding (red for high concentration, yellow for medium, and green for low) to indicate population density at different times of the day.

- **Daytime Activities:** Include bustling traffic, busy workplaces, shopping, and dining, with an influx of people from the suburbs.

- **Nighttime Quietude:** Characterized by reduced traffic, closed businesses, and a population retreating to suburban homes.

Figure 12 - Daytime Population Concentration (Upper Keys)

Red indicates high concentration, yellow medium, and green low

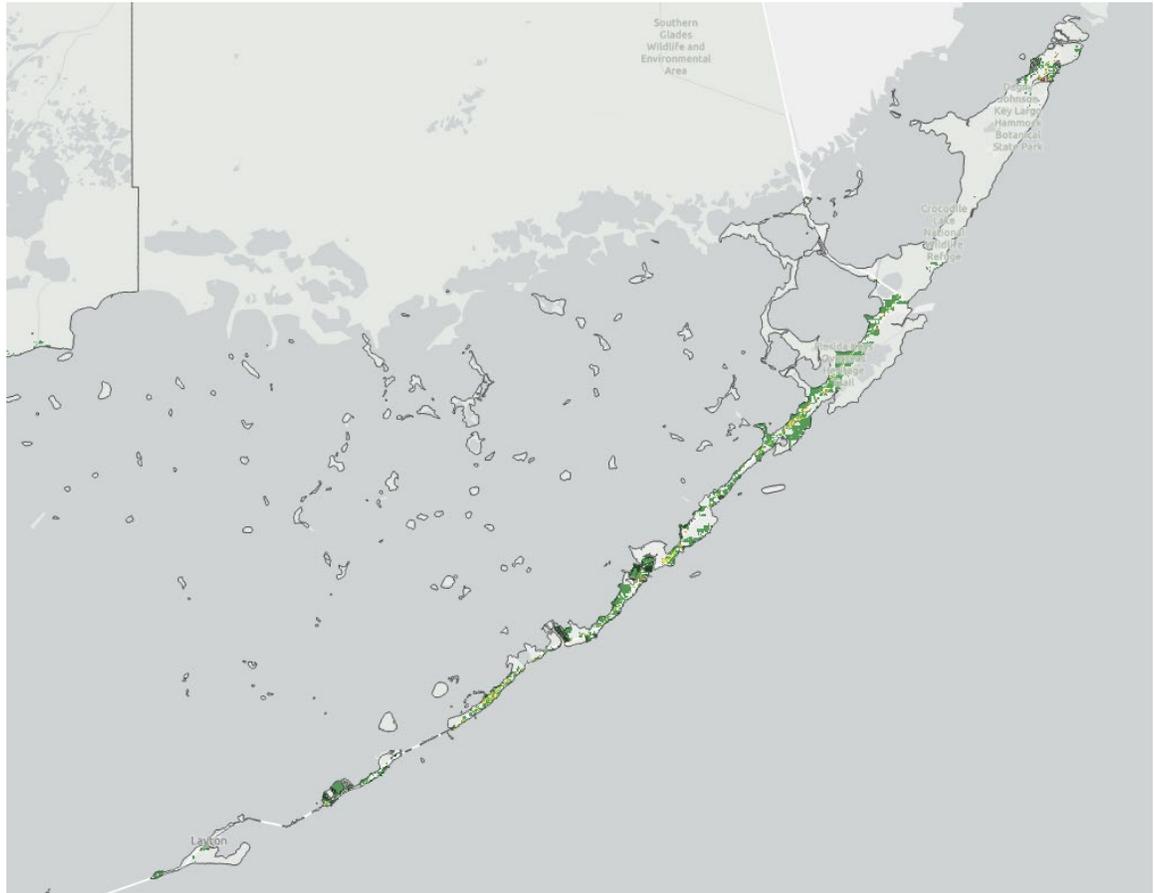


Figure 13 - Daytime Population Concentration (Lower Keys)

Red indicates high concentration, yellow medium, and green low



Figure 14 - Nighttime Population Concentration (Upper Keys)

Red indicates high concentration, yellow medium, and green low

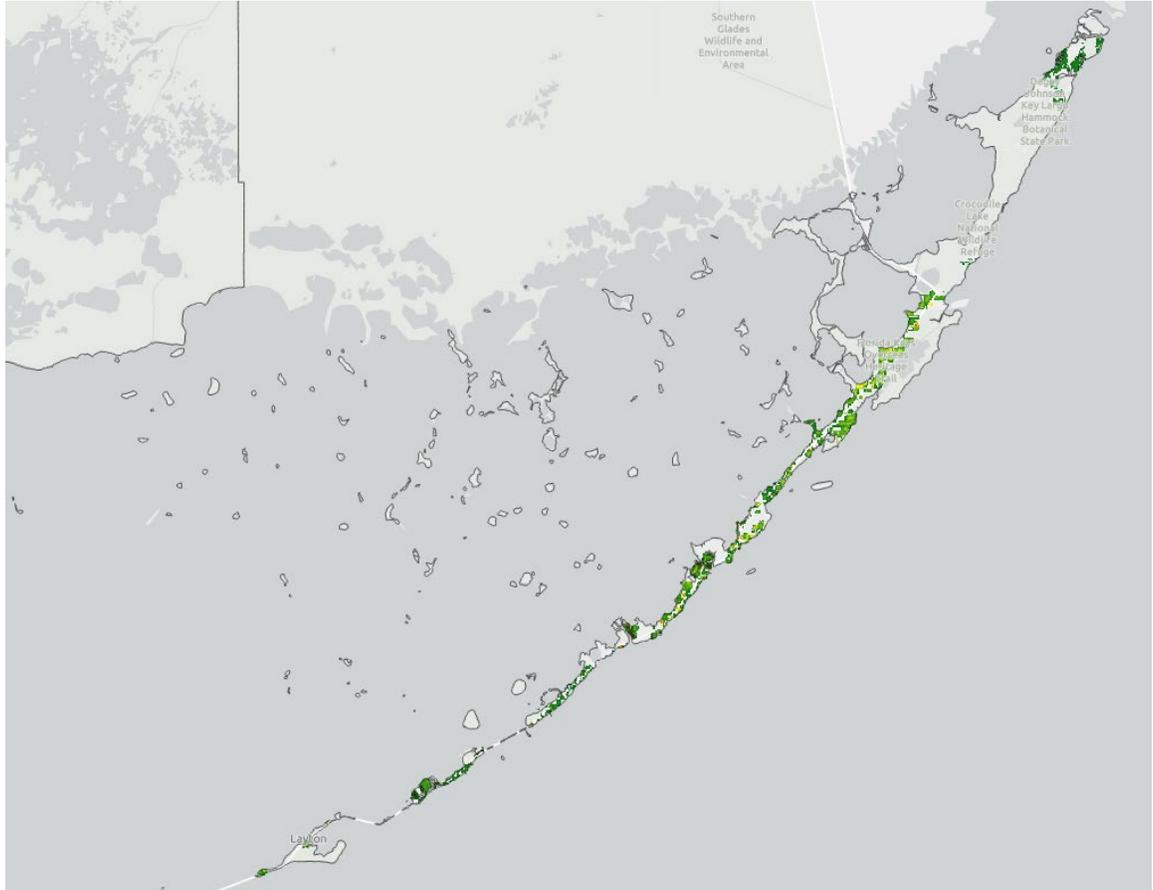
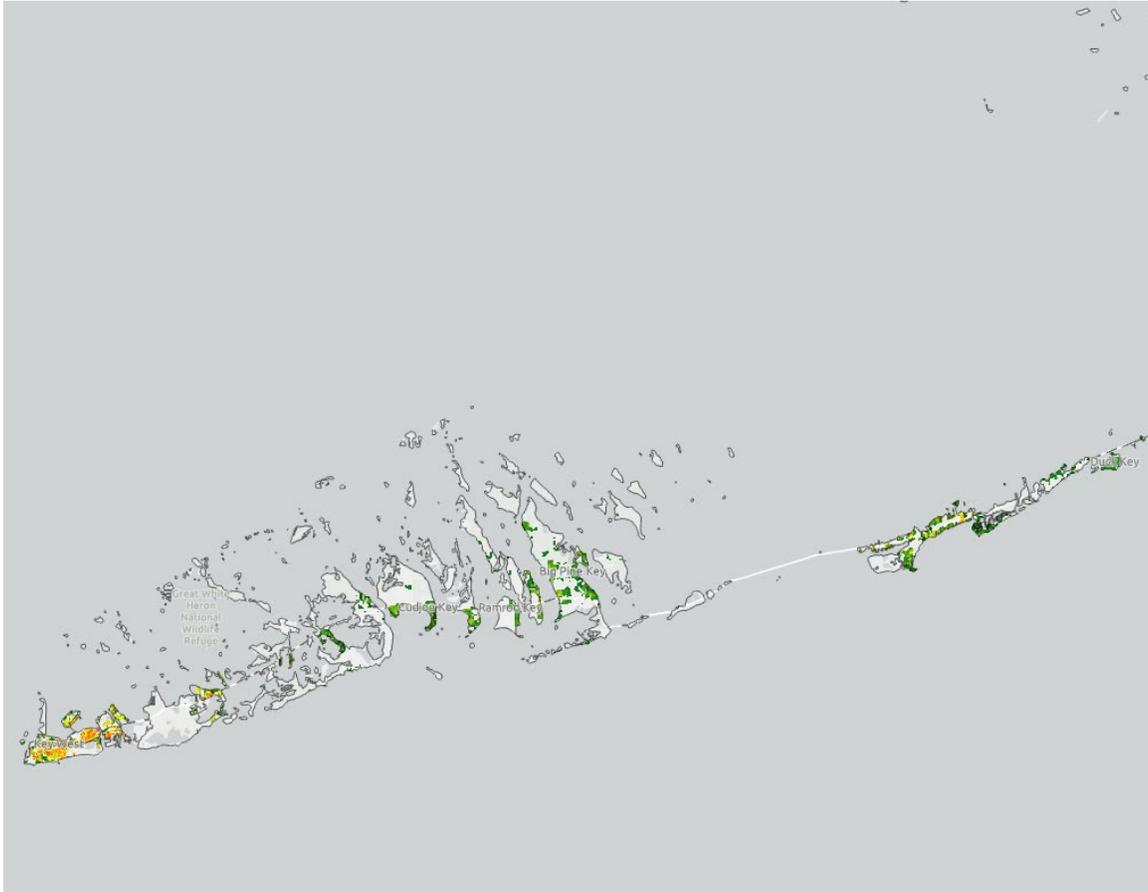


Figure 15 – Nighttime Population Concentration (Lower Keys)

Red indicates high concentration, yellow medium, and green low

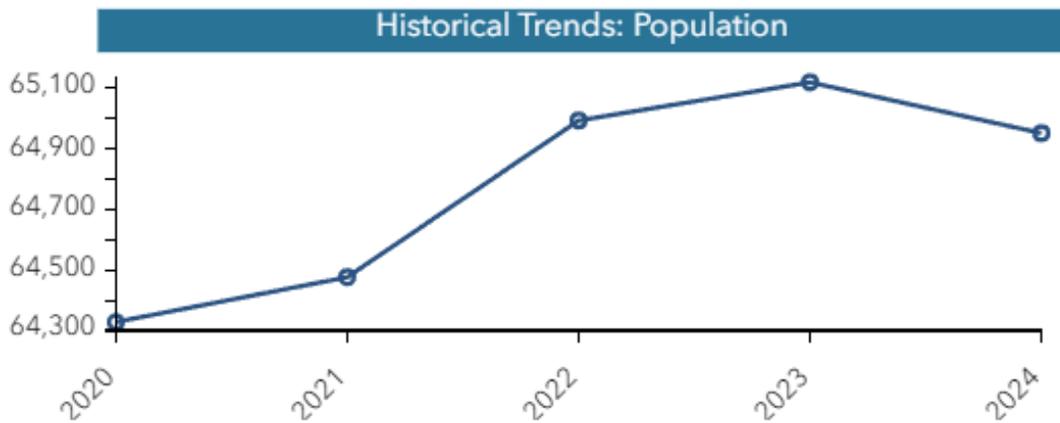


These insights underscore the importance of considering the dynamic nature of population distribution in climate vulnerability assessments. Where populations migrate throughout the day and night shows a reliance on assets and infrastructure that could be subject to more flooding impact.

Population Growth Trends

Examining population growth trends over time provides valuable insights into the county's changing demographics. Understanding how the population has evolved helps anticipate the potential increase in vulnerability due to a larger population. Rapid urbanization and population growth can lead to increased vulnerability, especially if it outpaces infrastructure development. Appendix H contains demographic information extracted from the American Community Survey and US Census Bureau.

Figure 16 – Unincorporated Monroe County Population Trends, 2020-2023



According to the historical trends graph (Figure 16), Monroe County's unincorporated area population has experienced fluctuations:

- The population grew from about 64,300 in 2020 to a peak of approximately 65,100 in 2023.
- Projections indicate a slight decline to 64,952 by 2024.

This trend suggests a relatively stable population with minor fluctuations, rather than consistent growth or decline. The 2024 projected total population for Monroe County is 83,702, of which 64,952 reside in the unincorporated areas. This indicates that unincorporated areas make up about 77.6% of the county's total population,

highlighting the significance of these areas in demographic and planning considerations.

Figure 17 - Population and Household Infographics

2024 Total Population (Esri)

for this area

64,952 which is less than the average for United States

Area	Value ▼	0	400,000,000
United States	338,440,954		
Florida	22,779,514		
Miami-Dade County	2,732,925		
Collier County	404,645		
Monroe County	83,702		
This area	64,952		

2024 Total Households (Esri)

for this area

29,417 which is less than the average for United States

Area	Value ▼	0	200,000,000
United States	130,716,571		
Florida	9,084,882		
Miami-Dade County	995,737		
Collier County	172,735		
Monroe County	37,310		
This area	29,417		

2024 Average Household Size (Esri)

for this area

2.18 which is less than the average for United States

Area	Value ▼	0.00	4.00
Miami-Dade County	2.70		
United States	2.53		
Florida	2.45		
Collier County	2.31		
Monroe County	2.22		
This area	2.18		

2024 Male Population (Esri): Percent

for this area

52.10 which is more than the average for United States

Area	Value ▼	0.00	60.00
Monroe County	52.15		
This area	52.10		
United States	49.82		
Florida	49.24		
Collier County	49.01		
Miami-Dade County	48.86		

2024 Female Population (Esri): Percent

for this area

47.90 which is less than the average for United States

Area	Value ▼	0.00	60.00
Miami-Dade County	51.14		
Collier County	50.99		
Florida	50.76		
United States	50.18		
This area	47.90		
Monroe County	47.85		

Monroe County's population is considerably smaller than neighboring counties:

- Monroe County: 83,702
- Miami-Dade County: 2,732,925
- Collier County: 404,645

This context is important when considering regional planning and resource allocation for climate resilience efforts.

Household Statistics and Demographics:

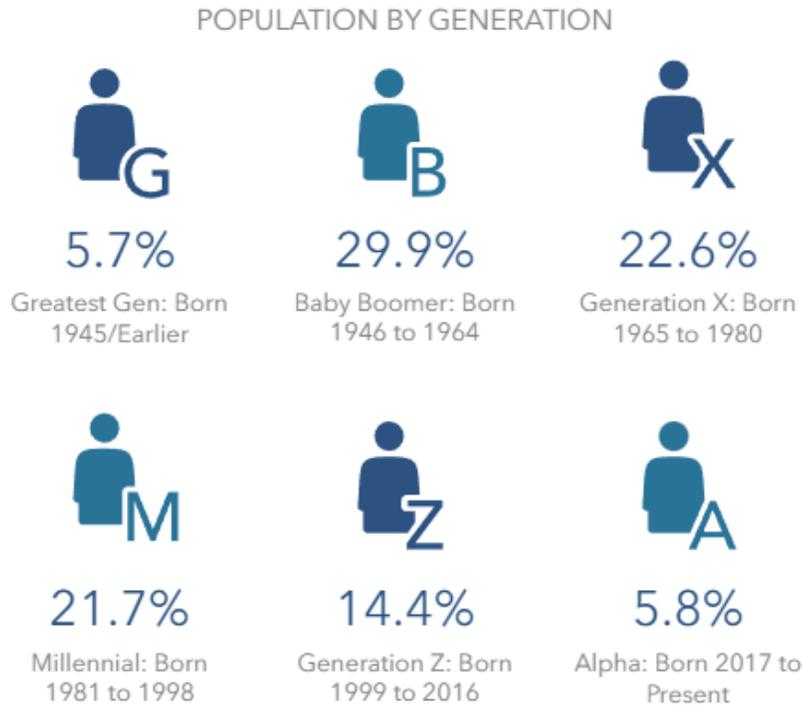
- The projected number of households for 2024 in the unincorporated areas is 29,417.
- The total number of households in all of Monroe County is 37,310.
- The average household size in the unincorporated areas can be calculated as approximately 2.21 persons per household (64,952 / 29,417).
- Gender distribution: 52.79% male and 47.21% female.

It is crucial to consider these household statistics and gender distribution when assessing climate change vulnerability and planning for resilience:

1. **Household Composition:** The average household size of 2.21 persons suggests a mix of family units and single-person households. This diversity requires varied approaches to emergency planning and resource allocation.
2. **Differential Vulnerability:** Both men and women face unique challenges in climate change scenarios. Women may be at higher risk due to socioeconomic factors or caregiving responsibilities. Men might face increased vulnerability due to occupational hazards in industries like construction or fishing, or societal expectations that may prevent them from seeking help.
3. **Resource Allocation:** Understanding household sizes and gender composition helps in tailoring support services. For instance, emergency shelters need to accommodate various family unit sizes and consider gender-specific needs.
4. **Economic Impacts:** The slightly higher male population (52.79%) may indicate gender-specific employment patterns. Industries that are more vulnerable to climate change impacts may affect genders differently, influencing overall community resilience.
5. **Health Considerations:** Climate change can have differing health impacts on males and females. Healthcare planning and emergency medical services should account for these potential differences.
6. **Participation in Decision-making:** Ensuring representation from all gender groups in climate change adaptation and mitigation planning is crucial for developing inclusive and effective strategies.
7. **Social Networks and Support Systems:** Gender can influence social networks and support systems, which are critical in disaster preparedness and recovery. Understanding these dynamics can help in creating more effective community-based resilience programs.

By considering these household and gender-related factors, Monroe County can develop more nuanced and effective strategies for climate change adaptation and disaster resilience. These strategies should aim to address the specific needs and vulnerabilities of all residents, regardless of gender or household composition.

Figure 18 - Percent of Population By Generation



Monroe County's population is distributed across generations as follows:

- Greatest Generation (born 1945 or earlier): 5.7%
- Baby Boomers (born 1946 to 1964): 29.9%
- Generation X (born 1965 to 1980): 22.6%
- Millennials (born 1981 to 1998): 21.7%
- Generation Z (born 1999 to 2016): 14.4%
- Alpha Generation (born 2017 to present): 5.8%

This generational distribution indicates an older population skew, with over half the population (52.5%) born before 1980. This demographic profile has significant implications for climate change and flood risk vulnerability:

1. **Aging Population:** The high percentage of Baby Boomers and older generations may increase overall vulnerability, as older residents might have mobility issues or require more assistance during evacuations.
2. **Socioeconomic Implications:** The generational mix suggests a need for diverse economic opportunities to retain younger generations while supporting an aging population.

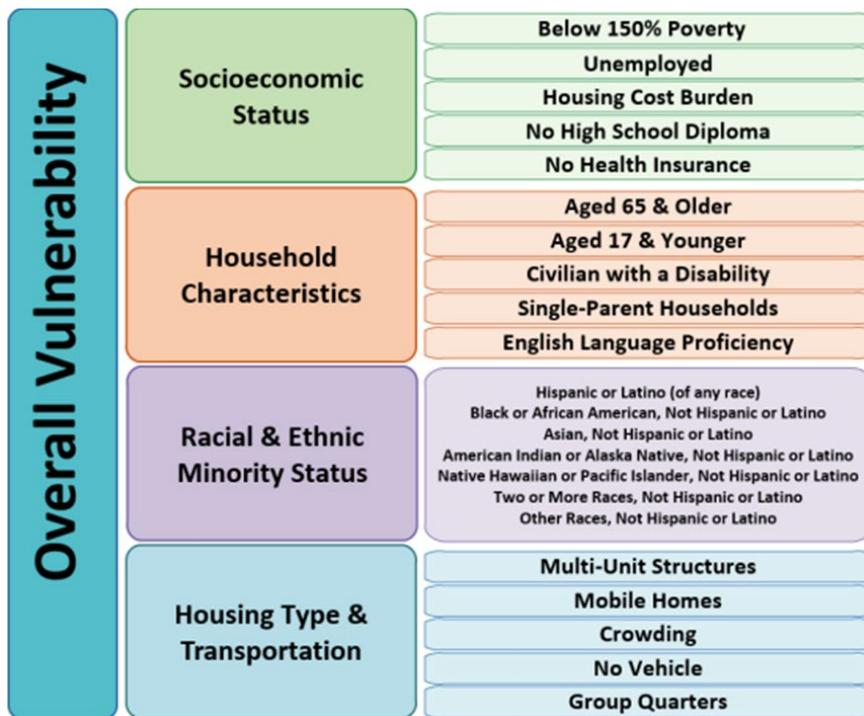
3. Long-term Planning: With a significant portion of the population in older age groups, long-term climate adaptation strategies should consider the evolving needs of an aging community.
4. Risk Communication: Strategies for communicating flood risks and preparedness measures should be tailored to reach all age groups effectively, considering varying levels of technology adoption and preferred communication channels.
5. Housing and Infrastructure: The needs of both older residents (potentially aging in place) and younger families should be considered in housing and infrastructure development, ensuring accessibility and resilience to flooding.

Socioeconomic Vulnerability

Socioeconomic disparities significantly influence community resilience to flood risk. Vulnerable populations may face disproportionate impacts from flooding and climate change due to limited resources and resilience. It is essential to identify and address socioeconomic disparities to ensure an equitable response to climate-related and increased flood-risk related challenges.

Socioeconomic disparities play a crucial role in determining a community's resilience to climate change. Vulnerable populations, identified through the most recent Centers for Disease Control and Prevention (CDC) Social Vulnerability Index (SVI), are at increased risk due to factors such as poverty, lack of vehicle access, and crowded housing conditions. The SVI provides a comprehensive assessment across four key themes—socioeconomic status, minority status and language, housing composition and disability, and housing and transportation—offering valuable insights for emergency preparedness, supply estimation, shelter identification, and evacuation planning in the face of sea-level rise and potential flooding scenarios. See Figure 19. The latest SVI data highlights Monroe County's at-risk communities, emphasizing the need for targeted support and intervention.

Figure 19 - Components of Social Vulnerability Index



The SVI was used to identify vulnerable populations and serve as a framework to discuss population characteristics that are exacerbated by flooding under future flooding conditions.

The CDC’s SVI database and mapping tools can assist with emergency preparedness in several ways. It can be used to estimate the amount of necessary supplies, such as food, water, medicine, and bedding, as well as how many emergency personnel are needed to assist at specific sites. The tool can also identify areas in need of emergency shelters and generically, in the preparation of evacuation plans, accounting for those with special needs, and highlighting those communities that may need continued support to recover from a natural disaster.

As reflected in Figure 19, the analysis of the county’s social vulnerability using the 2020 CDC’s SVI uses U.S. Census data to analyze the social vulnerability of every census tract. Each census tract is ranked on 15 social factors, including poverty, lack of vehicle access, and crowded housing, and groups them into four related themes to create an average score between 0% - 100%.

Figure 20 - CDC Social Vulnerability Index Map (Upper Keys)

Most vulnerable populations highlighted light to dark blue (<50% overall percentile ranking)



Figure 21 - CDC Social Vulnerability Index Map (Middle Keys)

Most vulnerable populations highlighted light to dark blue (<50% overall percentile ranking)



Figure 22 - CDC Social Vulnerability Index Map (Lower Keys)



The U.S. Department of Housing and Urban Development (HUD) with the help of the Department of Transportation launched the Location Affordability Index (LAI) which identifies areas based on cost estimates of housing and transportation for eight different household profiles (see Table 4). Furthermore, the LAI presents advanced insights into housing and transportation costs, which are critical for flood risk planning and enhancing climate resilience. By leveraging simultaneous equation modeling and an extensive dataset, the LAI accurately estimates costs for a variety of household profiles. This includes considerations of auto ownership, housing expenses, and transit usage, providing a nuanced understanding of affordability challenges faced by residents.

Table 4 - Location Affordability Index Household Income Profiles

Household Profile	Median Household Income for a Given Area (MHHI)
1. Median-Income Family	MHHI
2. Very Low-Income Individual	National Poverty Line
3. Working Individual	50% of MHHI
4. Single Professional	135% of MHHI
5. Retired Couple	80% of MHHI
6. Single-Parent Family	50% of MHHI
7. Moderate-Income Family	80% of MHHI
8. Dual-Professional Family	150% of MHHI

The term "Working Individual - 50% of MHHI" and others like it refer to metrics used to describe the income level of a working individual in relation to the Median Household Income (MHHI) of a given area. Here is a breakdown of what this means and its significance:

- **MHHI (Median Household Income):** This is the median income of all households in a specific area. The median is the middle value when you line up all the households by income, meaning half the households earn more than the MHHI and half earn less. It is a commonly used measure to understand the average income level of an area.
- **50% of MHHI:** When an individual's income is described as "50% of MHHI," it means their income is half the median household income for their area. This is a relative measure indicating the individual's earnings compared to the average household in the community.

These metrics have significance in the context of flooding and vulnerability assessments:

- **Economic Vulnerability:** Individuals earning a low percentage of the MHHI may have less financial flexibility to recover from flood damage or to invest in preventative measures such as insurance or home improvements that reduce flood risk.
- **Resource Allocation:** Understanding the income levels of affected individuals or households in relation to the MHHI helps in tailoring flood resilience and recovery programs. It highlights populations that may need more support in terms of subsidies, grants, or other assistance.
- **Planning and Preparedness:** Identifying areas where a significant portion of

the population earns a lower percentage of MHHI can inform emergency management agencies and local governments about potential needs for evacuation assistance, shelters, and other support services during and after a flooding event.

The incorporation of income levels as a percentage of MHHI in vulnerability assessments helps to paint a more detailed picture of risk and resilience within a community. It underscores the interconnectedness of socioeconomic status and disaster vulnerability, emphasizing the need for targeted approaches in resilience planning and support. The LAI scores across Monroe County identify areas of varying affordability and detail the distribution of owner-occupied versus renter-occupied housing (see Figures 23-26 below), illustrating the intersections of affordability, vulnerability, and climate risk. Higher renter areas are generally associated with more social vulnerability or where certain populations may be exponentially impacted by flooding. This comprehensive approach informs strategic planning and interventions, aiming to mitigate the impacts of climate change on the most vulnerable segments of the population. These enhancements, along with a broader dataset, make the LAI a robust tool for understanding and planning around housing and transportation affordability, potentially aiding in flood risk planning by highlighting areas where affordability and risk intersect.

In the context of flood risk, the correlation between higher rates of renters in a community and increased social vulnerability takes on an even more critical dimension. Renters often reside in areas more susceptible to flooding, either due to the lower cost of housing in such locations or due to limited availability of affordable options in safer areas. This situation places them at a disproportionate risk during flood events, not only in terms of immediate physical danger but also regarding the longer-term repercussions on their stability and well-being.

The transient nature of rental housing means that renters may have less knowledge about local flood risks and less incentive to invest in long-term flood preparedness measures. Furthermore, the financial instability associated with renting can exacerbate the challenges of recovering from flood damage. Renters may lack the insurance coverage, savings, or resources to quickly rebound from the loss of property or displacement caused by flooding. This can lead to significant disruptions in their lives, including the loss of employment, educational discontinuity, and mental health stresses.

Moreover, the areas with high concentrations of rental properties may receive less attention in terms of flood mitigation infrastructure and services. Investment in flood defenses, such as levees, floodwalls, and green infrastructure, is often prioritized in areas with higher property values and stronger political influence, which can leave renter-dominated neighborhoods more exposed and vulnerable.

Given these dynamics, addressing the flood risk in communities with a high

proportion of renters requires targeted policies and interventions. This includes not only enhancing the physical infrastructure to withstand flooding but also improving the resilience of the rental population through education on flood risks, access to affordable flood insurance, and the establishment of support systems for post-disaster recovery. Policies aimed at ensuring the availability of affordable, flood-resilient housing in safer areas are also crucial. Such comprehensive approaches can help mitigate the impact of floods on socially vulnerable populations, thereby reducing the overall risk and enhancing community resilience against climate change and natural disasters.

Figure 23 - HUD LAI Scores across Monroe County (Upper Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.

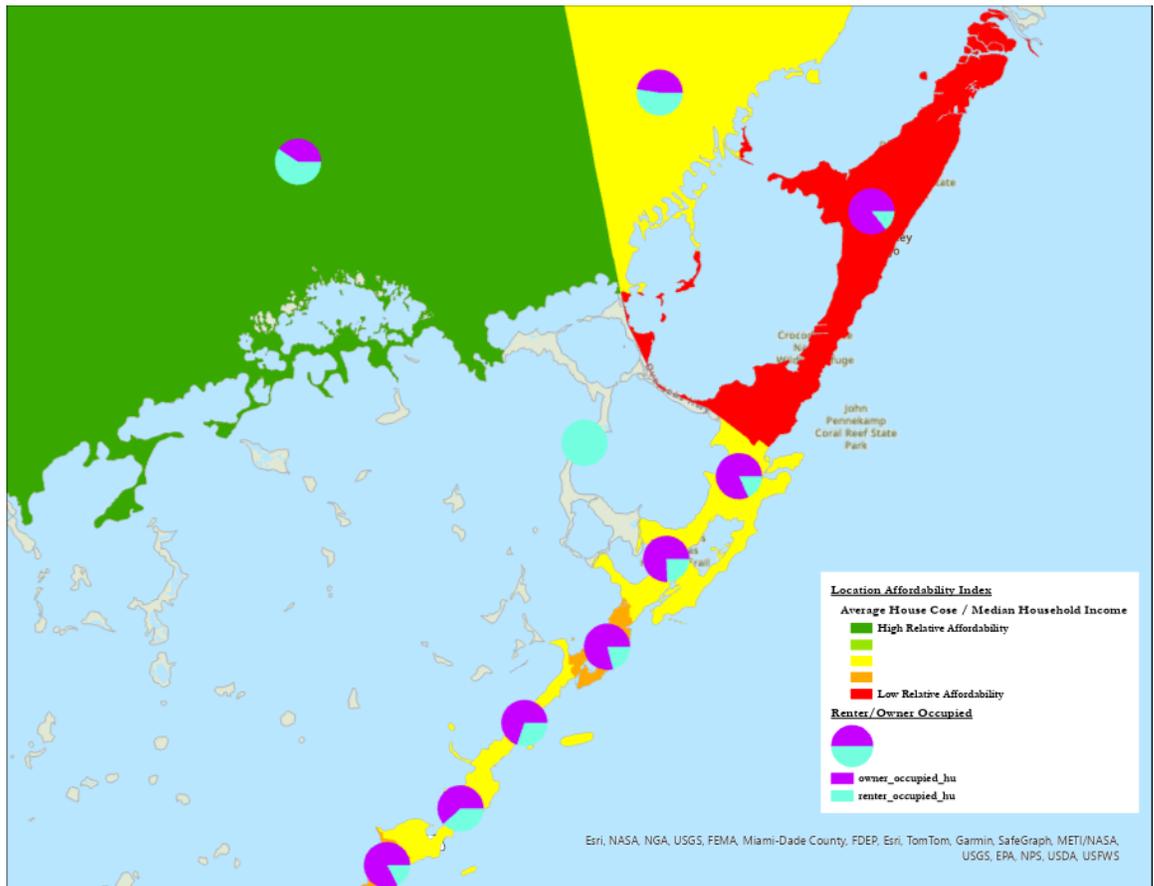


Figure 24 - HUD LAI Scores across Monroe County (Middle Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.

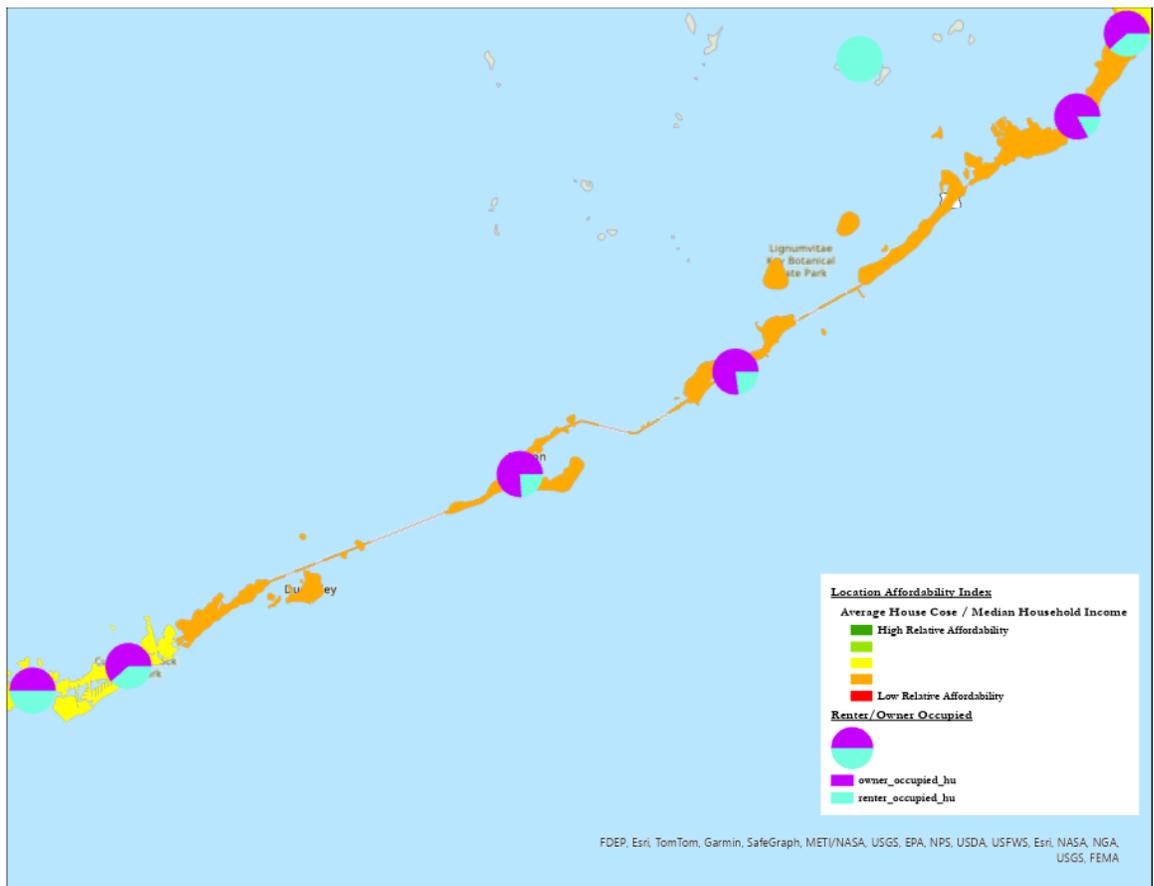
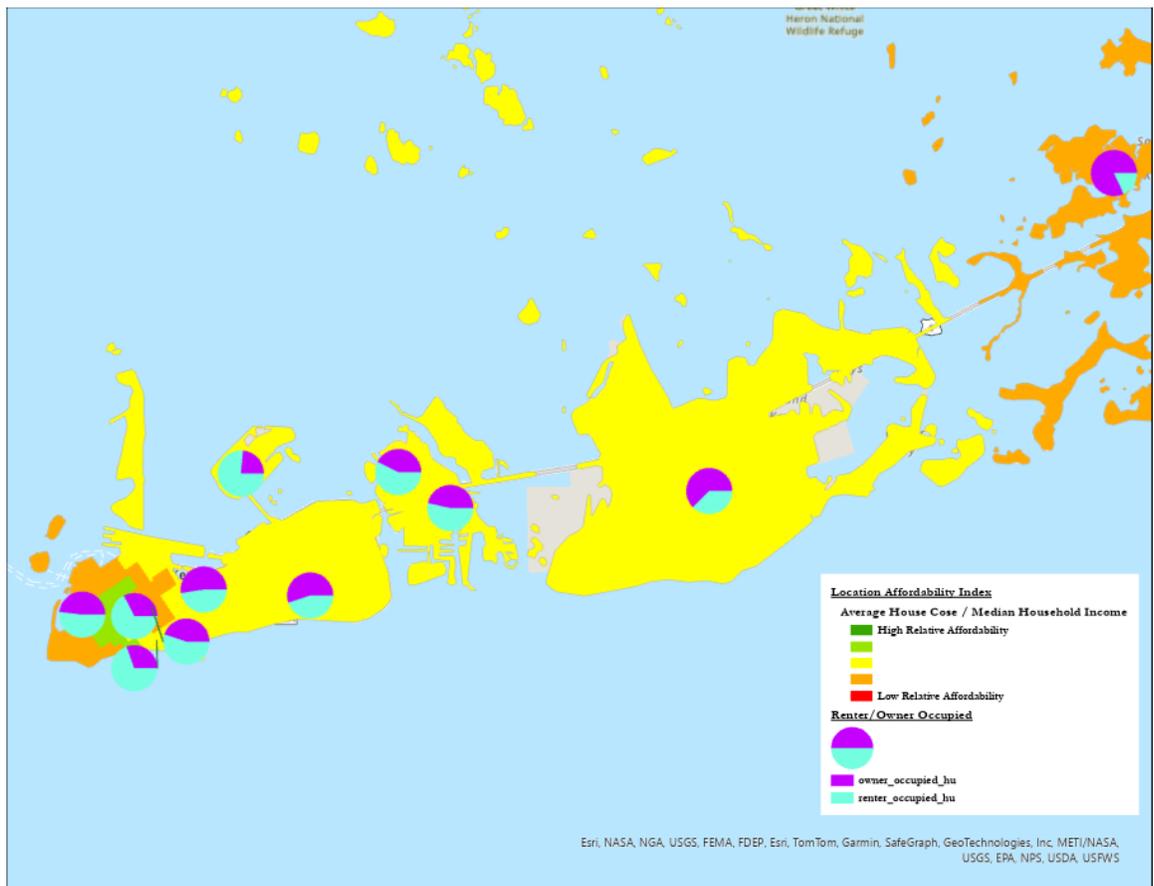


Figure 26 - HUD LAI Scores across Monroe County (Key West and Stock Island)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.



Key Infrastructure and Assets

Monroe County's critical infrastructure and assets are the backbone of the county's functionality and are integral to the vulnerability assessment. They are also required components of the analysis pursuant to statute divided out into four major “asset classes.”

- Transportation assets and evacuation routes:



- Critical infrastructure:



- Critical community and emergency facilities:



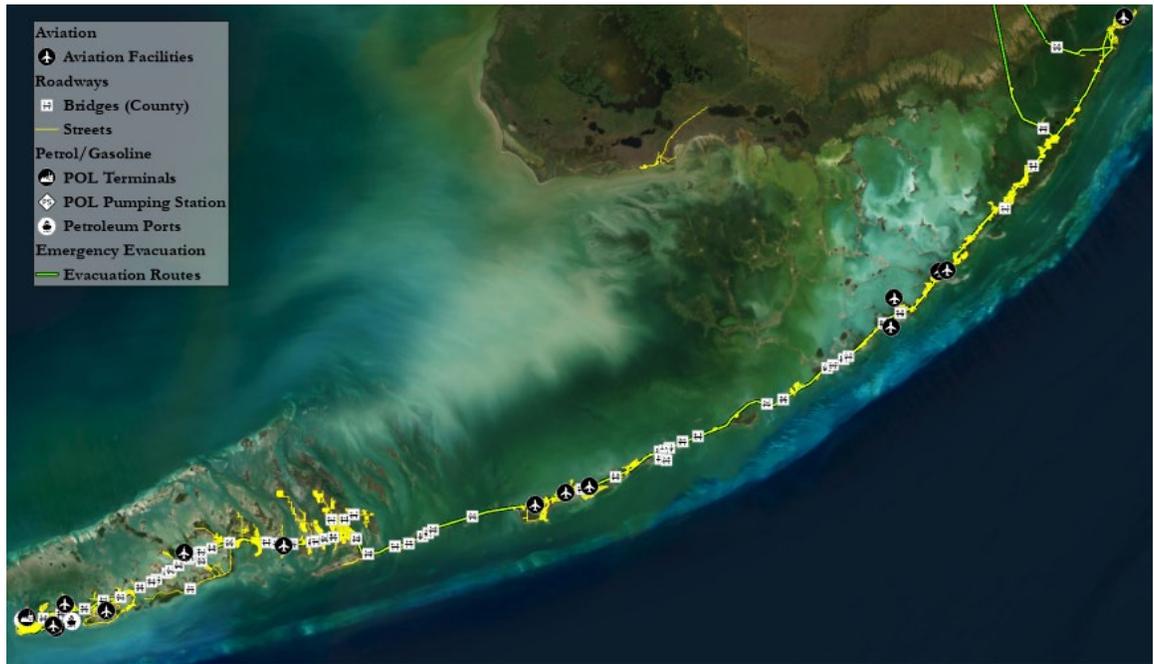
- Natural, cultural, and historical resources:



These assets encompass a wide range of essential components:

Transportation Infrastructure: Monroe County includes a network of vital transportation assets, including bridges, helipads, and major roadways. These arteries of connectivity are not only essential for daily life but also play a critical role in emergency response and evacuation during climate-related events. These include 13 major roadways including US highways and evacuation routes. Three public airports make up the county’s air transport infrastructure. Seven ports and 25 boat ramps comprise the marine facilities.

Figure 27 - Map of Transportation Infrastructure



Critical Infrastructure: The county relies on a robust network of utilities that includes stormwater components, wastewater treatment facilities, water supply systems, and electrical infrastructure. These utilities are indispensable for maintaining essential services, and their vulnerability to climate-related disruptions can have cascading effects on the community. Some are owned by the county, and some are regionally owned. These assets are included in Figures 28-31.

Figure 28 - Stormwater Map

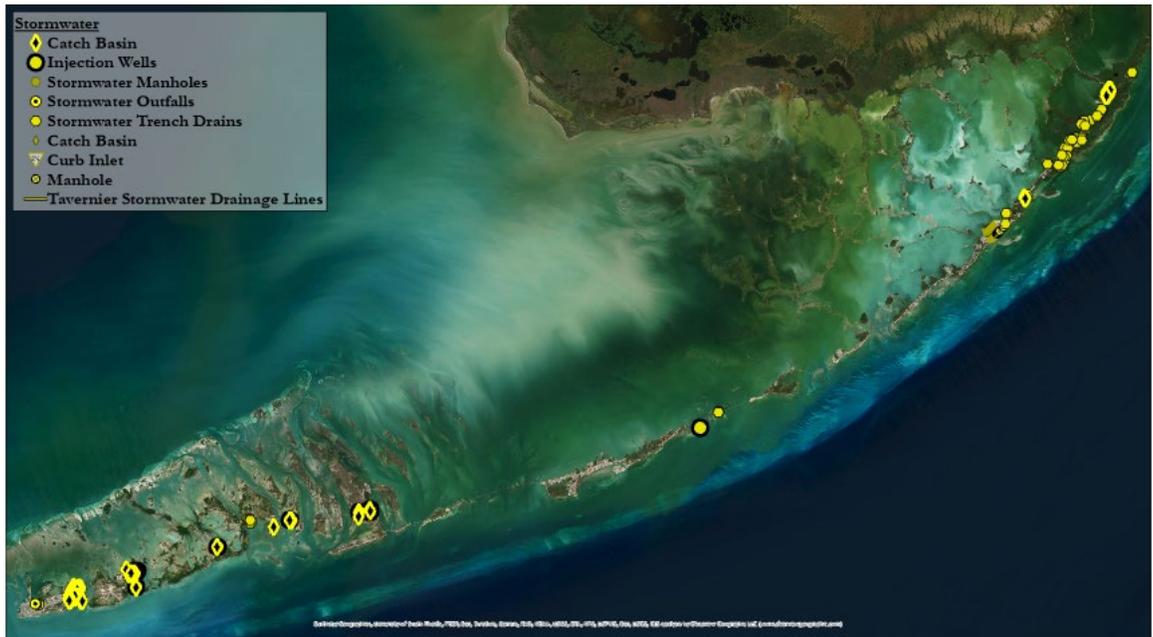


Figure 29 - Sanitary Sewer

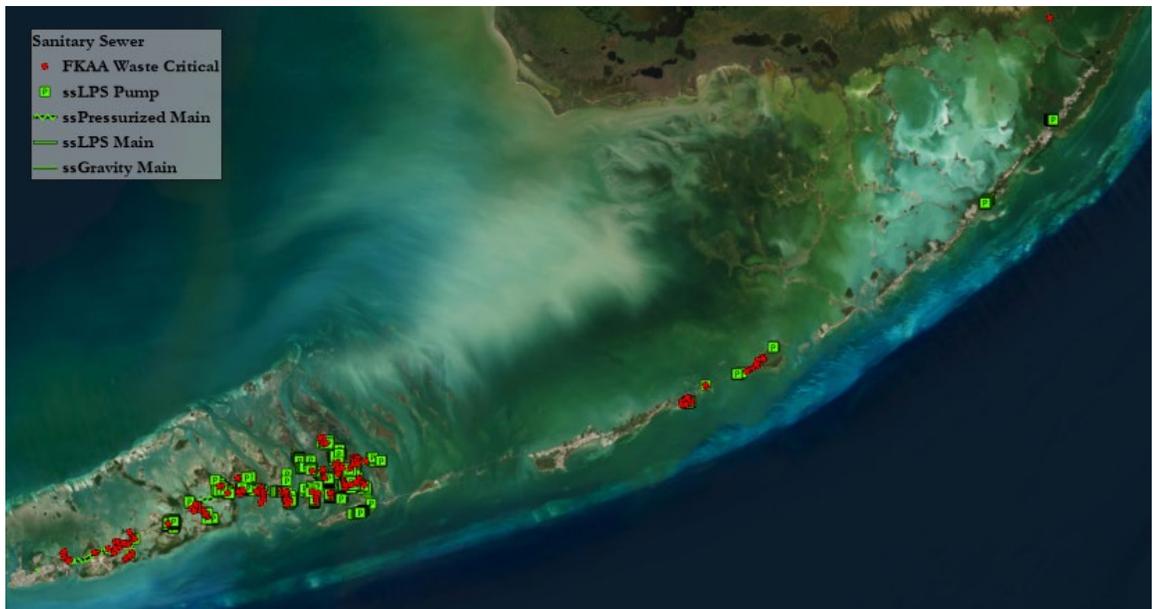


Figure 30 - Potable Water

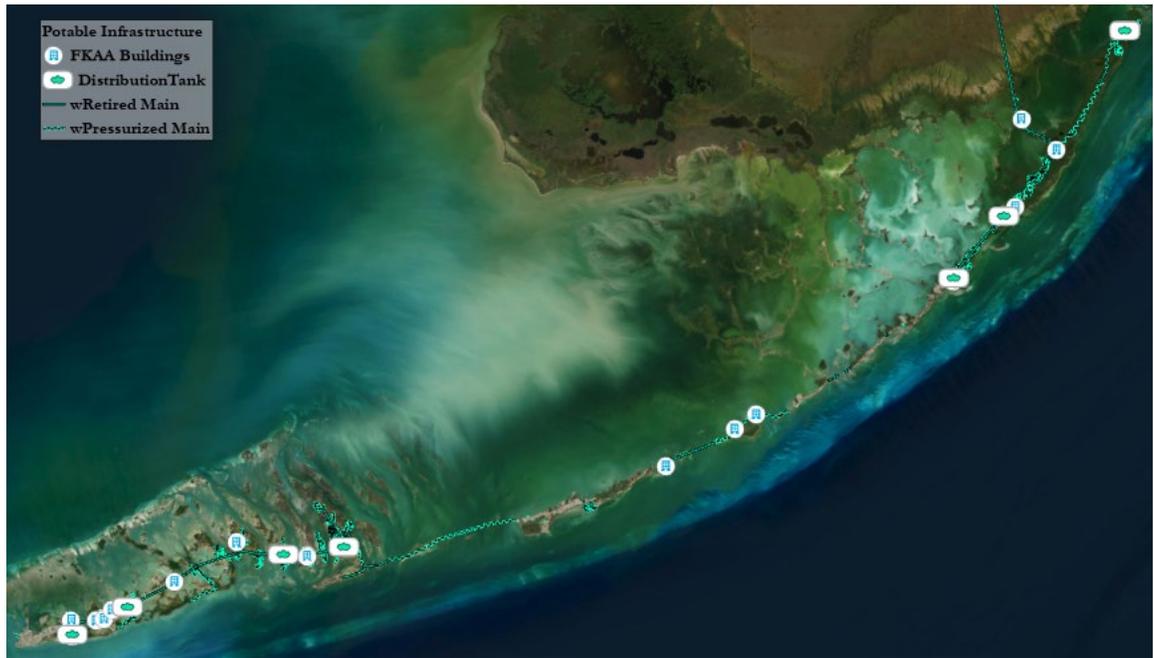
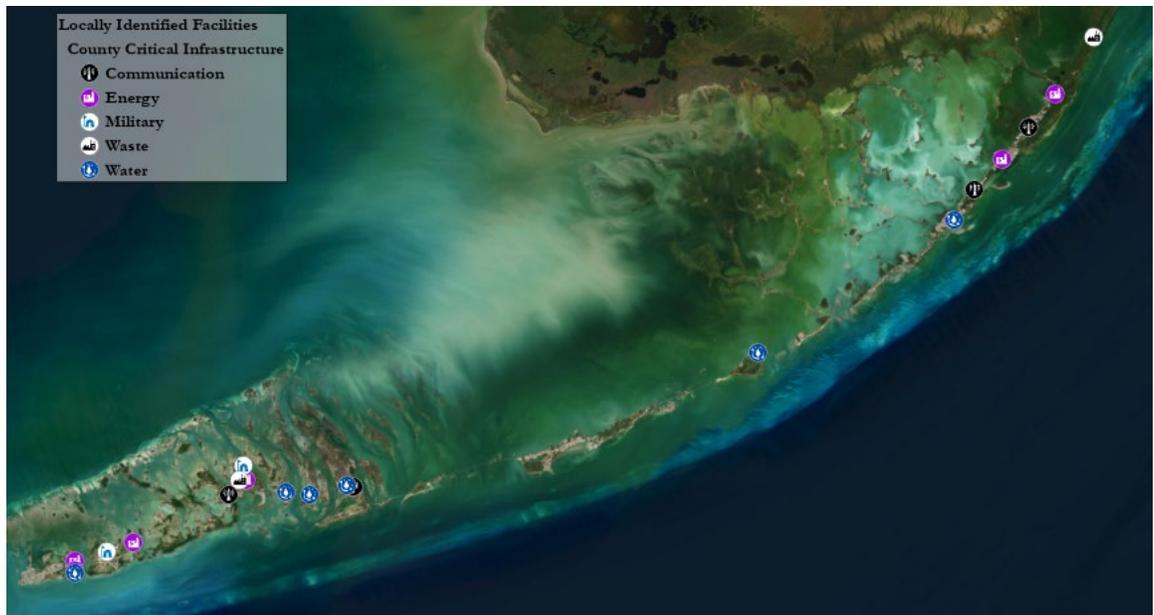


Figure 31 - Other Utility Assets



Critical Emergency and Community Facilities: Hospitals and healthcare facilities, while generally not owned and maintained by the county, are lifelines during disaster response and recovery, especially in the face of extreme weather events. Their ability

to function without interruption is vital for the well-being of the community. They are also required to be evaluated per statute.

Figure 32 - Map of Health Care Providers



Similarly, emergency response centers serve as command hubs for coordinating emergency response efforts. They are pivotal in disaster management and require robust infrastructure and connectivity to ensure effective response during climate-related emergencies.

Figure 33 - Map of Emergency Management Infrastructure



Natural and Cultural Resources: Monroe County's natural areas, cultural assets, and historical sites contribute significantly to its identity and quality of life. These resources are not only important for the well-being of the community but also need protection against climate change impacts to preserve the county's heritage.

Figure 34 - Map of Park Systems and Natural Areas

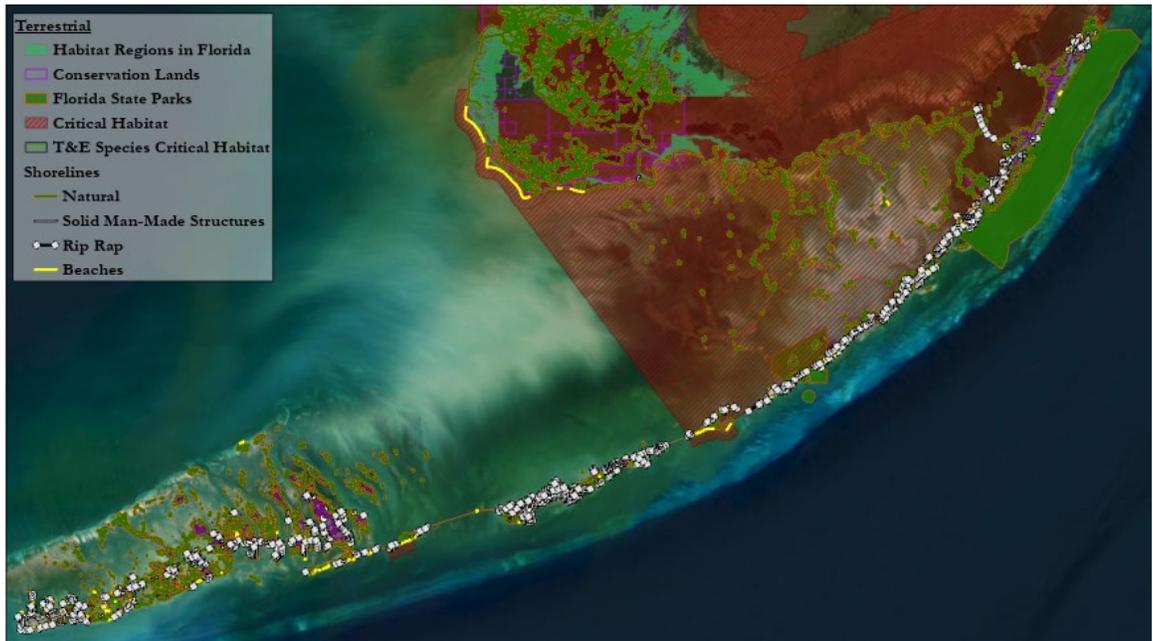


Figure 35 - Map of Cultural and Historic Assets



Regionally Significant Assets: As defined in Subsection 380.093, F.S., regionally significant assets are critical facilities that serve a broader geographic area, including neighboring communities, and are not necessarily owned and maintained by the county. These assets may encompass water resource facilities, regional medical centers, emergency operation centers, regional utilities, major transportation hubs,

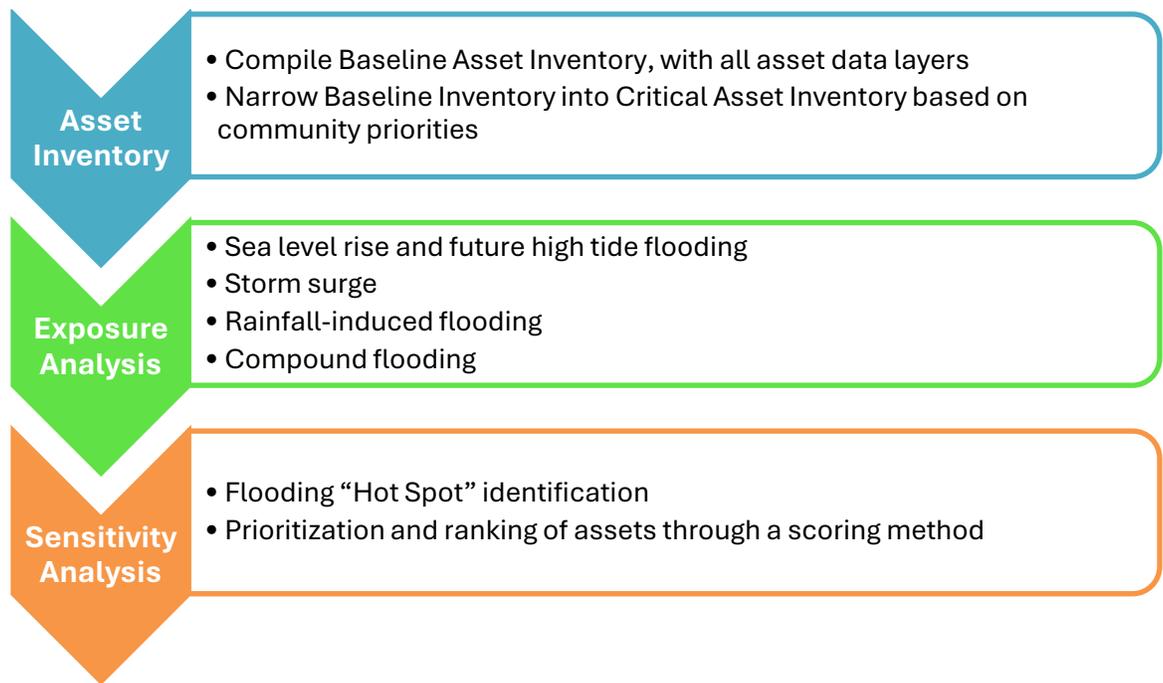
airports, and seaports. Identifying and safeguarding these assets is crucial for regional resilience and response coordination.

Assessment Methodology

Approach to Vulnerability Assessment

The methodology employed in this Vulnerability Assessment complies with Subsection 380.093, F.S., and uses a comprehensive set of data sources and modeling techniques. This approach is designed to provide a detailed analysis of the county’s vulnerability to climate change and sea-level rise. The primary components of this methodology are listed in Figure 36.

Figure 36 - Vulnerability Assessment Process Steps



The inundation outputs are a result of overlaying flood depths taken from a local NOAA tide gauge over a ground elevation surface extrapolated from the most recently available light detecting and ranging (LiDAR) data of Monroe County. It is important to acknowledge the limitations of this methodology. While it provides a valuable foundational assessment, it is not a substitute for detailed, site-specific studies as it is not a Hydrologic and Hydraulic model, nor does it account for the functions of in place stormwater structures. Future studies involving engineering-grade hydrologic and hydraulic modeling are recommended for more localized flood risk understanding.

Data Collection & Asset Inventory Evaluation

Process

To ensure comprehensiveness, this Vulnerability Assessment employed an exhaustive data collection strategy. Data was gathered from various authoritative sources, including federal agencies such as the Department of Homeland Security (DHS), National Oceanic and Atmospheric Administration (NOAA), and the Federal Emergency Management Agency (FEMA); state authorities such as the Florida Department of Environmental Protection (FDEP), Department of Transportation (FDOT) and the Fish and Wildlife Conservation Commission (FWC); and local authorities, including Monroe County staff. The collected data was categorized as follows:

1. **Transportation Assets and Evacuation Routes:** airports, bridges, bus terminals, boat ramps, major roadways, evacuation routes, port facilities, waterways, marinas, rail facilities, and railroad bridges.
2. **Critical Infrastructure:** wastewater treatment facilities and lift stations, stormwater treatment facilities and pump stations, drinking water facilities, water utility conveyance systems, drainage infrastructure and stormwater ponds, electric production and supply facilities, solid and hazardous waste facilities, military installations, post offices, communications facilities, and disaster debris management sites.
3. **Critical Community and Emergency Facilities:** schools, colleges, universities, assisted housing, 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, general-population risk shelters, special-needs risk shelters, and state government facilities.
4. **Natural, Cultural, Historical Resources:** This category is dedicated to preserving and protecting natural areas and cultural/historical sites, including conservation lands, historic buildings and cemeteries, national and state parks, shorelines, surface waters, wetlands, and historical and cultural assets.
5. **Supplementary Information:** This category includes additional data not explicitly required by Subsection 380.093, F.S., but valuable for a detailed vulnerability assessment. It encompasses the 2004 FIS, flood zones, frequently flooded structures, photos of flooding, green infrastructure, impervious surface areas, seawalls, and more. Geomorphological features and socioeconomic environment data are also included.

This categorization enables a systematic analysis of various asset types, their importance to the community, and their criticality in the event of flood events.

Regionally significant assets defined by statutory language include those spanning multiple jurisdictions and serving broader community needs. Regionally significant assets received special attention for their roles in resilience. These assets include Strategic Intermodal System (SIS), transportation facilities, ports, spaceports, waterways, railroad crossings, railroads, rail terminals, rail bridges, bus terminals, evacuation routes, electric power plants, electric power transmission lines, dams, and drainage assets maintained by water management districts. Additionally, stormwater ponds, wastewater facilities, public water supply tanks, public water supply plants (non-federal), emergency medical services facilities, emergency operations centers, risk shelters for the general population, and risk shelters for those with special needs are considered crucial in supporting the infrastructure and safety requirements of multiple regions.

Supplemental Information is included to augment resilience planning, capturing assets not explicitly identified in the statutory framework. This additional information can help verify or cross-check evaluation outputs.

Data Request

The data collection and evaluation process for Monroe County's Vulnerability Assessment was methodical and robust, involving a variety of authoritative sources. The collected data was categorized into four primary categories, tracking the State's defined asset classes, with a fifth supplementary category to enhance resilience planning efforts. Monroe County has an expansive database of asset classes available for the study in GIS shapefiles.

Data Gap Analysis

The Gap Analysis conducted for the Monroe County Vulnerability Assessment identified key areas of data insufficiency and proposed strategic solutions and pathways to obtain more information. These included enhancing geospatial data through mapping and system integration, improving infrastructure data with departmental reviews and responsible data management, and updating information on natural, cultural, and historic resources through community involvement. The analysis also recommended standardizing terminologies and developing comprehensive metadata to address inconsistencies and unclear data coverage. Employing a range of methods such as satellite imagery, government record analysis, and statistical modeling, the approach aims to achieve a thorough and dependable assessment to close gaps described in the Gap Analysis now and into the future.

Exposure Analyses: Tools and Models Used

The exposure analysis methodology of the Vulnerability Assessment Report encompasses a detailed analysis of the 2040, 2070 and 2100 planning horizons using tools and models, aligned with compliance requirements.

Future Sea Level Rise and High Tide Modeling: This involves modeling techniques using ArcGIS Pro and NOAA's methodology. The process includes use of the NOAA VDATUM conversion tool to generate a digital elevation model that is relative to MHHW and use of algorithms for tidal variability interpolation, ensuring accurate future high tide flood mapping accounts for the required tidal flooding threshold of 2' above mean higher high water.² This analysis also includes a representation of the number of tidal flood days that is expected for each scenario, as well as planning horizon in the map series titled "Days of Tidal Flooding" in the Exposure Map series.

Storm Surge Analysis: Utilizing FEMA's storm surge data and HAZUS-MH software, this analysis adjusts the historical storm surge data, captured within these stillwater elevation calculations and the coastal floodplain delineation module, by the future sea level rise projections discussed in more detail under the later section of this report. The approach integrates these projections with the community's existing 2004 Bay County FIS data, offering a nuanced understanding of future storm surge impacts.

Rainfall-Induced Flooding Evaluation: Adhering to specific legislative requirements, this part of the analysis employs the Hydrologic Engineering Center's River Analysis System (HEC-RAS) for rainfall simulation and runoff computation. It incorporates NOAA's Atlas 14 data, enriched with SFWMD's change factors¹, to create baseline rainfall depth grids essential for a comprehensive evaluation of potential future rainfall-induced flooding.

Compound Flooding Assessment: This segment addresses the compound effects of tidal, storm surge, and rainfall-induced flooding. It involves overlaying depth grids from various scenarios, acknowledging the resource and time constraints of the project.

Each of these risks are detailed in the report, providing a data-driven approach to assess Monroe County's vulnerability to climate-induced flooding threats. The methodology is designed to meet compliance standards and provide insight into the county's potential future flooding scenarios.

¹ <https://precipitationfrequency.ncics.org/index.html>

Scenario Development and Assumptions for Evaluations/Modeling

North American Vertical Datum of 1988

All elevations referenced in and analyzed for this Vulnerability Assessment are expressed in North American Vertical Datum of 1988 (NAVD 88) values.

Figure 37 - NAVD88 Digital Elevation Model (Upper Keys)



Figure 38 - NAVD88 Digital Elevation Model (Lower Keys)



Local Sea Level Rise Scenarios

The benefit of evaluating a range of sea level rise conditions is that the county can determine the tolerance for risk for any adaptation strategy decision and act upon data from this analysis that reflects a wider range of conditions. For assets, adaptation projects and policy decisions where there is a higher criticality for that decision, the higher end of the projections and output should be considered. Where there is a lower tolerance for flood impact, the lower end of the projections could be considered. The range provides options needed for more place-based and flood impact decision-making.

In the context of flood risk planning, the significance of assessing and preparing for risks varies significantly across different types of assets, reflecting the underlying concept of risk tolerance. This differentiation becomes particularly evident when contrasting the planning requirements for infrastructure with widely divergent risk profiles and societal impacts, such as recreational facilities versus nuclear power plants.

Recreational facilities, for example, though valuable for community well-being and local economies, generally represent assets with a relatively lower criticality in the broader scope of citywide emergency preparedness and long-term resilience planning. The risk tolerance for such facilities is comparatively higher, meaning that while flood impacts are undesirable, they are less likely to cause widespread or long-lasting harm. Therefore, in the adaptation strategy for these assets, a balanced approach may be adopted, potentially aligning with the lower end of sea-level rise

projections. This approach prioritizes cost-effectiveness and practicality, acknowledging the lower relative impact of flooding on these facilities.

Conversely, the planning and risk assessment for nuclear facilities demand an exceptionally low tolerance for risk due to the potential for catastrophic consequences in the event of flooding. The critical nature of such infrastructure—not only in terms of energy supply but also considering the immense implications for public health, safety, and environmental protection—necessitates that adaptation strategies are aligned with the most conservative projections and models available. In this case, the higher end of sea-level rise scenarios would be a prudent basis for planning, reflecting a commitment to safeguarding against even the most unlikely events. The imperative to ensure the utmost level of resilience against flooding underscores the non-negotiable demand for stringent precautionary measures in the context of nuclear planning.

To account for these differences in the importance of asset classes, the sea-level rise scenarios included in the Vulnerability Assessment include the 2017 NOAA Intermediate-Low Sea Level Rise Projection and the 2017 NOAA Intermediate-High Sea Level Rise Projection. These scenarios were the required scenarios when this Vulnerability Assessment was initiated prior to July 1, 2024. Legislation adopted by the Florida Legislature in 2024 will shift these required scenarios to the 2022 NOAA Intermediate Low and Intermediate scenarios. These new scenarios will apply to Vulnerability Assessments initiated after July 1, 2024.

Planning Horizons

The planning horizons for this assessment coincide with NOAA’s forecasting years: 2040, 2070 and 2100. While Section 380.093(3), F.S only requires the 2040 and 2070 planning scenarios currently, this Vulnerability Assessment also includes the 2100 condition. Including this third scenario allows for an extended vision and long-term strategic planning.

Sea Level Data Selection

According to statute, vulnerability assessments must include local sea level data that has been interpolated between the two closest National Oceanic and Atmospheric Administration tide gauges or use the sea level data from whichever of those two nearest gauges reports a higher mean sea level.

For Monroe County, this Vulnerability Assessment uses NOAA’s VDATUM software to interpolate between the two closest tide gauges, Vaca Key (8723970) and Key West (8724580). This interpolation is integrated directly into the exposure analysis methodology by converting the original North American Vertical Datum of 1988 (NAVD88) elevations from the Digital Elevation Model (DEM) to the localized vertical

tidal datums. By aligning the DEM elevations with data from local tide gauges, this conversion ensures accurate and consistent comparisons, correctly reflecting local sea level elevations and allowing precise data manipulations.

The datum chart below (Figure 39) is a visual representation of various reference levels (datums) related to the Key West tide gauge. These datums are standardized elevations used to serve as reference points for measuring water levels. Each datum is related to specific tidal conditions and is used to predict tidal flooding, navigate ships, and for coastal and marine engineering. Here is a brief explanation of common datums on Figure 39.

- **Mean Higher High Water (MHHW):** This is the average elevation of the higher high tides over a specific period. It is important for construction and development in coastal zones as it indicates the highest average water level that can be expected.
- **Mean High Water (MHW):** This is the average of all the high-water heights observed over the National Tidal Datum Epoch (usually a period of 19 years).
- **Mean Sea Level (MSL):** This is the average sea level. The mean level of the ocean's surface, calculated from hourly tidal heights measured over extended periods.
- **Mean Low Water (MLW) and Mean Lower Low Water (MLLW):** These represent the average of the lowest tides and the lowest average tide recorded, respectively, and are often used for navigational purposes to ensure boats and ships don't run aground.

The specific values and their vertical relationship to each other provide critical information for a range of activities, including coastal planning, construction, and navigation. The chart is typically set against the North American Vertical Datum of 1988 (NAVD88), which is a standard geodetic datum for elevations used in the United States for mapping and construction.

The exact purpose and usage of these datums can vary depending on the context, such as flood risk assessment, where knowing the heights of various tide conditions is essential for preparing for potential flooding events.

Figure 39 - Datums for Key West Tide Gauge

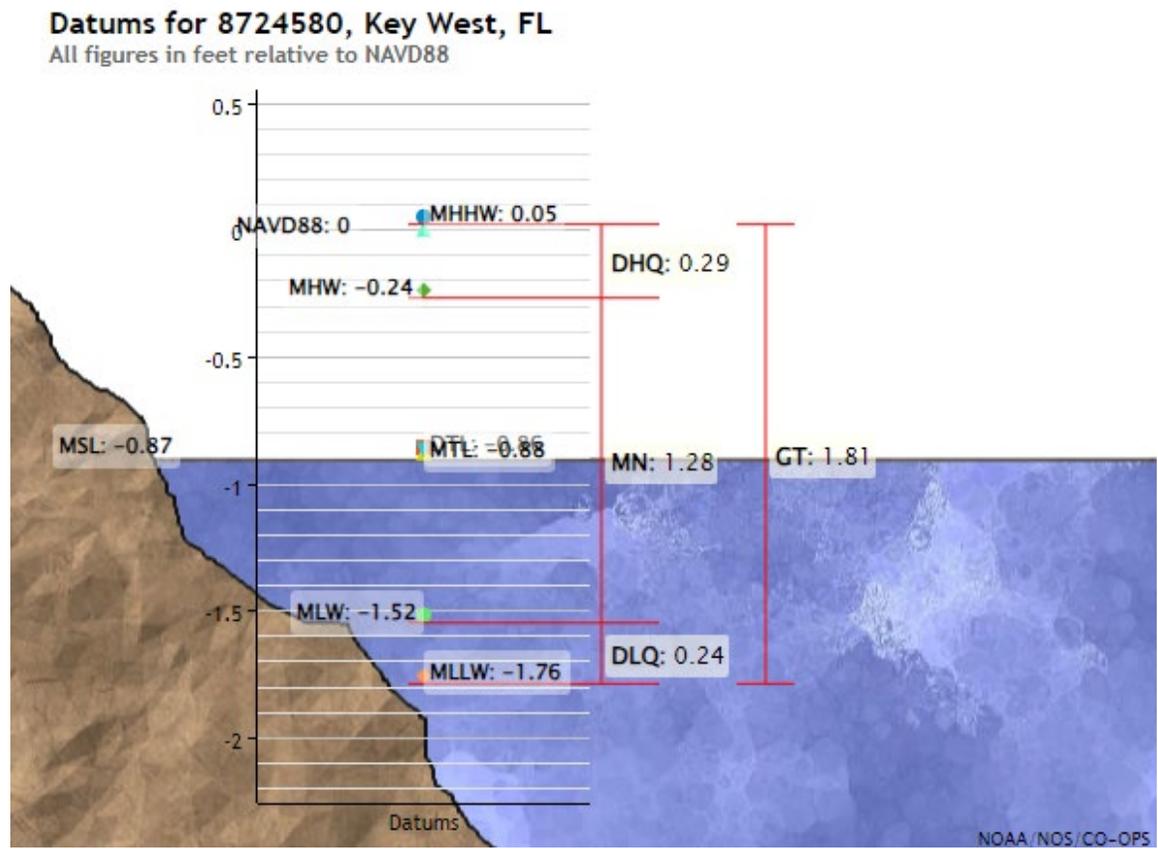


Figure 40 - Key West Tide Gauge Sea Level Data and Projections

Sea Level Data and Projections: Key West, FL (8724580) NOAA Tide Gauge

Feet above North American Vertical Datum of 1988
(1983-2001 epoch)



Click on legend items to hide/show them in the plot

- MHHW - 19-Year Moving Average
- - - MHHW - NOAA et al. 2017 - Extreme
- - - MHHW - NOAA et al. 2017 - High
- - - MHHW - NOAA et al. 2017 - Intermediate
- - - MHHW - NOAA et al. 2017 - Intermediate-High
- - - MHHW - NOAA et al. 2017 - Intermediate-Low
- - - MHHW - NOAA et al. 2017 - Low

MSL record span: 1913 to 2024 (111 years)

NOAA et al. 2017 datum-to-start-year offset (est. SLC from 1992 to 2000): 0.088 ft.

The USACE Sea Level Change Curve Calculator² and Sea Level Analysis Tool were utilized to calculate the sea level rise values required for NOAA's method for mapping sea level rise³ with the most recent digital elevation model and VDATUM⁴ derived tidal surfaces. After reviewing the closest tide gauges available within the USACE Sea Level Change Curve Calculator, the NOAA tide gauge, referenced as "Key West, FL" (NOAA Gauge Station ID: 8724580, 2024) was selected for its highest mean sea level. The Key West tide gauge indicates a relative sea-level trend of 2.61 millimeters/year

² USACE Sea Level Change Curve Calculator: https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html

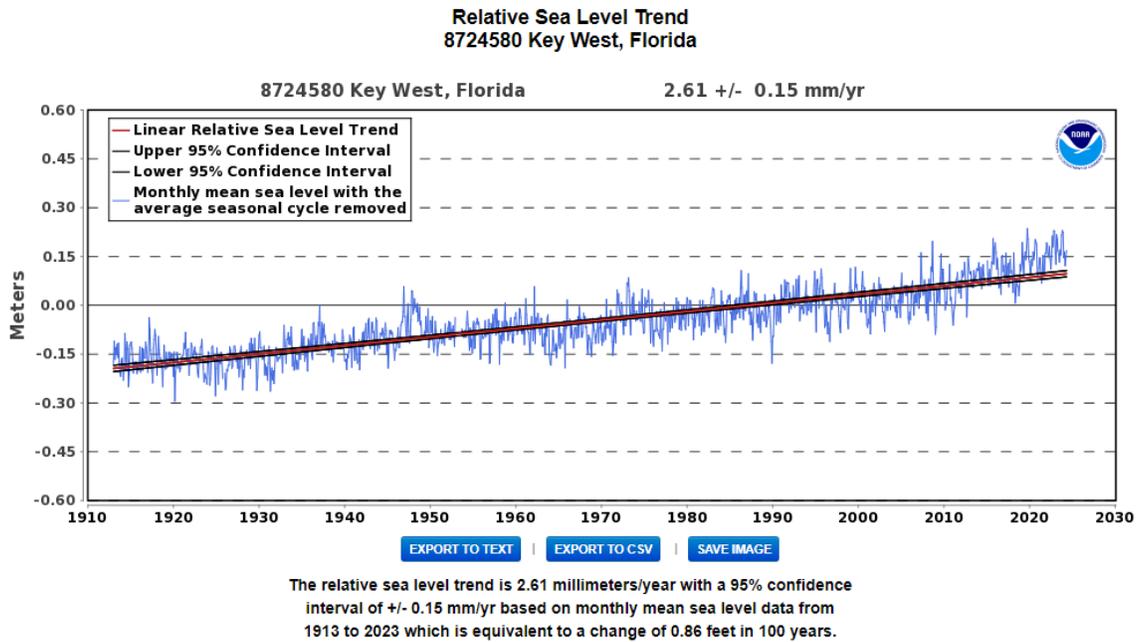
³ Detailed Method for Mapping Sea Level Rise Inundation (NOAA, 2017): <https://coast.noaa.gov/data/digitalcoast/pdf/slr-inundation-methods.pdf>

⁴ NOAA Vertical Datum Transformation: <https://vdatum.noaa.gov/welcome.html>

with a 95% confidence interval of +/- 0.15 millimeters/year based on data from 1913 to 2023 (Figure 41).

Figure 41 - Sea Level Increase from 1913 to 2023

(2.61 +/- 0.15 millimeters/year, equivalent to 0.86 feet in 100 years)



The plots above and below describe the observed and future projected increase in sea levels within the region. The table values listed below correspond with each of the sea level rise curves (Low, Intermediate-Low, Intermediate, Intermediate-High, High, and Extreme) for the year 2100 in Figure 42.

Table 5 - Mean Sea Level Values for Monroe County

Measurement Unit	Low	Intermediate Low	Intermediate	Intermediate High	High	Extreme
Feet	0.53	0.99	3.06	5.35	7.78	9.65
Inches	6.36	11.88	36.72	64.2	93.36	115.8

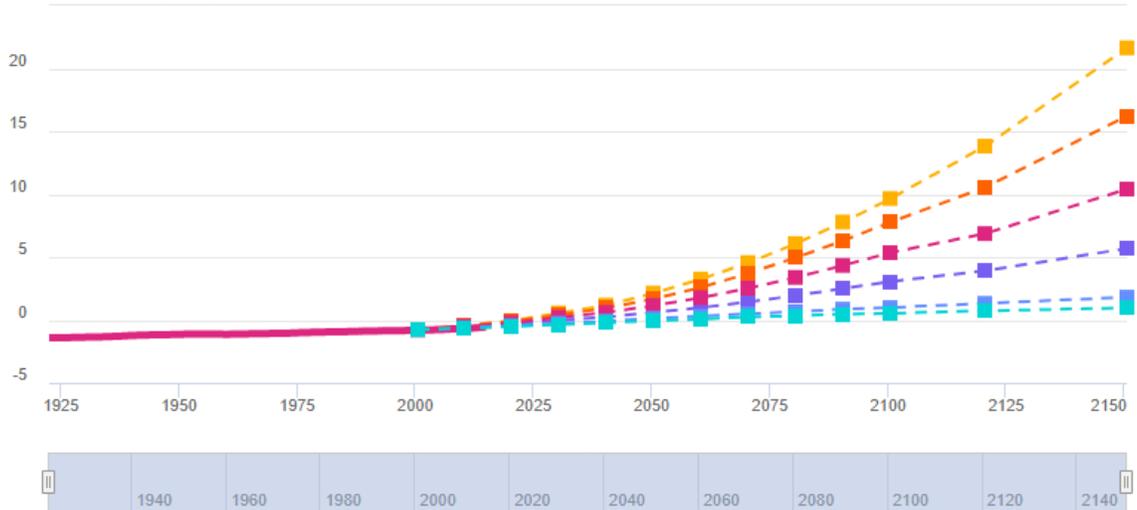
Figure 42 - Mean Sea Level Projections for Monroe County

Sea Level Data and Projections: Key West, FL (8724580)



NOAA Tide Gauge

Feet above North American Vertical Datum of 1988
(1983-2001 epoch)



Click on legend items to hide/show them in the plot

- MSL - 19-Year Moving Average
- MSL - NOAA et al. 2017 - High
- MSL - NOAA et al. 2017 - Intermediate-High
- MSL - NOAA et al. 2017 - Low
- MSL - NOAA et al. 2017 - Extreme
- MSL - NOAA et al. 2017 - Intermediate
- MSL - NOAA et al. 2017 - Intermediate-Low

MSL record span: 1913 to 2024 (111 years)

NOAA et al. 2017 datum-to-start-year offset (est. SLC from 1992 to 2000): 0.088 ft.

Exposure: Future High Tide

Using a planning-grade static coastal hydrology sea level rise modeling approach (NOAA, 2017), the project team assessed the area for its vulnerability to sea level rise (SLR) inundation, leveraging future projection sea level rise with an added two feet (2') to account for high tide flooding and the latest version of ArcGIS Pro to generate inundation results, (Environmental Systems Research Institute, 2022). By following this comprehensive modeling process, detailed future high tide flooding maps are generated that account for both regional and local variations in tidal flooding, and specifically identify areas with similar elevation that are not tidally connected according to the elevation surface. These areas are low-lying and may still be vulnerable to flooding, especially if they are connected to tidally connected coastal systems via stormwater conveyance or some other type of groundwater/surface water connection not captured within elevation data.

Table 6 below outlines Monroe County’s high tide flooding projections over the coming decades as sea levels rise, utilizing the latest available data and climate models. These projections serve as a crucial foundation for the risk assessment, enabling evaluation of the potential consequences of rising sea levels in the context of Monroe County’s coastal areas.

Table 6 - SLR with High Tide Flooding Modeling Scenarios

Timeframe	NOAA Intermediate Low 2017 (feet NAVD88)	NOAA Intermediate High 2017 (feet NAVD88)
Present Day	2.33	2.56
2040	2.69	3.38
2070	3.18	5.31
2100	3.77	8.14

The Future High Tide method applies ArcGIS Pro and NOAA's methods to predict flooding. It involves adjusting measurements for differences in sea level at various points and using algorithms to fill in gaps between these points. This process helps to accurately predict how high tides can rise, considering both current and future sea levels. Combining information on sea level rise with existing tide patterns yields detailed maps that show where and how high tide flooding could happen in the future. This method offers a clear picture of the risks of future high tide flooding.

NOAA’s VDATUM tool is used within the modeling to convert between datums, specific to this assessment, conversions between NAVD88, and mean higher high water (MHHW) and mean sea level (MSL) all common place benchmarks in floodplain management. Utilizing derivatives of this tool, local tide records, future change factors and a digital elevation model the exposure analysis was conducted considering both the elevation of current storms but also and adjustment of current heights to projected future condition.

Monroe County’s vulnerability to climate change, particularly concerning sea-level rise, necessitates a meticulous examination of projections tailored specifically to this coastal county. The analysis of sea-level rise projections and potential impacts is greatly enhanced by the incorporation of Monroe County-specific data and scenarios, especially those focused on the county’s location along the coast. In Monroe County, as in many other coastal areas, the imminent threat of sea-level rise has the potential to significantly impact communities, infrastructure, and environment.

Exposure: Depth of Tidal Flooding, including Future High Tide Flooding

The following maps identify which communities, infrastructure, and natural areas are at increased risk due to high tide flooding in the present day and under future conditions based on the NOAA Intermediate-Low (NIL) and NOAA Intermediate-High (NIH)⁵ sea level rise curves.

Figure 43 - NIH 2070 SLR with High Tide Flooding (Key Largo)



Future Days of High Tide Flooding Analyses

The assessment of tidal flooding is an essential element of comprehensive vulnerability evaluations aimed at understanding the impacts of sea level rise on coastal communities. This analysis is conducted through the collection and examination of high and low tide data spanning at least 19 years, a period that encompasses the full Metonic cycle, from the Key West Tide Gauge. The objective is to extrapolate high tide values from historical data, project them forward using the observed sea level trend, and then assess the potential frequency of tidal flooding events in the future.

⁵ [1] Section 380.093(3)(d)2.b. requires: At least two local sea level rise scenarios, which must include the 2017 National Oceanic and Atmospheric Administration intermediate-low and intermediate-high sea level rise projections.

Table 7 - Statistical Analysis of Historical Tide Record

Calculating the number of days where water elevations surpassed a “critical elevation”

Approximate Days of Tidal Flooding Observed	1992-2011 (NAVD88)	2004-2022 (NAVD88)
1	1.21	1.54
5	1.05	1.34
10	0.94	1.22
15	0.86	1.10
20	0.80	1.02
30	0.71	0.93
40	0.63	0.86
50	0.53	0.75
100	0.37	0.58
≥150	0.09	0.29

The above analysis employs statistical methods to correlate historic tide records with observed and projected days of tidal flooding, as illustrated in the provided table. Table 7 above reveals the changes in tide elevations over two distinct periods, 1992-2011 and 2004-2022, and associates these elevations with the observed frequency of tidal flooding events. The elevation figures are presented in NAVD88. A key observation from this data is the trend of increasing tide elevations over time, indicating rising sea levels and, consequently, an increased risk of tidal flooding.

Table 8 - Future Tidal Flooding Frequency

(feet NAVD88)

Approx. Days	2040-NIL	2070-NIL	2100-NIL	2040-NIH	2070-NIH	2100-NIH
1	1.72	2.07	2.26	2.60	4.51	6.95
5	1.54	1.83	2.09	2.39	4.26	6.76

Approx. Days	2040-NIL	2070-NIL	2100-NIL	2040-NIH	2070-NIH	2100-NIH
10	1.43	1.71	1.99	2.28	4.08	6.65
15	1.33	1.60	1.90	2.18	3.93	6.51
20	1.25	1.53	1.81	2.09	3.85	6.42
30	1.17	1.44	1.73	1.98	3.74	6.30
40	1.09	1.38	1.66	1.89	3.64	6.21
50	0.98	1.27	1.55	1.76	3.51	6.07
100	0.81	1.10	1.38	1.57	3.32	5.82
≥150	0.53	0.81	1.09	1.23	2.95	5.32

Understanding the implications of these findings is crucial. The elevations for the two periods underscore not just the absolute rise in sea levels but also the increasing likelihood of flooding events as these levels continue to rise. The observed days of tidal flooding serve as a direct indicator of how frequently communities might experience such events, given current and projected sea level rises.

The vulnerability assessment further contextualizes these findings by projecting future sea level rise under different NOAA scenarios, including both intermediate-low and intermediate-high projections for the years 2040, 2070, and 2100. These projections enable the estimation of future tidal flooding events' frequency, providing invaluable insights for planning and adaptation strategies. For instance, the NOAA intermediate-high scenario estimates that by 2040, high tide flooding for 150 or more days out of the year will increase to 1.23 feet, escalating to 2.95 feet by 2070 and 5.32 feet by 2100.

This analysis is vital for infrastructure project planning, urban planning, policymaking, and the community at large, offering a data-driven basis for understanding the risks associated with sea level rise and tidal flooding. By identifying the elevations at which tidal flooding becomes a significant risk and estimating the frequency of such events under various sea level rise scenarios, the assessment highlights the critical need for adaptive measures. These measures may include infrastructure improvements, policy adjustments, and community preparedness initiatives designed to mitigate the impacts of tidal flooding and enhance resilience against the growing threat of sea level rise.

Tidal flood days expected for each scenario and planning horizon

These maps, which can be found in the Exposure Map series, identify which

communities, infrastructure, and natural areas are at increased risk due to multiple days of tidal flooding, capturing the various vulnerabilities from the range of tides based on the NIL and NIH sea level rise projections.

Figure 44 - NIH 2070 Days of Tidal Flooding (Key Largo)



Exposure: Storm Surge

Storm Surge modeling in this context uses FEMA's data and HAZUS-MH⁶ software, adapted for future sea level rise. The approach integrates historical storm surge data from the 2005 Monroe County FIS⁷ with projections of sea level rise, creating models of adjusted storm surge inundation. This methodology is crucial to understand and anticipate the augmented impacts of storm surges in the future, enabling effective planning and resilience strategies against these events. The models suggest how rising sea levels could intensify storm surges, which is essential for informed decision-making and mitigation efforts. Unlike sea level rise and tidal flooding, storm surge is a less permanent condition, but due to the force and depth of flooding can be extremely debilitating to a community.

⁶ <https://www.fema.gov/flood-maps/products-tools/hazus>

⁷ Specifically adjusting the 100-year stillwater elevations by the rate of sea level change.

Figure 45 - FEMA Flood Insurance Study Coastal Stillwater Elevations



FLOOD INSURANCE STUDY

MONROE COUNTY, FLORIDA AND INCORPORATED AREAS

COMMUNITY NAME	COMMUNITY NUMBER
ISLANDORA, VILLAGE OF	125404
KEY COLONY BEACH, CITY OF	125121
KEY WEST, CITY OF	120168
LAYTON, CITY OF	125189
MARATHON, CITY OF	125681
MONROE COUNTY (UNINCORPORATED AREAS)	125129



Monroe County

REVISED:
FEBRUARY 18, 2005



Federal Emergency Management Agency
FLOOD INSURANCE STUDY NUMBER
12087CV000A

FLOODING SOURCE AND TRANSECT	FLOOD INSURANCE RATE MAP PANEL	STILLWATER ELEVATIONS (FEET NGVD)				ZONE	BASE FLOOD ELEVATION (FEET NGVD) ^{1,2}
		10% (10 YR.)	2% (50 YR.)	1% (100 YR.)	0.2% (500 YR.)		
GULF OF MEXICO 1	1506, 1516	3.2	5.5	8.4 ³	7.3	VE AE	11-13 8-10
		3.2	5.5	6.8	7.3	VE AE	9-11 7- 9
ATLANTIC OCEAN 2	1516	2.7	4.8	7.6 ³	6.4	VE AE	10-12 8-10
		2.7	4.8	6.0	6.4	AE	6- 8
GULF OF MEXICO 3	1509	5.1	6.5	7.4	9.2	VE AE	9-11 7- 9
		ATLANTIC OCEAN 4	1506, 1517	3.0	5.5	8.5 ³	7.4
3.0	5.5			7.2	7.4	VE AE	9-11 7- 9
GULF OF MEXICO 5	1528	4.7	7.6	8.4	10.4	VE AE	11-13 9-11

¹Rounded to Nearest Foot and may include effects of wave action
²Due to map scale limitations, Base Flood Elevations (BFEs) shown on the FIRM may represent average elevations for the zones depicted
³Include effects of wave setup

TABLE 2	FEDERAL EMERGENCY MANAGEMENT AGENCY	SUMMARY OF STILLWATER ELEVATIONS
	MONROE COUNTY, FL AND INCORPORATED AREAS	GULF OF MEXICO – ATLANTIC OCEAN

Stillwater Elevations

The transects taken from the Flood Insurance Study are integral to the HAZUS-MH framework, which is designed to estimate storm surge and its potential impacts by modeling how surges of varying heights could affect both natural landscapes and urban development. The transects are used in the model to establish the still water elevations for the modeling to project surge. This process, depicted in Figure 46, is critical for urban planners and emergency management professionals as it aids in anticipating the extent of possible flooding and crafting preemptive measures. While HAZUS-MH offers robust modeling capabilities, it does not factor in elements such as landscape friction, the carrying capacity of stormwater systems, the protective effects of shoreline armoring or the effects of employing nature-based shoreline resilience strategies — all variables that can dampen the real-world effects of storm

surge. Consequently, the tool may present an overestimated scope of surge impact, highlighting the importance of contextual adaptation of its findings. Despite this, the results from HAZUS-MH provide valuable insights for vulnerability assessments, laying the groundwork for informed, risk-conscious planning and the evolution of resilient infrastructure strategies.

Figure 46 - Transect Location Map Example (Upper Keys)

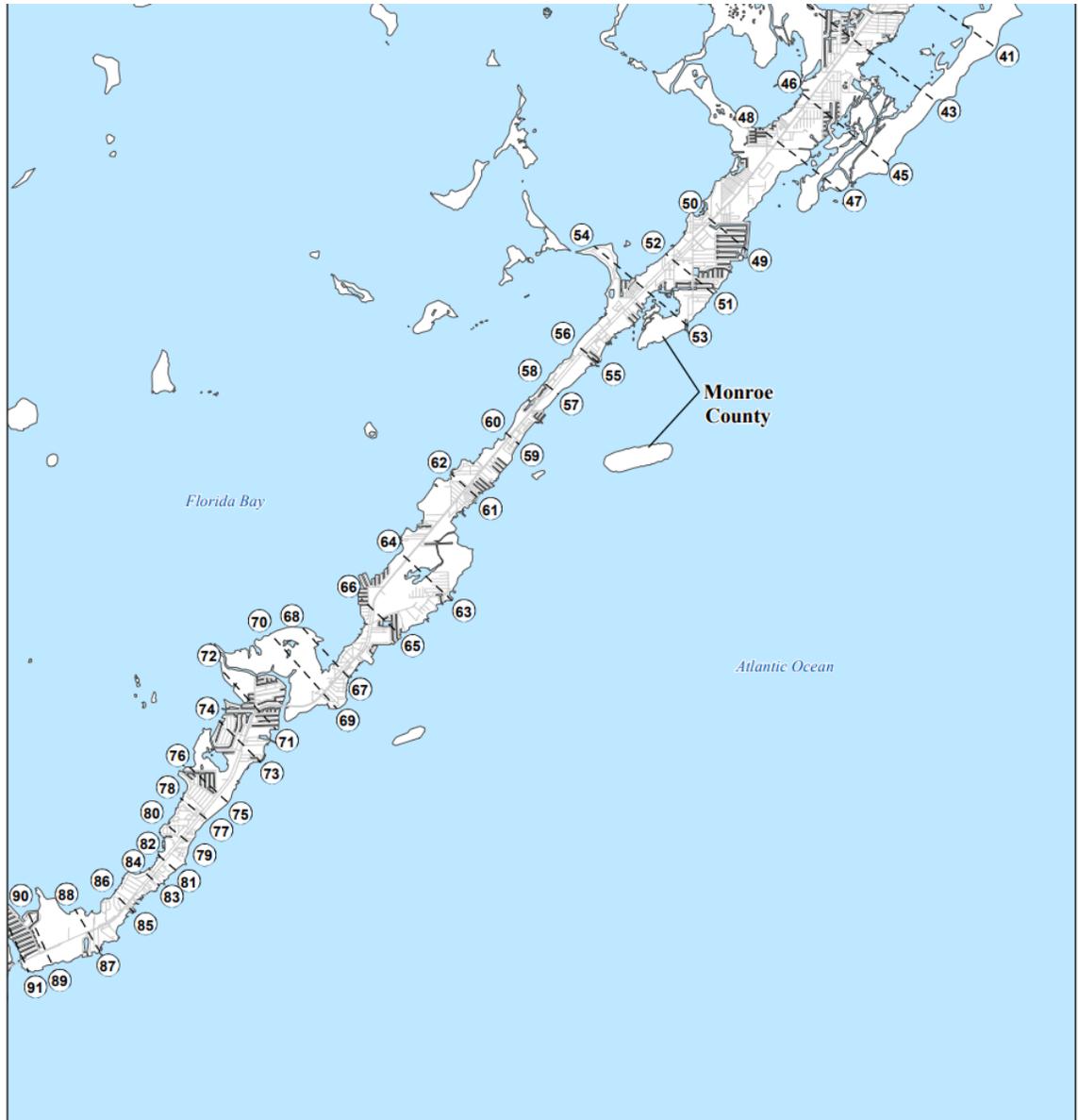


Table 9 - Critical Elevations/Stillwater Elevations

(feet NAVD88)

Planning Horizon	100-Year	500-Year
Present Day Average Stillwater	8.17	9.63
NIL 2040 Adjusted Average Stillwater	8.86	10.32
NIL 2070 Adjusted Average Stillwater	9.45	10.91
NIL 2100 Adjusted Average Stillwater	9.94	11.40
NIH 2040 Adjusted Average Stillwater	9.58	11.01
NIH 2070 Adjusted Average Stillwater	11.48	12.94
NIH 2100 Adjusted Average Stillwater	14.31	15.77

Using the outputs from the HAZUS-MH software, depth grids representing the maximum surge elevation (and corresponding flood depth) are created for a comparative overlay analysis with the critical asset inventory. Critical elevations utilized with the coastal floodplain module of HAZUS-MH are provided in Table 9 above.

Exposure: Depth of current and future storm surge flooding

These maps identify the areas at increased risk from the combined effects of storm surges and sea level rise, combining the 2040, 2070, and 2100 NIH SLR projections with 100-year (1.0% annual chance) and 500-year (0.2% annual chance) storms. In the figures below, by 2070, flooding from even the 100-year storm inundates most coastal areas by a depth of eight feet or more.

Figure 47 - NIH 2040 SLR + 100-Year Storm Surge (Key Largo)

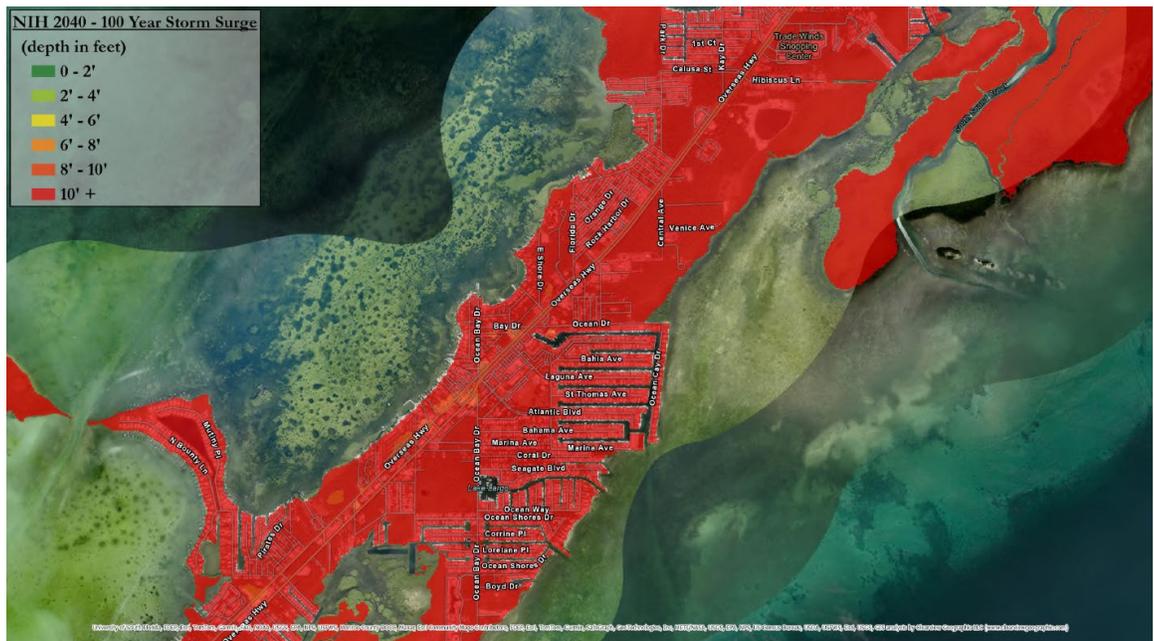
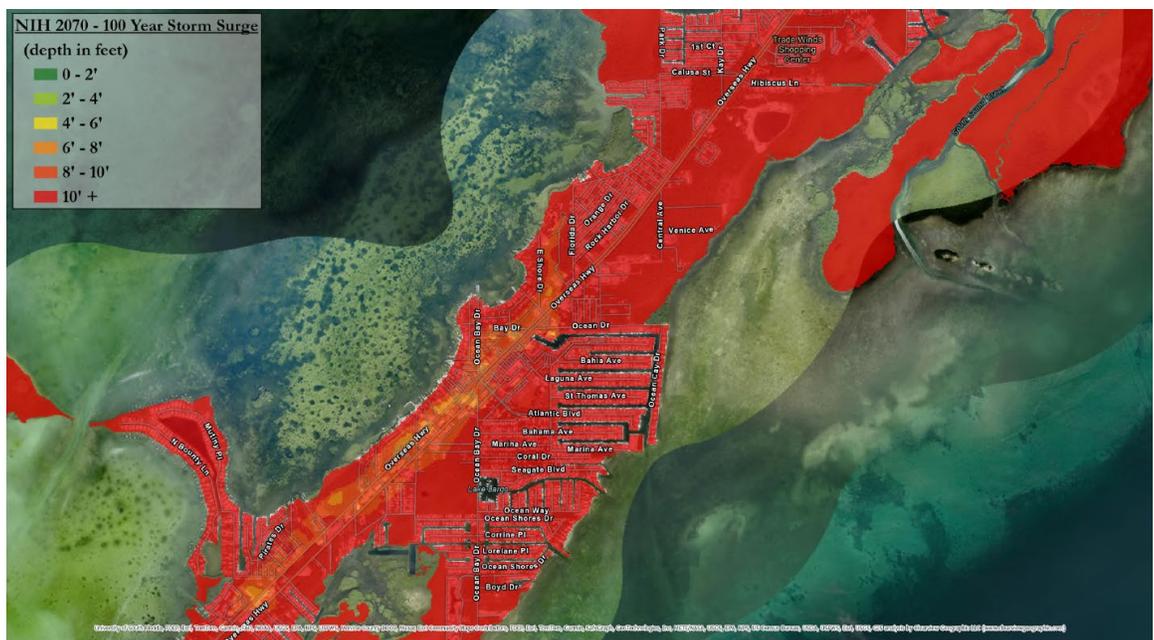


Figure 48 - NIH 2070 SLR + 100-Year Storm Surge (Key Largo)



Exposure: Rainfall

The rainfall analysis in the Vulnerability Assessment employs HEC-RAS software for rainfall simulation and runoff computation. This part of the assessment integrates

NOAA's Atlas 14 data and SFWMD change factors to create baseline rainfall depth grids, aligning with legislative requirements without relying on developing an entirely new Hydrologic and Hydraulic (H&H) Model. This comprehensive approach makes it possible to understand and prepare for future climate impacts, especially in areas with both coastal and non-coastal characteristics. This approach meets and exceeds the statutory requirements for rainfall evaluation in vulnerability assessments.

NOAA Atlas 14 provides high-quality data based on ongoing investigations of historical rainfall patterns across the United States. It offers site-specific rainfall distributions, which are essential for accurate evaluation. Compared to previous volumes, Atlas 14 estimates have longer periods of record and greater station density. NOAA Atlas 14 bases standard design rainfall distributions by integrating high-intensity short durations within longer, lower-intensity durations. These distributions are used in models to estimate rainfall intensity for specified durations and annual exceedance probabilities (Table 10). The NOAA Atlas 14 serves as a guideline to assess flood potential in water resource flow ways.

This document delineates the process of model development, touching upon terrain modeling, design storms, infiltration, runoff dynamics, soil conditions, boundary conditions, and the resultant analysis outputs.

Table 10 - NOAA Atlas 14 Rainfall Time Series Table for Monroe County

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches) ¹										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.522 (0.438-0.642)	0.594 (0.497-0.731)	0.714 (0.595-0.882)	0.817 (0.676-1.02)	0.963 (0.768-1.25)	1.08 (0.838-1.43)	1.20 (0.895-1.65)	1.32 (0.941-1.89)	1.49 (1.02-2.22)	1.63 (1.07-2.46)
10-min	0.765 (0.641-0.940)	0.869 (0.727-1.07)	1.04 (0.871-1.29)	1.20 (0.990-1.49)	1.41 (1.12-1.84)	1.58 (1.23-2.10)	1.76 (1.31-2.41)	1.94 (1.38-2.77)	2.19 (1.49-3.24)	2.38 (1.57-3.60)
15-min	0.933 (0.781-1.15)	1.06 (0.887-1.30)	1.28 (1.06-1.57)	1.46 (1.21-1.81)	1.72 (1.37-2.24)	1.93 (1.50-2.56)	2.14 (1.60-2.94)	2.36 (1.68-3.38)	2.67 (1.81-3.96)	2.90 (1.92-4.40)
30-min	1.41 (1.18-1.74)	1.62 (1.35-1.99)	1.95 (1.63-2.41)	2.24 (1.86-2.78)	2.65 (2.11-3.45)	2.97 (2.31-3.95)	3.30 (2.47-4.54)	3.65 (2.60-5.21)	4.12 (2.80-6.11)	4.48 (2.96-6.78)
60-min	1.95 (1.63-2.40)	2.21 (1.85-2.72)	2.65 (2.21-3.27)	3.04 (2.52-3.78)	3.62 (2.90-4.73)	4.09 (3.18-5.45)	4.58 (3.43-6.32)	5.11 (3.64-7.32)	5.84 (3.98-8.69)	6.43 (4.24-9.73)
2-hr	2.49 (2.09-3.04)	2.80 (2.35-3.42)	3.35 (2.80-4.11)	3.85 (3.20-4.75)	4.59 (3.70-5.98)	5.20 (4.08-6.91)	5.86 (4.41-8.05)	6.57 (4.71-9.37)	7.57 (5.19-11.2)	8.37 (5.56-12.6)
3-hr	2.82 (2.38-3.43)	3.16 (2.66-3.84)	3.78 (3.17-4.62)	4.36 (3.64-5.36)	5.24 (4.26-6.84)	6.00 (4.73-7.97)	6.82 (5.16-9.37)	7.72 (5.57-11.0)	9.01 (6.21-13.3)	10.1 (6.70-15.1)
6-hr	3.31 (2.81-4.00)	3.72 (3.16-4.50)	4.52 (3.82-5.49)	5.29 (4.44-6.47)	6.52 (5.35-8.53)	7.60 (6.04-10.1)	8.79 (6.71-12.1)	10.1 (7.36-14.4)	12.1 (8.38-17.8)	13.6 (9.16-20.3)
12-hr	3.67 (3.13-4.40)	4.21 (3.59-5.06)	5.28 (4.48-6.37)	6.33 (5.34-7.68)	8.02 (6.63-10.5)	9.52 (7.62-12.6)	11.2 (8.60-15.3)	13.1 (9.57-18.5)	15.8 (11.1-23.2)	18.1 (12.2-26.7)
24-hr	4.04 (3.46-4.82)	4.74 (4.06-5.65)	6.09 (5.20-7.30)	7.42 (6.29-8.95)	9.57 (7.96-12.5)	11.5 (9.23-15.1)	13.6 (10.5-18.5)	15.9 (11.8-22.5)	19.4 (13.7-28.3)	22.3 (15.1-32.7)
2-day	4.66 (4.02-5.52)	5.45 (4.69-6.46)	6.98 (5.99-8.31)	8.49 (7.23-10.2)	10.9 (9.13-14.1)	13.1 (10.6-17.1)	15.4 (12.0-20.9)	18.1 (13.4-25.3)	22.0 (15.6-31.9)	25.2 (17.3-36.8)
3-day	5.26 (4.55-6.21)	6.02 (5.20-7.12)	7.54 (6.48-8.94)	9.05 (7.74-10.8)	11.5 (9.67-14.8)	13.7 (11.1-17.9)	16.2 (12.6-21.8)	18.9 (14.1-26.4)	23.0 (16.4-33.2)	26.3 (18.1-38.3)
4-day	5.75 (4.98-6.77)	6.50 (5.63-7.66)	8.01 (6.91-9.48)	9.52 (8.16-11.3)	12.0 (10.1-15.4)	14.2 (11.6-18.5)	16.7 (13.1-22.4)	19.5 (14.5-27.1)	23.5 (16.8-33.9)	27.0 (18.6-39.1)
7-day	6.80 (5.91-7.96)	7.64 (6.64-8.96)	9.26 (8.02-10.9)	10.8 (9.33-12.8)	13.4 (11.3-16.9)	15.6 (12.7-20.0)	18.0 (14.2-24.0)	20.7 (15.6-28.6)	24.7 (17.7-35.3)	28.0 (19.4-40.4)
10-day	7.76 (6.77-9.06)	8.66 (7.54-10.1)	10.3 (8.97-12.1)	11.9 (10.3-14.1)	14.4 (12.1-18.1)	16.6 (13.6-21.2)	18.9 (14.9-25.0)	21.5 (16.2-29.5)	25.3 (18.2-36.0)	28.4 (19.8-40.8)
20-day	10.7 (9.40-12.4)	11.6 (10.2-13.5)	13.2 (11.5-15.4)	14.7 (12.8-17.2)	17.0 (14.3-21.0)	18.9 (15.5-23.8)	21.0 (16.6-27.4)	23.3 (17.6-31.5)	26.5 (19.2-37.3)	29.2 (20.4-41.6)
30-day	12.9 (11.3-14.8)	13.9 (12.2-16.1)	15.7 (13.8-18.2)	17.3 (15.1-20.2)	19.6 (16.5-24.0)	21.5 (17.7-26.8)	23.5 (18.6-30.3)	25.6 (19.3-34.3)	28.5 (20.6-39.6)	30.8 (21.6-43.7)
45-day	15.1 (13.3-17.4)	16.6 (14.6-19.1)	19.1 (16.7-22.0)	21.0 (18.4-24.5)	23.7 (19.9-28.6)	25.7 (21.1-31.7)	27.7 (21.9-35.4)	29.7 (22.5-39.4)	32.3 (23.4-44.5)	34.2 (24.1-48.3)
60-day	16.6 (14.7-19.1)	18.8 (16.6-21.5)	22.0 (19.4-25.4)	24.6 (21.5-28.5)	27.8 (23.3-33.3)	30.1 (24.7-36.8)	32.3 (25.5-40.8)	34.2 (25.9-45.0)	36.6 (26.5-50.0)	38.1 (27.0-53.8)

¹ Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS). Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values. Please refer to NOAA Atlas 14 document for more information.

Terrain

To accurately capture the nuances of the terrain's elevation and slope, a model was constructed utilizing digital elevation models (DEMs). These DEMs serve as a foundational element in mapping and understanding the area's physical characteristics. The elevation data within these models adhere to the North American Vertical Datum of 1988 (NAVD88). Figure 49 contains the outline of the 2D DEM area and the boundary condition lines used in conjunction with the DEM as terrain inputs in the modeling environment.

Figure 49 - LiDAR Data Extent and Boundary Condition Lines for Northern, Southern, Eastern, and Western Boundaries



Design Storms

The Precipitation Data files were generated using Intensity/Precipitation curves derived from the FDOT Drainage manual for 24-hour design storms. The design storms represent current (2023) rainfall patterns: 500-, 100-, 50-, and 25-year return interval 24-hour rainfall events and the Rainfall depths representing each 24-hour hypothetical storm event were taken from National Oceanic and Atmospheric Administration (NOAA) Atlas 14 annual maximum series to represent 2023 rainfall patterns (NOAA, 2023). Future rainfall depths were computed using the current precipitation depths in Table 11 and deriving the intensity for the respective future conditions by using the Department of Defense change factors to arrive at the projected precipitation in Table 12. The current and projected precipitation depths are then applied to the storm design criteria in Table 13 to arrive at a storm design that is suitable for various present and future conditions.

Table 11 - Precipitation in Inches for 24-Hour Storm Duration – Present Day

Year	Scenario	Precipitation (inches) ⁸
Present Day	25-Year	9.93
Present Day	50-Year	11.70
Present Day	100-Year	13.70
Present Day	500-Year	19.00

Table 12 - Projected Precipitation in Inches for 24-hour Storm Duration

Year	Scenario	Precipitation (inches)
2040	25-Year	13.05
2040	100-Year	18.82
2070	25-Year	14.15
2070	100-Year	20.28
2100	25-Year	15.61
2100	100-Year	22.34

Table 13 - Rainfall Design Storm Criteria for Varying Storm Events⁹

T hours	I/P Total	25-Year Intensity	50-Year Intensity	100-Year Intensity	500-Year Intensity
0	0	0	0	0	0
1	0.010	0.094	0.112	0.133	0.191
2	0.020	0.187	0.224	0.266	0.382
3	0.030	0.281	0.336	0.399	0.573

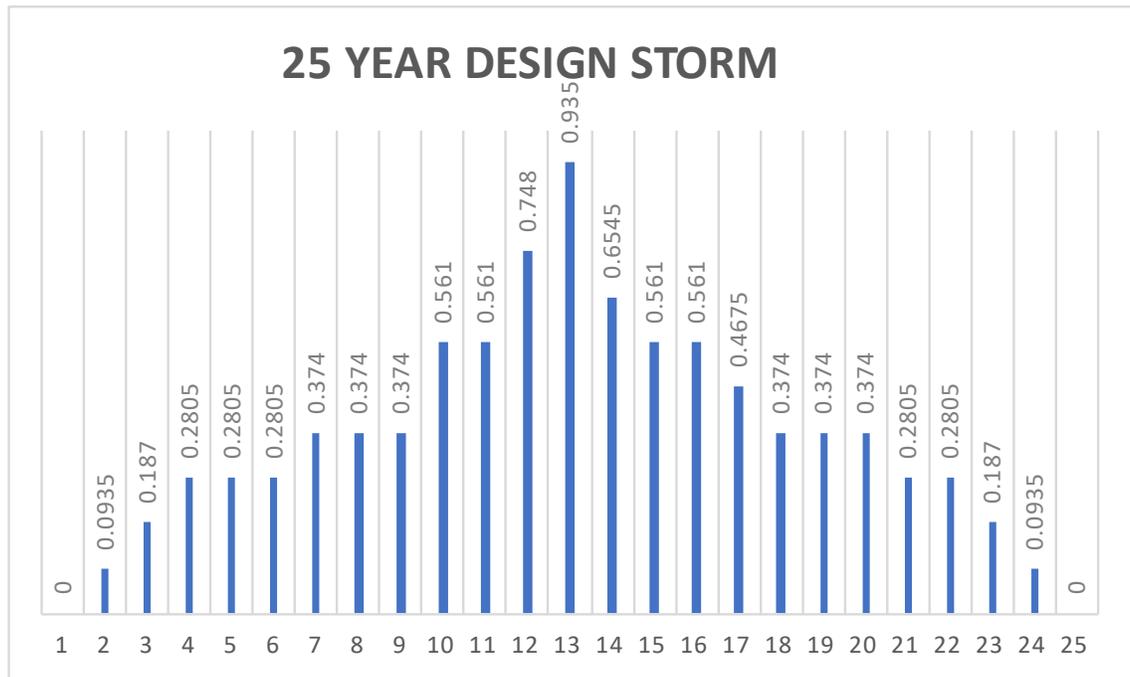
⁸ 1 (NOAA, 2023)

⁹ FDOT drainage manual for design storms,

<https://fdotwww.blob.core.windows.net/sitefinity/docs/default-source/roadway/drainage/files/idfcurves.pdf>

T hours	I/P Total	25-Year Intensity	50-Year Intensity	100-Year Intensity	500-Year Intensity
4	0.030	0.281	0.336	0.399	0.573
5	0.030	0.281	0.336	0.399	0.573
6	0.040	0.374	0.448	0.532	0.764
7	0.040	0.374	0.448	0.532	0.764
8	0.040	0.374	0.448	0.532	0.764
9	0.060	0.561	0.672	0.798	1.146
10	0.060	0.561	0.672	0.798	1.146
11	0.080	0.748	0.896	1.064	1.528
12	0.100	0.935	1.120	1.330	1.910
13	0.070	0.655	0.784	0.931	1.337
14	0.060	0.561	0.672	0.798	1.146
15	0.060	0.561	0.672	0.798	1.146
16	0.050	0.468	0.560	0.665	0.955
17	0.040	0.374	0.448	0.532	0.764
18	0.040	0.374	0.448	0.532	0.764
19	0.040	0.374	0.448	0.532	0.764
20	0.030	0.281	0.336	0.399	0.573
21	0.030	0.281	0.336	0.399	0.573
22	0.020	0.187	0.224	0.266	0.382
23	0.010	0.094	0.112	0.133	0.191
24	0	0	0	0	0

Figure 50 - 25-Year Design Storm Criteria for Monroe County



Infiltration and Runoff

The infiltration method employed in this HEC-RAS model utilizes the Soil Conservation Service (SCS) Curve Number (CN) method, designed to estimate direct runoff and infiltration rates from rainfall events. This approach is particularly suitable for varying soil conditions and land use offering a comprehensive understanding of how different terrains respond to precipitation.

The SCS CN method is based on empirical data, correlating soil type and land use to a curve number that represents the potential for runoff. This method simplifies the calculation of effective rainfall (precipitation that contributes to runoff) by considering the initial abstraction and potential maximum retention after runoff begins.

Infiltration rates are dynamically adjusted for each simulation. This adaptation ensures the model's responsiveness to varying hydrological conditions, offering a more nuanced depiction of infiltration and runoff dynamics within the study area. Manning's n roughness and percent impervious values were assigned to each USGS National Land Cover Database (NLCD) land cover category representing 2021 conditions (USGS, 2023a). Manning's n roughness ranges were taken from the HEC-RAS technical reference guide (USACE, 2021). Table 15 shows the land cover categories, Manning's n roughness, percent impervious, and area within the modeled 2D flow area.

Soil Classification

Using the Gridded Soil Survey Geographic (gSSURGO) Database, as recommended by the USDA-NRCS in 2023, the project team conducted a comprehensive assessment of the soil textures and Hydrologic Soil Groups (HSGs) within the 2D flow area. As depicted in Figures 51-53, the gSSURGO soil map units provided a detailed visualization of the soil distributions across the study area. Within the geographical boundaries, the dominant soil texture identified was Muck, detailed further in Table 14.

The most common soil texture, Muck, is partially drained with a high organic content, which limits water transmission capabilities due to a shallow water table. Typically, muck is classified within HSG C or D, indicating a lower infiltration rate and a higher water-holding capacity, thereby increasing the potential for runoff. This texture covers an extensive area of 120,647.8 acres, significantly influencing the hydrological characteristics of the region.

Marly Silt Loam, covering 39,218.75 acres, are also somewhat common within the area. These soils are classified as in HSG B and have a moderate infiltration rate.

Further soil textures identified in the analysis include:

- **Extremely Gravelly Sand:** With an area of 12,456.04 acres, Gravelly Sand includes small gravel particles that enhance its drainage capabilities over finer sands. Typically assigned to HSG A or B, this soil texture supports high infiltration rates.
- **Gravelly Muck:** This soil type covers 9,986.52 acres of Monroe County and is typically classified as HSG B or C due to its limited potential for infiltration.
- **Mucky Fine Sand:** Composed of fine particles, mucky fine sand spans 9,746.7 acres. This soil type has moderate to high infiltration rates, placing it in the HSG A or B category.
- **Very Gravelly Marly Silt Loam:** This texture, covering 2,511.29 acres, is known for a wide size range among its particles and exceptional drainage properties. These soils are generally placed in HSG A or B, displaying low runoff potential and moderate to high infiltration rates.

Table 14 - Acres of Soil Textures

Soil Texture	Acres
Muck	120,647.80
Marly Silt Loam	39,218.75

Soil Texture	Acres
Extremely Gravelly Sand	12,456.04
Gravelly Muck	9,986.52
Mucky Fine Sand	9,746.70
Very Gravelly Marly Silt Loam	2,511.29
Fine Sand	438.52
Gravelly Sand	25.97

Figure 51 - Soil Texture Categories (Upper Keys)

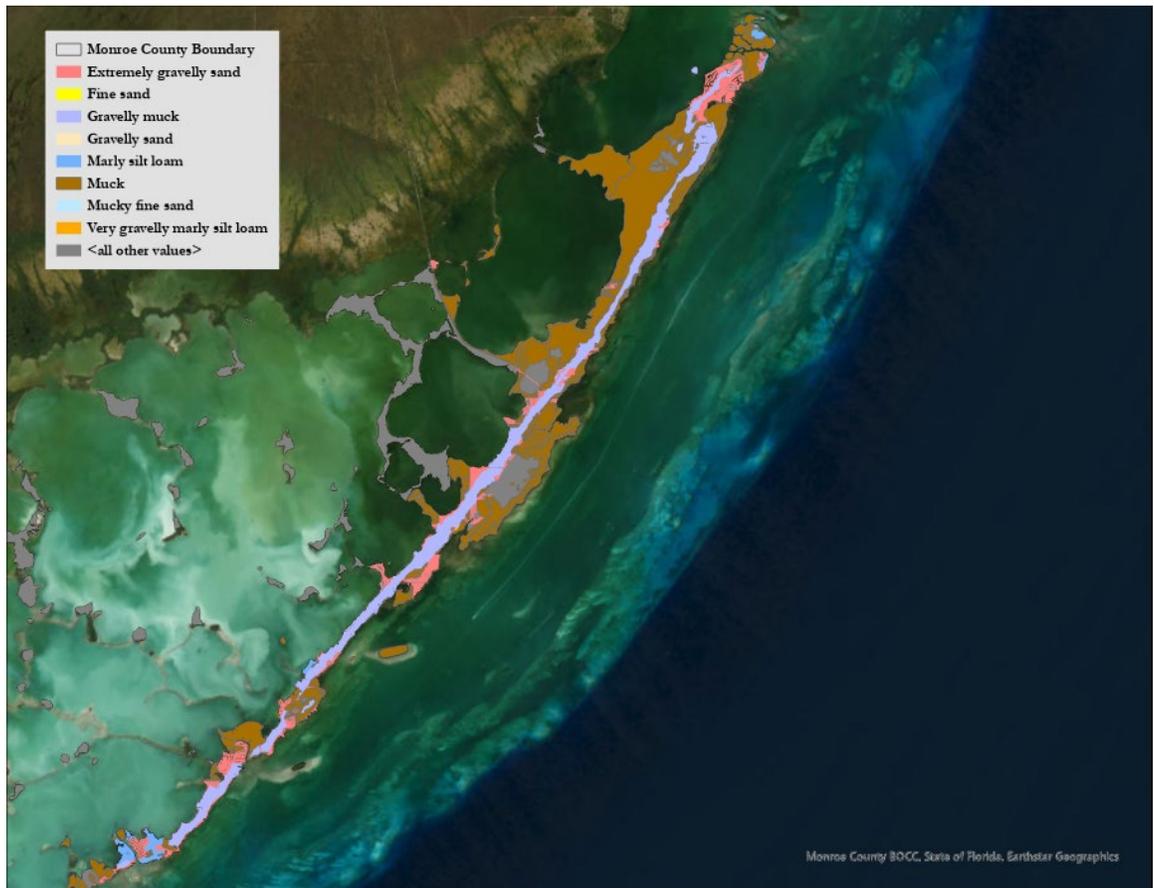


Figure 52 - Soil Texture Categories (Middle Keys)

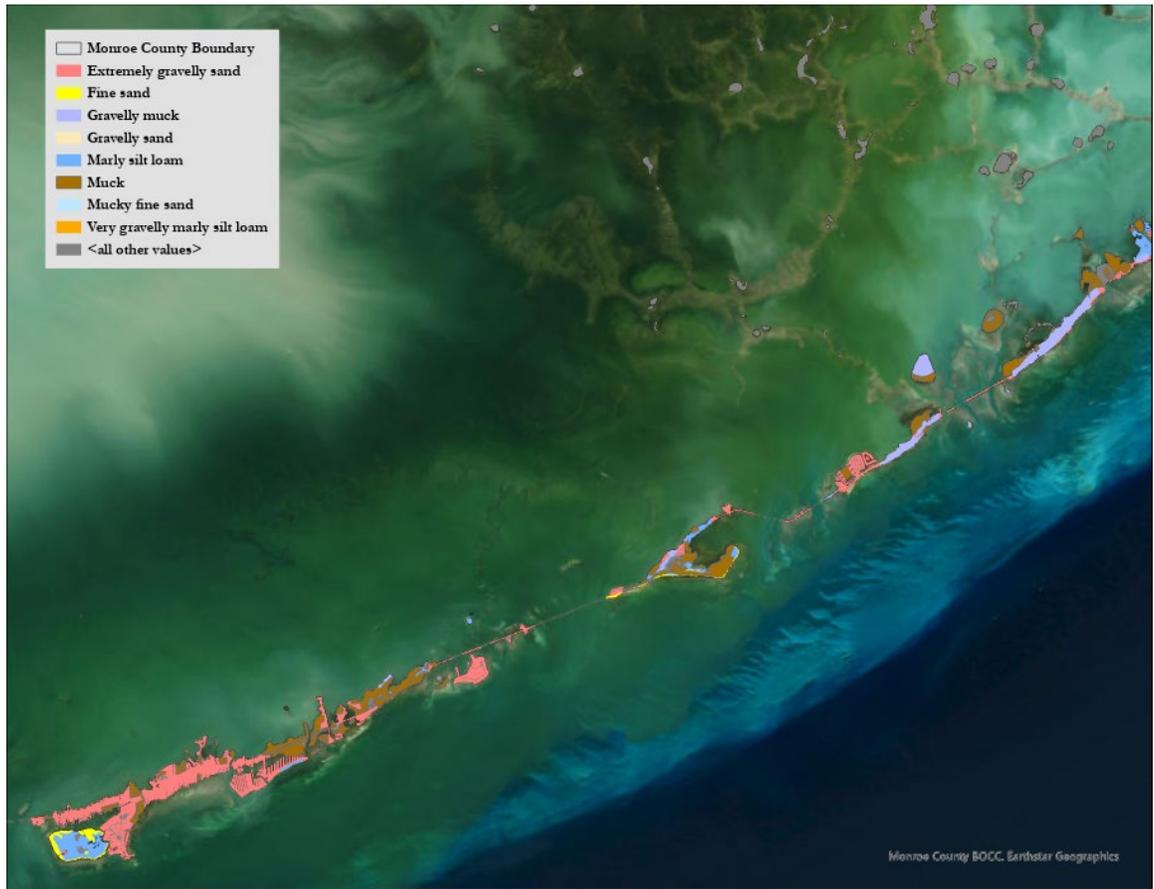


Figure 53 - Soil Texture Categories (Lower Keys)

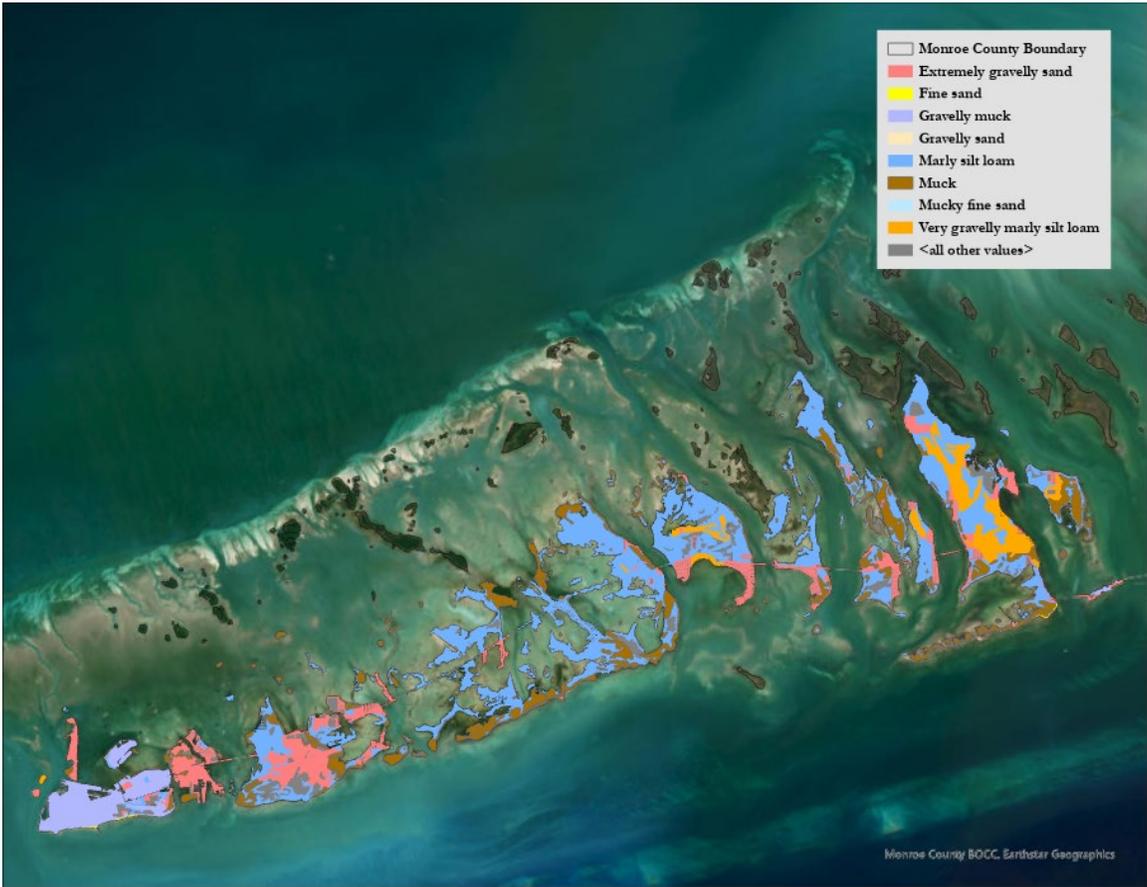


Figure 54 - Land Cover Categories (Upper Keys)

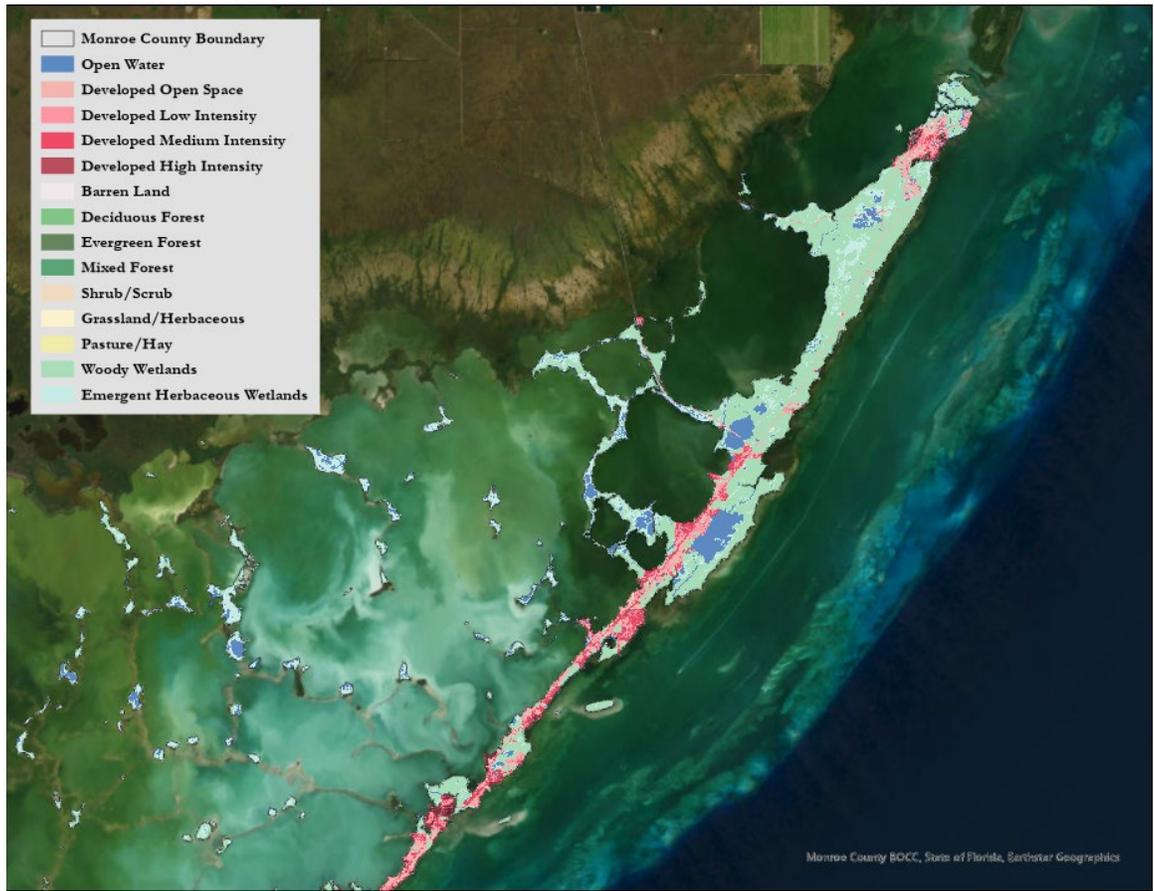


Figure 55 - Land Cover Categories (Middle Keys)

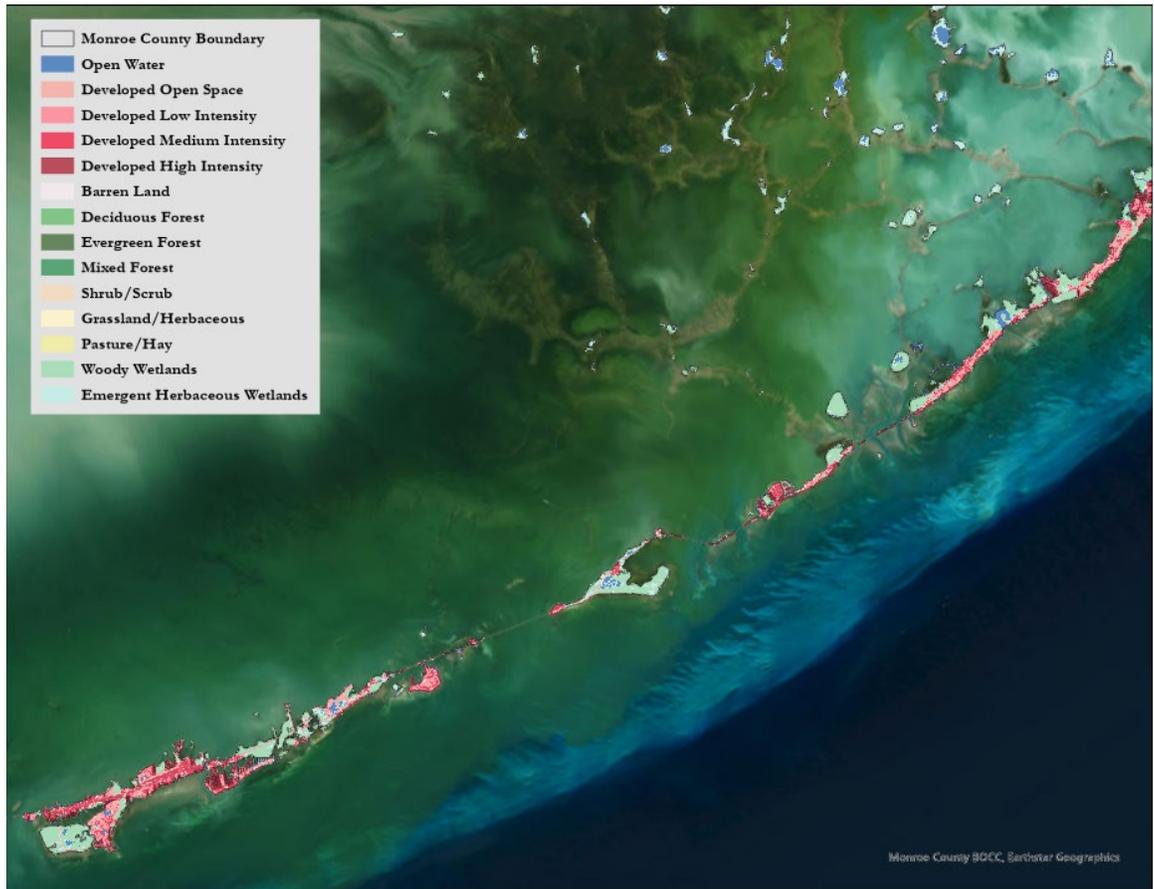


Figure 56 - Land Cover Categories (Lower Keys)



Table 15 - Land Cover Category, Mannings N Roughness, and Percent Impervious

ID	Name	Manning's n Range ¹⁰	Mannings n ¹¹	Impervious % ¹²
31	Barren Land Rock-Sand-Clay	0.023-0.030	0.030	0
82	Cultivated Crops	0.020-0.050	0.050	0
24	Developed, High Intensity	0.120-0.200	0.150	80
22	Developed, Low Intensity	0.060-0.120	0.080	40
23	Developed, Medium Intensity	0.080-0.160	0.120	60
21	Developed, Open Space	0.030-0.050	0.035	0

¹⁰ USACE *Creating Land Cover*

¹¹ USACE *Manning's N Values*

¹² USACE *% Impervious Layers*

ID	Name	Manning's n Range ¹⁰	Mannings n ¹¹	Impervious % ¹²
95	Emergent Herbaceous Wetlands	0.050-0.085	0.070	75
42	Evergreen Forest	0.080-0.160	0.150	0
71	Grassland-Herbaceous	0.025-0.050	0.040	0
43	Mixed Forest	0.080-0.200	0.120	0
11	Open Water	0.025-0.050	0.035	100
81	Pasture-Hay	0.025-0.050	0.045	0
52	Shrub-Scrub	0.070-0.160	0.080	0
90	Woody Wetlands	0.045-0.150	0.100	50

Future Rainfall-Induced Flooding

These baseline depth grids are then adjusted by the sea level rise projection data based on NOAA's Intermediate Low and Intermediate High projections for the respective timeframes and rainfall precipitation by the published SFWMD change factors. Interpolation of these coefficients predict approximately 1.12 times more rain in 2040 than today, 1.22 times more rain in 2070, and 1.34 times more rain in 2100. Since Monroe County has tidally connected non-coastal areas, the rainfall-induced flooding analysis is included to provide a comprehensive VA over the entire area.

Figure 57 - NIH 2070 SLR + 100 Year 24 Hour Rainfall (Key Largo)



Exposure: Compound Modeling

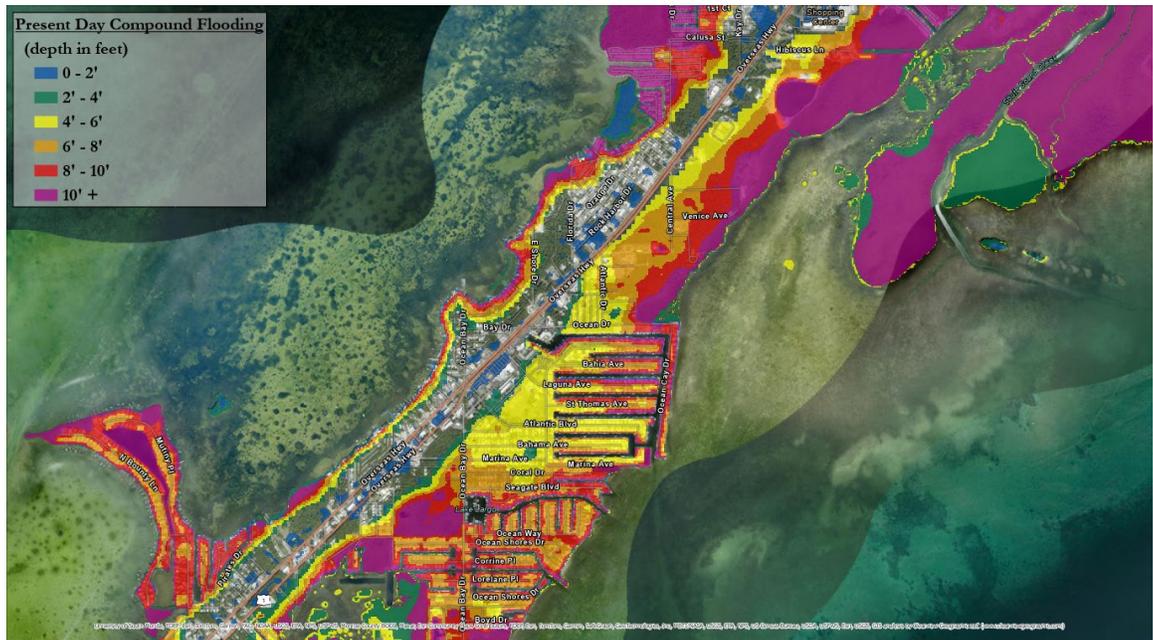
The compound modeling section of the Vulnerability Assessment focuses on assessing the combined impacts of various flooding scenarios. This includes high tide flooding, storm surge, and rainfall-induced flooding. The methodology involves overlaying depth grids from each scenario to identify compounded flood heights at a well-defined scale. The approach is designed to provide a comprehensive understanding of the potential cumulative impacts of different flooding events simultaneously occurring, aiding in effective planning and mitigation strategies. This planning process, however, does not simulate the hydrologic interactions between these events or the stormwater management system's response. This could be done with a more complex engineering-based model.

Sea level rise inundation modifies the “coastline” representing an approximate boundary of new coastal under mean higher high water (MHHW) or the highest high tide of the day. Stormwater structures along coastal waters, inundated by sea level rise are expected to no longer function and exacerbate flooding impacts. Surge impacts are large but temporary in nature, caused by the force of storm pushing water onto the terrain.

Table 16 - NOAA Intermediate Low and High Combined Flood Scenario Water Rise Impacts

Sea Level Rise Scenario	Surge Scenario	Rainfall Scenario	Combined Water Rise (ft)
NIL Present Day	100-Year	25-Year 24-Hour	11.3
NIL Present Day	100-Year	100-Year 24-Hour	11.6
NIL Present Day	500-Year	25-Year 24-Hour	12.8
NIL Present Day	500-Year	100-Year 24-Hour	13.1
NIH Present Day	100-Year	25-Year 24-Hour	11.6
NIH Present Day	100-Year	100-Year 24-Hour	11.9
NIH Present Day	500-Year	25-Year 24-Hour	13.1
NIH Present Day	500-Year	100-Year 24-Hour	13.4
NIL 2040	100-Year	25-Year 24-Hour	12.6
NIL 2040	100-Year	100-Year 24-Hour	13.1
NIL 2040	500-Year	25-Year 24-Hour	14.1
NIL 2040	500-Year	100-Year 24-Hour	14.6
NIH 2040	100-Year	25-Year 24-Hour	14.1
NIH 2040	100-Year	100-Year 24-Hour	14.6
NIH 2040	500-Year	25-Year 24-Hour	15.5
NIH 2040	500-Year	100-Year 24-Hour	16.0
NIL 2070	100-Year	25-Year 24-Hour	13.8
NIL 2070	100-Year	100-Year 24-Hour	14.3
NIL 2070	500-Year	25-Year 24-Hour	15.8
NIL 2070	500-Year	100-Year 24-Hour	16.3
NIH 2070	100-Year	25-Year 24-Hour	18.0
NIH 2070	100-Year	100-Year 24-Hour	18.5
NIH 2070	500-Year	25-Year 24-Hour	19.4
NIH 2070	500-Year	100-Year 24-Hour	19.9
NIL 2100	100-Year	25-Year 24-Hour	15.0
NIL 2100	100-Year	100-Year 24-Hour	15.5
NIL 2100	500-Year	25-Year 24-Hour	16.5
NIL 2100	500-Year	100-Year 24-Hour	17.0
NIH 2100	100-Year	25-Year 24-Hour	23.8
NIH 2100	100-Year	100-Year 24-Hour	24.4
NIH 2100	500-Year	25-Year 24-Hour	25.2
NIH 2100	500-Year	100-Year 24-Hour	25.8

Figure 58 - Present Day SLR + 100 Year Storm Surge + 25 Year Rainfall (Key Largo)



Sensitivity: Ranked Prioritization in Hot Spots

The sensitivity analysis helps prioritize resilience adaptation efforts based on how various sea level rise projections affect critical assets within key geographic areas in Monroe County. The assessment can be used to guide land use regulations, building codes, land development policies, emergency response strategies and various justice, equity, diversity, and inclusion initiatives¹³ associated with climate resilience adaptation planning. This integration signifies a commitment to a resilience framework that is equitable and inclusive, consciously addressing the needs of those disproportionately affected by climate risks.

Regions that are highly exposed to multiple flood scenarios are identified as a flooding “hot spot” area. These hot spots contain a mix of assets including government facilities, commerce areas, critical transportation hubs, and residential neighborhoods where there is a high concentration of publicly owned assets. By mapping these hot spots and prioritizing the assets within them, resources can be focused where multiple risks intersect prioritized by geographic area and immediate need.

¹³ <https://www.cdc.gov/climateandhealth/JEDI.htm>

Ranked Flood Exposure Tiers

To add context to the flood exposure analysis, the team developed Table 17 in tandem with county officials. It defines the flood thresholds used to assign no, low, medium, high, and very high flood exposure levels based on the GIS modeling. They are critical for understanding the specific flood risks that Monroe County faces, allowing for targeted measures to be implemented in areas predicted to be most affected by flooding.

Table 17 - Exposure Descriptions

Flood Depth	Exposure Ranking	Description
0 feet	No Exposure	No flooding detected. Areas with no impact from sea level rise or flooding.
0 to 0.5 feet	Low Exposure	Minor flooding. Shallow inundation typically causing minimal impact.
0.5 feet to 1.0 foot	Medium Exposure	Moderate flooding. Likely to impact structures and disrupt daily life. One foot or more of flooding also generally compromises emergency management operations.
1.0 foot to 3.0 feet	High Exposure	Significant flooding. Serious degree of inundation causing damage and major disruptions.
More than 3.0 feet	Very High Exposure	Severe flooding. Extensive inundation posing critical threats and causing extensive damage.

Table 17 above outlines Monroe County’s determined exposure levels for this project. These ranking levels serve as a foundation for the risk assessment, enabling evaluation of the potential consequences of rising sea levels and overall flooding impact in Monroe County’s specific context.

Identifying High-Risk Areas with Hot Spots

Identifying high-risk areas and assets is a cornerstone of this effort. Based on

modeling and the concentration of critical assets, high-risk areas within Monroe County have been identified (Figure 59). This map series reflects the areas 1) where there are aggregations of critical assets that are 2) subject to some level or multiple levels of flood risk. The map is color coded to reflect the type of flood risk and the approximate year that area will be impacted by that flood risk. A summary table is embedded that shows each hot spot breakdown and which flood scenarios impact that hot spot. The hot spots are numbered according to their priority of impact, based on need and geography as defined in FDEP’s Vulnerability Assessment Checklist and by statute. Numbering is based on a systematic evaluation of impact urgency and geographic spread. This prioritization ensures that the most critical areas receive attention promptly, consistent with FDEP’s Vulnerability Assessment Checklist and statutory requirements.

Figure 59 – Hot Spot Map of Monroe County



Modeling Impact to Assets

Within the highest risk areas, quantitative analysis was performed on the critical assets to assign the flood depths derived from the exposure modeling directly to the assets within the underlying data tables. This impact modeling contributes directly to the method of prioritization discussed later in this section and aligns with FDEP Vulnerability Assessment Checklist criteria and the methodologies outlined in the assessment framework, ensuring an identification process for asset risk and enabling the identification of specific flood scenarios for each impacted asset. This approach ensures that the specific flood risks to each asset are accurately captured, facilitating a targeted and effective adaptation strategy.

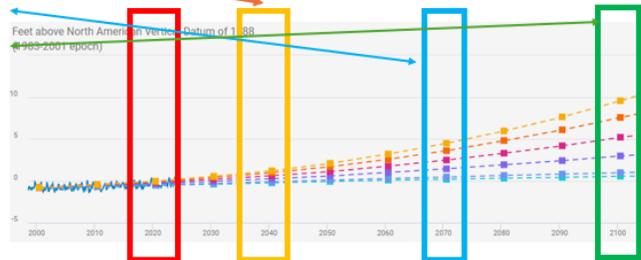
Prioritizing Based on Planning Horizon

The planning horizons are categorized into present day, near-term (2040), mid-term (2070), and long-term (2100). The Horizon Index reflects this temporal segmentation, using a multiplier system to emphasize the criticality of impacts in the near term. Assets are ranked based on their Horizon Index scores, a derived metric that segments out the modeling into the planning horizons and applies a multiplier system specifically targeting those with the nearest term impacts. It serves as a metric for prioritizing investments in infrastructure and formulating policy responses to the challenges posed by sea level rise and climate change.

Figure 60 - Planning Horizon Prioritization

Horizon Index

- Present Day (Multiplier: 15)
- 2040 Exposure (Multiplier: 10)
- 2070 Exposure (Multiplier: 5)
- 2100 Exposure (Multiplier: 1)



Prioritizing Based on Flood Risk

Assets are ranked based on their Flood Risk Index scores, with a tiered system identifying those at highest risk. This prioritization informs resource allocation and intervention strategies by delineating areas of high vulnerability where adaptation strategies can be the most impactful.

Table 18 - Flood Risk Metric Weighting

Metric	Weight
Sea Level Rise Effect	0.35
Rain and Sea Level Rise Combo	0.25
Rain, Sea Level Rise, and Storm Surge	0.15
Number of Times Asset is Exposed	0.10
Average Flood Depth	0.10

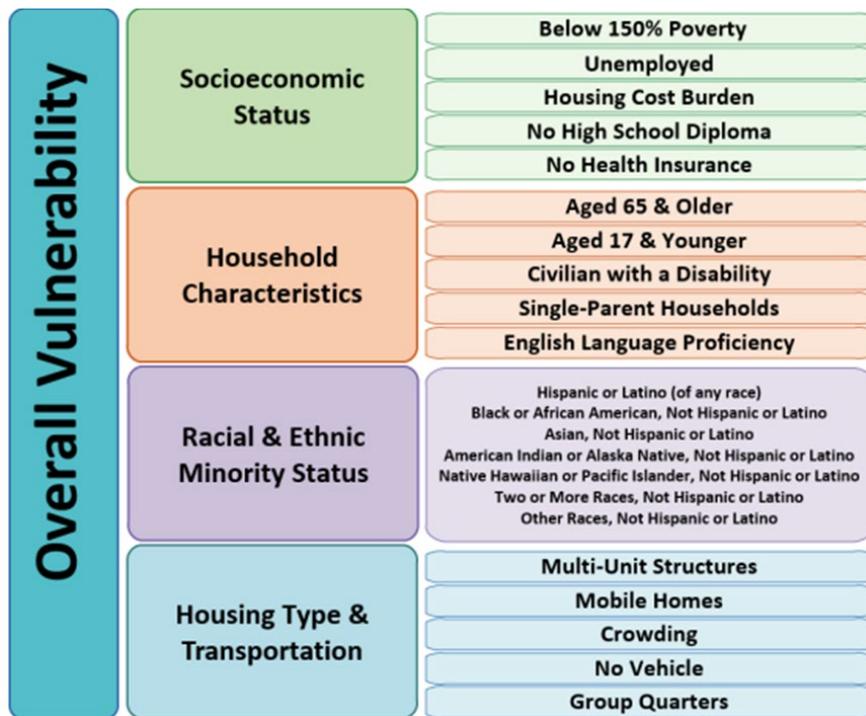
Metric	Weight
Average Flood Depth Percentile Rank	0.05
Total	1.00

Prioritizing Based on Social Vulnerability

This assessment recognizes that social vulnerability significantly affects how communities experience and recover from flood events. Hence, integrating these factors ensures that resilience strategies are inclusive and equitable. Assets are ranked based on their Social Index scores, a derived metric that helps support prioritization of more socially vulnerable census tracts. The Social Index scores integrate the CDC Social Vulnerability Index and the HUD Location Affordability Index, each with its own set of values and corresponding multipliers, reflecting the severity of social vulnerability and housing affordability issues, respectively.

In the CDC Social Vulnerability Index, values range from 0.25 to 1.00, with higher values indicating greater vulnerability, and are thus assigned multipliers from 1 to 4. It assesses aspects like socioeconomic status, household composition and disability, minority status and language, and housing and transportation.

Figure 61 – CDC Social Vulnerability Index Metrics



The HUD Location Affordability Index considers housing affordability in various household profiles, ranging from median-income families to dual-professional families, in relation to the median household income (MHHI) for a given area. Similar to the CDC index, values assigned to each profile range from 0.25 to 1.00, with associated multipliers from 1 to 4.

Table 19 – HUD LAI Household Profile Median Household Income Thresholds

Household Profile	Median Household Income (MHHI) for a Given Area)
1. Median-Income Family	100% MHHI
2. Very Low-Income Individual	National Poverty Line
3. Working Individual	50% of MHHI
4. Single Professional	135% of MHHI
5. Retired Couple	80% of MHHI
6. Single-Parent Family	50% of MHHI
7. Moderate-Income Family	80% of MHHI
8. Dual-Professional Family	150% of MHHI

By combining these factors, the Social Index creates a weighted sum that helps to identify and prioritize intervention areas where people may be more affected by socioeconomic and housing-related challenges. This tool is particularly useful for policy makers and planners to direct resources and efforts to improve the resilience and support of communities that are most at risk.

Prioritizing within the Composite Index

Each of the components described above assesses different aspects of risk and vulnerability and is assigned a specific weight within the Composite Index.

- 1. Horizon Index:** This measures the potential future impact of flooding, considering the planning horizon or the timeframe within which the impacts are expected. It is given a weight of 0.659, indicating that it accounts for more than half of the Composite Index value, recognizing the importance of long-term flood risk projections in overall risk assessment but focusing on the immediacy of near-term impacts.
- 2. Flood Risk Index:** It evaluates the current exposure to flood risks, including

the frequency and depth of potential flooding events. This index has a weight of 0.34, suggesting that immediate flood risks are also a significant factor in the overall assessment but less so than long-term projections.

3. **Social Vulnerability Index:** It incorporates socioeconomic factors into the risk evaluation, with a weight of 0.001. This reflects the understanding that the social context, including the socioeconomic vulnerabilities of affected populations, plays a crucial role in how impacts are felt and managed.

The final metric, the Composite Index, offers a holistic measure of flood-related risk by combining these weighted components. It provides a more comprehensive assessment that can guide decision making in urban planning, emergency preparedness, resource allocation, and other critical areas of public policy and infrastructure development. This Composite Index is essential to this toolkit, allowing various risk factors to be overlaid and identifying where they converge to create heightened risk profiles. It is not just a measure, but also a strategic guide for directing efforts effectively. By factoring in both the likelihood and potential severity of flood events, as well as the social dimensions of vulnerability, the Composite Index serves as a robust tool for prioritizing actions and investments to mitigate flood risks.

Identifying Most At-Risk Assets Based on Three-Tiered Prioritization

Employing the composite index described above, the hot spot prioritization analysis assigned a priority 1 through 5, or not prioritized, ranking based on the indexed score. Below is a table providing the index thresholds of utilized to assign the priorities.

Table 20 - Composite Risk Index Scores and Prioritization

Composite Index Score Threshold	Assigned Priority
Top 5% Highest Values	1
5-10%	2
10-15%	3
15-25%	4
25-50%	5
Below 50%/Median Value – Not Prioritized	0

These derived outputs, together, provide the prioritized asset inventory when linked back to the critical asset inventory and the assets unique identifier. This prioritization is a critical step in linking strategic planning with on-the-ground realities, ensuring that responses are not only theoretically sound but practically actionable.

To carry the prioritization process into the various high-risk areas and provide numerical calculations that harmonize various Resilient Florida Grant criteria, the analysis results were then re-ordered by the overall risk determination, assigned based on percentages of land area inundated and the number of critical assets affected in the identified hot spots, as described in Table 21 below. This final step of the analysis harmonizes the various assessment criteria to produce a coherent risk profile for each hot spot. It ensures that both the spatial extent of the flood risk and the density of critical assets are factored into the overall risk determinations.

Table 21 - Hot Spot Risk Assessment Criteria

Overall Risk Assessment	Land Area Inundated (% of Census Tract or Neighborhood)	Critical Assets Affected (% of Total Assets or Within Each Asset Category)
None	0%	0%
Low	Less than 25%	<25%
Medium	25-50%	25-50%
High	50-75%	50-75%
Very High	>75%	>75%

Results and Analysis Overview

This assessment identifies key vulnerability flooding hot spots within Monroe County, focusing on critical assets that are at risk from sea level rise (SLR), high tide flooding (HTF), storm surges, and extreme rainfall. The goal is to prioritize actions and strategies that bolster collective resilience by addressing both immediate flooding risks and long-term climate threats. Through a comprehensive analysis of four critical asset classes—transportation infrastructure, critical infrastructure, critical community and emergency facilities, and the preservation of natural, cultural, and historical resources—this assessment provides a structured approach to mitigation and adaptation.

This approach follows federally aligned guidelines from the Infrastructure Resilience Planning Framework (IRPF)¹⁴ and state-aligned recommendations from the Florida Adaptation Planning Guidebook, ensuring that Monroe County’s strategies reflect both national standards for infrastructure resilience and state-specific adaptation measures. The IRPF’s five-step process is applied to identify critical infrastructure, assess risks, evaluate and implement resilience actions, and ensure ongoing monitoring. Meanwhile, the Florida Adaptation Guidebook emphasizes community involvement, iterative planning, and the integration of adaptation into existing local and regional plans. Together, these frameworks guide the prioritization of interventions and the identification of vulnerabilities within the identified flooding hot spots.

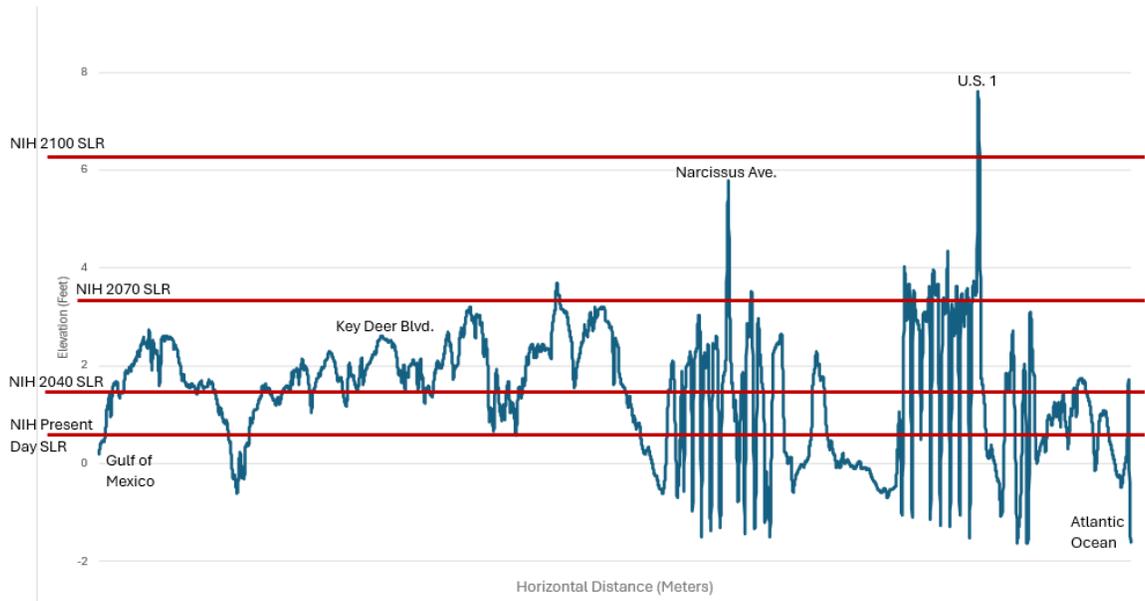
Flood Vulnerability

Flood risk in Monroe County is characterized by its diverse elevation profiles and proximity to coastal areas. Big Pine Key's elevation profile (Figure 62) provides an important tool for planners to visualize varying heights and depths that affect flood risk across natural and built environments. This elevation data helps identify high-risk zones for future development and informs where flood defenses should be prioritized. By examining these profiles, planners and developers can make informed decisions about where and how to construct infrastructure, considering factors such as flood risk, sea level rise, and coastal erosion. The goal is to promote resilient coastal development that accounts for the unique challenges posed by critical elevations, ensuring that communities are better prepared to face the impacts of climate change and protect valuable ecosystems.

¹⁴ Infrastructure Resilience Planning Framework (IRPF) available at: <https://www.cisa.gov/sites/default/files/2024-03/infrastructure-resilience-planning-framework03-22-2024.pdf>

Figure 62 – Elevation Profile of Big Pine Key

(feet NAVD88 with flooding threshold overlays relative to MHHW)



The county-wide application of sea level rise (SLR) and high tide flooding (HTF) thresholds provides a clearer view of flooding events such as king tides, utilizing a SLR-adjusted HTF threshold (+2 feet above mean higher high water (MHHW)). This adjusted threshold captures the immediate and recurrent impacts of nuisance flooding. The 90-day metric, based on statistical analysis, highlights chronic flooding that occurs for at least one-quarter of the year. This chronic inundation metric is a critical tool in guiding decisions on critical infrastructure improvements and land use planning, as areas facing 90 days or more of tidal inundation represent an urgent need for flood-proofing and mitigation efforts.

This chronic inundation metric is essential for guiding decisions related to critical infrastructure improvements and land use planning. Areas projected to face 90 days or more of tidal inundation annually represent the highest priority for flood-proofing or mitigation, elevation of infrastructure, and stormwater management improvements to reduce risk. Table 22 below quantifies the projected landward inundation for 2040, 2070, and 2100 under various sea level rise and high tide flooding scenarios, helping Monroe County target areas where mitigation efforts are most urgent:

Table 22 - Area of Inundation

Based on SLR and tide extent 90 days/year

Projection	NIL SLR + High Tide Flooding (in acres)	NIL 90 days	NIH SLR + HTF	NIH 90 Days
2040	504,765.05	41,326.31	510,158.52	47,520.55
2070	509,309.55	44,043.48	521,100.77	57,716.29
2100	513,180.41	46,334.83	526,415.16	63,757.04

As seen in the projections, the extent of landward inundation increases significantly as sea levels rise over time. By 2040, Monroe County is expected to experience up to 510,158 acres of inundation due to a combination of SLR and HTF, with 47,520 acres experiencing 90 days or more of inundation annually. This scenario worsens by 2070, with 521,100 acres affected by SLR and HTF, and 57,716 acres inundated for at least 90 days. By 2100, inundation could impact 526,415 acres, with a staggering 63,757 acres subject to 90 days of chronic flooding each year.

These projections underscore the urgency of implementing flood-resilience measures, such as elevating roadways, reinforcing bridges, flood-proofing critical infrastructure, and enhancing natural defenses like wetlands and mangroves. Strategic planning based on this data will be crucial for Monroe County to protect its residents, ecosystems, and economic assets from the long-term impacts of SLR and HTF.

Sea level rise (SLR) and high tide flooding (HTF), as illustrated in Table 22, are two critical concepts within the broader context of climate change and its escalating impacts on coastal and low-lying regions. While these terms are closely related, they represent different but interconnected phenomena, each playing a significant role in shaping flood risks and informing resilience strategies.

- **Sea level rise (SLR)** refers to the gradual, long-term increase in the average global sea level. This phenomenon is driven primarily by two key factors: the melting of ice sheets and glaciers and the thermal expansion of seawater as global temperatures rise. SLR is a process that unfolds over decades and centuries, progressively altering coastal landscapes. Over time, SLR increases the frequency and intensity of coastal flooding, contributes to shoreline erosion, and accelerates the loss of habitat for plants, animals, and

human communities. The long-term effects of SLR can lead to permanent inundation of low-lying areas, threatening infrastructure, displacing populations, and impacting ecosystems essential for coastal protection and biodiversity.

- **High tide flooding (HTF)**, often termed nuisance flooding or sunny day flooding, occurs when tidal levels exceed 2 feet above mean higher high water (MHHW), as defined by the Florida Department of Environmental Protection (FDEP) threshold (Section 380.0937(1)(b), F.S. Unlike SLR, which represents a slow and gradual rise, HTF manifests as immediate and recurring flooding events triggered by regular high tide cycles, often in the absence of storms or heavy rainfall. As sea levels rise, HTF is becoming increasingly frequent, pushing seawater onto streets, inundating coastal areas that were previously dry, and disrupting daily activities. This type of flooding may appear minor, but its cumulative impact can be severe—overwhelming drainage systems, damaging property, degrading infrastructure, and creating public safety hazards. HTF poses a growing challenge to coastal communities, as it can interfere with daily life, economic activity, and emergency services.
- **Days of tidal inundation** is a specific metric used to quantify the frequency and duration of tidal flooding events each year. This metric measures the number of days within a year when tidal levels exceed a pre-determined threshold, resulting in chronic flooding conditions. The 90-day inundation metric, for example, identifies areas that experience flooding for at least one-quarter of the year. This measurement is essential for understanding how frequently certain areas will be affected by tidal flooding as sea levels continue to rise. It is a crucial tool for resilience planning, helping to pinpoint vulnerable infrastructure, high-risk communities, and critical assets that require immediate attention. By anticipating the number of tidal inundation days, planners and policymakers can develop more precise flood-proofing measures, adjust land-use planning, and prioritize adaptation strategies to mitigate long-term risks.

In summary, while Sea Level Rise (SLR) refers to the global, long-term elevation of sea levels caused by climate change, its effects set the stage for more frequent and disruptive High Tide Flooding (HTF) events, which result from tides exceeding traditional thresholds and causing immediate flooding. Both SLR and HTF are key drivers of coastal vulnerability, and together they demand a comprehensive, forward-looking approach to flood resilience planning. Understanding the nuances of each impact is vital for communities as they work to safeguard their infrastructure, manage land use, and protect both natural and human assets from the growing impacts of climate change.

Critical and Prioritized Assets in Flooding Hot Spots

This assessment adopts a methodical approach in analyzing Monroe County’s most vulnerable assets, focusing on those that are most critical for maintaining community resilience and service continuity. Each section of the analysis identifies specific flooding hot spots, evaluates the types of assets located within these areas, and considers the broader impact of flooding on Monroe County’s infrastructure.

Through the DEP Vulnerability Assessment Checklist and methodologies outlined in the Florida Adaptation Planning Guidebook, Monroe County planners ensured that the vulnerability identification process is aligned with statewide standards and reflects community priorities. The IRPF’s interdependency analysis is also applied at a high level, to help highlight how failures in one asset class (e.g., transportation) could have cascading effects on others, such as emergency services or utility systems. This allows for a holistic evaluation of risks and helps prioritize areas where mitigation efforts are most urgently needed.

The in-depth analysis of these high-risk areas aims to:

- **Quantify potential impacts** of SLR, HTF, storm surges, and extreme rainfall on identified assets.
- **Discuss interdependencies** among critical systems, emphasizing the potential for cascading failures.
- **Prioritize adaptation measures** based on the vulnerability and importance of each asset, ensuring that critical systems are protected first.
- **Guide mitigation strategies** with a focus on long-term sustainability, ensuring that adaptation actions are effective in both current conditions and future climate scenarios.

1. Transportation Infrastructure

Monroe County’s transportation infrastructure—including roads, bridges, and culverts—is essential for both daily connectivity and emergency evacuation routes. However, these systems are highly vulnerable to SLR, HTF, and storm surges. Disruptions to transportation infrastructure can lead to community isolation, delaying emergency response and restricting access to essential services. In addition, transportation systems are interdependent with utilities, emergency services, and supply chains, meaning failures in this sector can cause cascading disruptions across other critical services.

IRPF emphasizes understanding the interdependencies between transportation and other critical systems, while the Florida Adaptation Guidebook highlights the need

for community-driven planning to ensure evacuation routes remain passable during extreme weather events. Both frameworks stress the importance of adaptive solutions such as road elevation and stormwater management improvements.

Assets Impacted:

- **Roadways**, particularly those serving as primary evacuation routes and critical access points to essential services including residential and business access.
- **Bridges and culverts** that are crucial for maintaining connectivity but are at risk during flooding events.

Recommendations:

- **Elevate and Reinforce Bridges and Culverts:** Elevate critical routes like the Overseas Highway and reinforce bridges and culverts to withstand SLR and storm surge, ensuring they remain functional during and after flood events.
- **Improve Drainage Systems:** Implement enhanced drainage systems to effectively manage runoff during HTF and extreme rainfall, preventing road closures.
- **Develop Elevated Pathways for Evacuation Routes:** Ensure evacuation routes remain accessible by elevating key sections of roadways. This is crucial for maintaining emergency access during flood events, as outlined in both the IRPF and Florida Adaptation Guidebook.

2. Critical Infrastructure

Monroe County’s critical infrastructure, including water treatment plants, sewage systems, and electrical substations, is highly susceptible to flooding, which can result in widespread service disruptions, contamination of water supplies, and cascading failures across interdependent systems such as healthcare and emergency services. These services are essential to public health and safety, and their failure during a flood event could have severe consequences for residents.

The IRPF focuses on hardening critical infrastructure and ensuring service continuity, while the Florida Adaptation Guidebook suggests integrating resilience strategies into existing infrastructure plans. Both frameworks prioritize utility redundancy to ensure that essential services are not disrupted by flooding.

- **Assets Impacted:**
 - Water treatment facilities and sewage systems that are essential for public health but can be overwhelmed by floodwaters, leading to contamination and service disruptions.

- Electrical substations and distribution networks that are at risk from flooding, causing widespread power outages.

- **Recommendations:**

- **Flood-proof Water and Sewage Treatment Plants:** Implement flood-proofing measures, including elevating structures and installing flood barriers, at key facilities like the FKA RO Plant on Stock Island and Cudjoe Key, ensuring continued operation during flood events.
- **Elevate and Secure Electrical Substations:** Electrical infrastructure, particularly substations, should be elevated and reinforced to prevent power outages caused by floodwaters. These actions ensure service continuity, reducing the risk of cascading failures.
- **Implement Utility Redundancy:** Develop redundant power supplies such as backup generators and microgrids to ensure critical services remain operational during floods, in line with federal guidelines for infrastructure resilience.

3. Critical Community and Emergency Facilities

Hospitals, fire stations, police departments, and emergency shelters are critical for Monroe County's disaster response and community safety. These facilities must remain operational during flood events to ensure efficient disaster recovery. However, they are vulnerable to SLR, HTF, and storm surges, which could compromise their ability to provide life-saving services.

The IRPF emphasizes the importance of hardening emergency facilities and ensuring they have backup systems for power and communications. The Florida Adaptation Guidebook recommends integrating these resilience strategies into local planning processes and ensuring community engagement in planning for disaster response. Both frameworks stress the need for reliable emergency power and flood response protocols to ensure continuous operations during and after disasters.

- **Assets Impacted:**

- Hospitals and healthcare facilities must remain operational to provide emergency services during disaster situations.
- Emergency response facilities, including fire stations and police departments are crucial for disaster response and recovery efforts.

- **Recommendations:**

- **Hardening of Emergency Facilities:** Strengthen the structural resilience of hospitals, fire stations, and police departments to

withstand flood events. Facilities such as Mariner’s Hospital and those located at Key West International Airport should be prioritized.

- **Reliable Emergency Power Solutions:** Equip all critical facilities with backup generators and renewable energy systems to ensure they remain functional during power outages caused by flooding.
- **Comprehensive Flood Response Plans:** Develop and implement detailed flood response plans for all emergency facilities, including evacuation strategies and continuity of operations protocols. Regular emergency drills and community education programs should be conducted to ensure readiness.

4. Preservation of Natural, Cultural, and Historical Resources

Monroe County’s natural habitats, cultural landmarks, and historical sites are integral to the county’s ecological balance and heritage but are increasingly vulnerable to SLR, flooding, and coastal erosion. Loss of these resources would impact not only the environment but also the county’s tourism-driven economy and cultural identity.

The IRPF encourages integrating nature-based solutions to enhance ecosystem resilience, while the Florida Adaptation Guidebook emphasizes the preservation of natural and cultural resources through community involvement and the use of sustainable practices. Both frameworks stress the importance of using nature-based flood protection, such as living shorelines and mangrove restoration, which help mitigate flooding and protect critical ecosystems.

- **Assets Impacted:**

- **Parks and natural habitats** that play a vital role in the county's ecological balance but are susceptible to damage from flooding.
- **Cultural and historical sites** that are irreplaceable parts of the county's heritage and may be vulnerable to floodwaters.

- **Recommendations:**

- **Protective Landscaping:** Utilize natural and engineered landscaping
- **Protective Landscaping and Nature-Based Solutions:** Utilize mangrove restoration, living shorelines, and other nature-based strategies to protect parks, wetlands, and coastal ecosystems from erosion and flooding.
- **Elevate and Protect Cultural and Historical Sites:** Implement flood-proofing measures around critical cultural landmarks and historical sites, such as those in Key West and Pigeon Key, ensuring their protection from floodwaters.

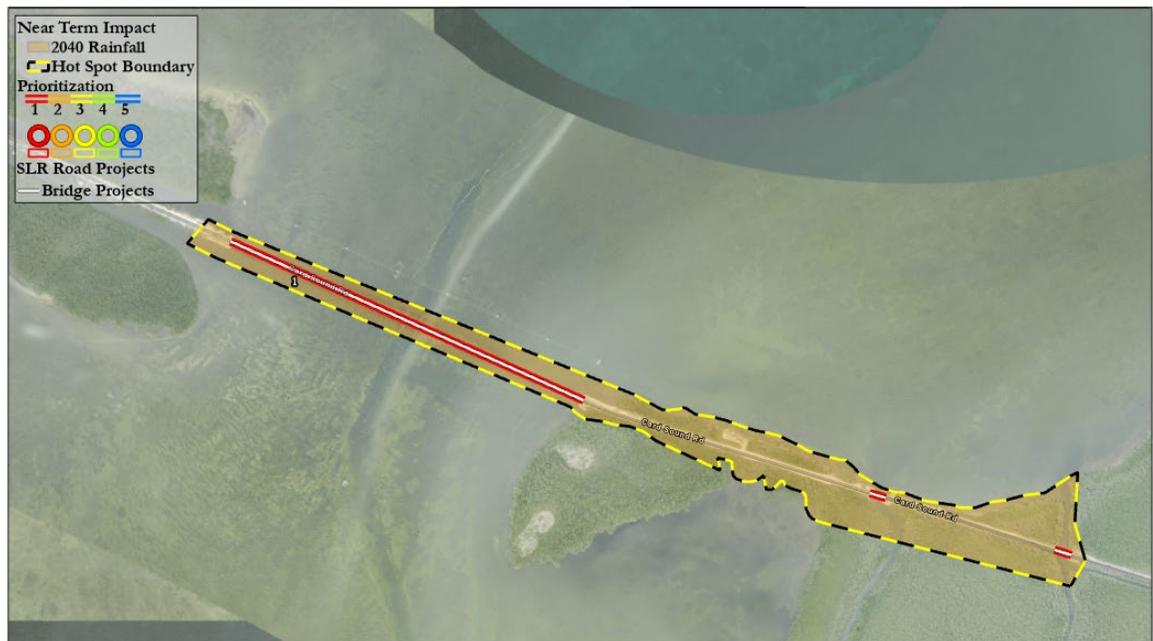
- **Community Engagement and Preservation Education:** Foster community involvement in the preservation of natural and cultural resources through public outreach and educational programs that raise awareness of the importance of flood resilience.

This comprehensive assessment of Monroe County’s flooding hot spots and the assets at risk within each hot spot underscores the need for a targeted approach to infrastructure resilience. By leveraging both the IRPF and the Florida Adaptation Planning Guidebook, Monroe County is positioned to effectively prioritize interventions, ensuring that critical infrastructure remains resilient and that the county can adapt to both immediate and long-term climate risks.

Key to the successful implementation of these measures is active community engagement, continuous monitoring, and adaptive management. Launching educational programs, conducting emergency response drills, and deploying real-time monitoring systems will ensure that the county remains prepared for changing climate conditions. Through this proactive approach, Monroe County can enhance its preparedness for flood events, safeguard its essential services, and build a more resilient and sustainable future for all its residents.

Hot Spot 1: Card Sound Bridge

Figure 63 - Prioritized Assets in Hot Spot 1



Card Sound Bridge and Card Sound Road serve as critical infrastructure, providing essential connectivity between Monroe County and the mainland. The region’s low

elevation and coastal proximity make these assets highly vulnerable to storm surge, sea-level rise (SLR), and extreme rainfall events. The vulnerability assessment's exposure analysis reveals that this area faces near-term risks related to 2040 rainfall projections, highlighting the urgent need for interventions.

Given the potential for isolation of Monroe County during extreme weather events and the essential role these transportation routes play in daily operations, evacuations, and emergency services, targeted resilience-building measures are critical. If compromised, the Card Sound Bridge and Card Sound Road could become impassable, cutting off vital transportation access to and from the mainland. This would pose significant risks to public safety, economic activities, and emergency response capabilities. Coordination with the Florida Department of Transportation will be necessary to protect

For further details regarding specific assets within this hot spot and other prioritized locations, please refer to Appendix G, which contains additional asset information, including vulnerability ratings and project prioritizations.

Recommendations

1. Elevation and Structural Reinforcement of Card Sound Bridge

- The location and elevation of Card Sound Bridge makes it highly susceptible to storm surge and SLR projections by 2040. Current projections indicate that combined effects of storm surges and increased water levels could make the bridge impassable, threatening to isolate Monroe County's communities, especially during extreme weather events like storms and hurricanes.
- Recommendation:
 - Elevate the bridge deck to account for projected future water levels and storm surge heights. This elevation would ensure the bridge remains above floodwaters even during extreme storm events, reducing the risk of submersion.
 - Reinforce bridge piers and foundations to improve structural integrity. This involves deepening foundations to resist erosion and storm surge forces, and using stronger materials such as corrosion-resistant steel or reinforced concrete to combat the effects of saltwater and wave impacts.
 - Incorporate storm-resistant materials that can withstand high winds and flood conditions. Advanced materials like high-strength concrete or fiber-reinforced composites should be considered to extend the bridge's lifespan in the face of changing climate conditions.

- Hydrodynamic design integration: Design the bridge in such a way that allows water to flow under it efficiently, minimizing lateral pressure from floodwaters. This would prevent water buildup that could weaken the structure over time, reducing the risk of long-term damage and failure.

2. Flood Resilience for Card Sound Road

- The location and low-lying elevation of Card Sound Road is prone to frequent flooding, exacerbated by SLR, storm surges, and rainfall events. Flooding on this road could render it unusable as an evacuation route, further risking the isolation of communities during extreme weather.
- Recommendation:
 - Raise the roadbed to ensure Card Sound Road remains functional during flood events. This is critical for maintaining evacuation routes and emergency access, especially during peak flood conditions.
 - Install advanced drainage systems, such as permeable pavement, culverts, and stormwater retention basins or pumps to manage surface water runoff from heavy rainfall and reduce water accumulation on the roadway.
 - SLR-adapted designs should be employed, such as elevated pathways or causeways, in areas most vulnerable to flooding. This would create flood-proofed road sections to ensure year-round accessibility, even during severe weather events.

3. Storm Surge Barriers and Nature-Based Solutions

- Both Card Sound Bridge and Road are exposed to storm surges and coastal flooding during tropical storms and hurricanes, threatening the infrastructure's longevity and functionality.
- Recommendation:
 - Install storm surge barriers along the coastline to protect critical infrastructure from direct impacts of storm surge. These barriers could include seawalls, levees, living shorelines or movable floodgates to control the flow of water during high tide and storm events.
 - Reinforce and restore natural ecosystems such as mangrove forests and coastal wetlands to serve as natural buffers. These systems reduce wave energy and can absorb excess

stormwater, acting as a first line of defense for the bridge and road.

- Consider offshore breakwaters or jetties to further reduce wave action before it reaches the bridge and road, reducing the stress placed on these vital infrastructure assets during major storms.

4. Emergency Management and Flood Monitoring Systems

- Lack of real-time monitoring makes it difficult to anticipate and respond to flood risks, leaving residents and emergency services unprepared for potential road closures and bridge inaccessibility.
- Recommendation:
 - Deploy sensor networks and flood forecasting systems that provide real-time data on water levels, storm surge activity, and rainfall. This information will allow emergency services to anticipate road closures and prepare evacuation routes in advance of storm events.
 - Implement traffic management systems that reroute vehicles during flood events, ensuring continuous access for emergency services and the public, and avoiding dangerous areas that have become impassable.
 - Establish early warning systems to notify the public and authorities about incoming floods, allowing for more efficient evacuations and response strategies.

5. Long-Term Adaptation and Maintenance Strategies

- Even with immediate interventions, SLR projections beyond 2040 present ongoing risks to these transportation assets. Without a long-term strategy, the efficacy of resilience measures could deteriorate over time.
- Recommendation:
 - Develop a long-term maintenance plan for both Card Sound Bridge and Road that includes routine evaluations of their condition and performance. This should include structural integrity assessments, especially after major weather events, to ensure all systems remain fully functional.
 - Integrate flexible adaptation measures that allow for future modifications as climate projections evolve. For example, the

road and bridge designs should allow for further elevation or additional protective reinforcements if needed.

- Ensure resilience measures are included in budgetary planning and emergency management frameworks to guarantee that there are funds available for ongoing maintenance and any necessary upgrades as climate risks increase over time.
- Align these plans with Monroe County's emergency management strategies to ensure all resilience efforts are coordinated with broader disaster response plans, creating a comprehensive approach to flood preparedness.

These detailed recommendations for Card Sound Bridge and Road aim to bolster the resilience of Monroe County's critical transportation infrastructure in the face of increasing climate threats, ensuring these assets continue to support daily operations, emergency services, and evacuation needs for years to come. As previously stated, all efforts will need to be coordinated with the Florida Department of Transportation.

Hot Spot 2: Big Coppitt Key

Figure 64 - Prioritized Assets in Hot Spot 2



Big Coppitt Key is a primarily residential area northeast of Key West, characterized by low-lying terrain and proximity to the coast. This area faces significant vulnerability to sea-level rise (SLR) and storm surge, which are projected to impact the community

by 2040. With a mix of residential properties, critical transportation routes like the Overseas Highway (U.S. Route 1), and recreational spaces, targeted interventions are essential to maintain the functionality of key infrastructure and protect the community.

The vulnerability assessment has identified priority areas for interventions, with a focus on addressing flood risks to homes, roadways, and public spaces. Given the high exposure to SLR and storm surge, the following projects are recommended to improve resilience in Big Coppitt Key. It should be noted that the County is in receipt of grant funds to elevate portions of the roadway network with work expected to be completed in the next 3-5 years. Additionally, adaptation relative to US-1 will need to be led by the Florida Department of Transportation because it is a state transportation facility.

Recommendations:

1. Road Elevation and Drainage Improvements on Local Streets

- Local roads and streets in Big Coppitt Key are at high risk of becoming impassable due to flooding from storm surge and rainfall events. These streets provide vital connectivity for residents and access to the main evacuation route, U.S. Route 1.
- Recommendation:
 - Elevate flood-prone local roads to reduce the risk of roadway submersion during flood events. Roads like Avenue F and Avenue G, which are particularly low-lying, are already prioritized for elevation.
 - Upgrade drainage systems along local streets by installing permeable pavement, swales, pumps and retention ponds to manage surface runoff and prevent water accumulation on roadways.
 - Install additional culverts under key intersections to enhance water flow during storm events and reduce the potential for road closures.

2. SLR Resilience for Overseas Highway (U.S. Route 1)

- The Overseas Highway is a critical transportation route for both local traffic and regional evacuation. However, its proximity to the coast makes it highly vulnerable to SLR and storm surge, particularly near Big Coppitt Key.

- Recommendation:
 - Led by FDOT, elevate critical sections of the Overseas Highway within Big Coppitt Key to ensure continuous access during extreme weather events. The eastern section of the highway is particularly vulnerable and should be raised to accommodate future water levels.
 - Implement shoreline protection measures along the highway to mitigate erosion and buffer the road from storm surges. This could involve building revetments, seawalls, or utilizing living shorelines (e.g., mangroves) to protect against coastal impacts.

3. Floodproofing Residential Areas

- Residential neighborhoods on Big Coppitt Key are susceptible to flooding due to their low elevation and proximity to the coastline. Properties closest to the shoreline face the greatest risk from storm surge and SLR.
- Recommendation:
 - Encourage homeowners to implement floodproofing measures on properties. This could include installing elevated foundations or retrofitting homes with flood barriers, water-resistant materials, and backflow prevention systems for sewage lines.
 - Promote the voluntary buyout of high-risk properties closest to the shoreline (Priority Levels 3-4) to allow for future managed retreat in areas that will become increasingly difficult to protect from chronic flooding and storm surge. It should be noted the County already has a program in place for voluntary buyouts.

4. Green Infrastructure and Stormwater Management

- Big Coppitt Key's stormwater systems are not designed to manage the increased volume of runoff expected from both intensifying rainfall and the related impacts of rising sea levels, leading to frequent localized flooding.
- Recommendation:
 - Implement green infrastructure solutions such as bioswales, rain gardens, and constructed wetlands in key locations to enhance stormwater absorption and mitigate flooding. These systems should be strategically placed along low-lying roads

and near residential areas to capture and treat stormwater naturally.

- Consider installing stormwater pumps in areas with high flood risk, such as the residential sections along 4th Street, to actively remove excess water during heavy rainfall events.

5. Resilient Public Access and Recreational Spaces

- Public access points to the water and recreational areas like portions of the Florida Keys Overseas Heritage Trail are vulnerable to SLR and storm surge, threatening both public safety and the integrity of these spaces.
- Recommendation:
 - Elevate portions of the Florida Keys Overseas Heritage Trail where they cross low-lying areas within Big Coppitt Key to prevent flooding and ensure the trail remains usable for pedestrians and cyclists.
 - Install flood barriers and natural buffers such as mangrove restoration in vulnerable public access points to the shoreline, creating protective layers that prevent erosion and reduce the impact of flooding on recreational spaces.

6. Emergency Management Enhancements

- Without real-time data and effective early warning systems, it becomes difficult to anticipate the full impact of storm surges and flooding on Big Coppitt Key. This can lead to delayed evacuations and ineffective emergency response.
- Recommendation:
 - Deploy flood monitoring systems throughout Big Coppitt Key to provide real-time data on water levels and potential risks, ensuring that residents and emergency services are better prepared for flooding events.
 - Implement early warning systems that notify residents of impending flood risks, giving them enough time to evacuate or take protective measures to secure their properties.

Long-Term Resilience Strategy

While immediate interventions are critical, it is equally important to adopt a long-term resilience strategy that takes into account future SLR projections and climate change impacts. Recommendations include:

- **Continuous Monitoring:** Establish a long-term monitoring plan to track the effectiveness of flood protection measures and adjust based on updated SLR projections and environmental changes.
- **Flexible Infrastructure Design:** Ensure that new infrastructure projects in Big Coppitt Key, including road elevation and green infrastructure, are designed with flexibility in mind. These projects should be adaptable to accommodate further modifications as SLR and flood risks increase over time.
- **Community Education and Engagement:** Engage residents and local businesses in resilience efforts by providing educational resources on floodproofing techniques, insurance options, and the importance of green infrastructure. Encourage community involvement in decision-making to ensure that resilience measures align with local needs and priorities.

By implementing these targeted recommendations, Big Coppitt Key can withstand the increasing threats of SLR, storm surge, and extreme weather events, while ensuring the safety and well-being of its residents. For additional details on prioritized assets and specific vulnerabilities, please refer to Appendix G, which contains further information on the region’s exposure to climate risks and ongoing mitigation efforts.

Hot Spot 3: Stillwright Point

Figure 65 - Prioritized Assets in Hot Spot 3



Stillwright Point, located in northern Monroe County, is a residential area adjacent to the Florida Keys Overseas Heritage Trail and near John Pennekamp Coral Reef State Park. The area contains numerous residential properties along North Blackwater Lane, South Blackwater Lane, and adjacent streets (Priority Level 4-5), many of which are vulnerable to flooding and storm impacts. The community's low-lying topography, combined with its proximity to coastal ecosystems like mangrove forests, coastal wetlands, and nearshore marine habitats (Priority Level 3-4), puts it at significant risk from sea-level rise (SLR), storm surge, and present-day rainfall flooding.

The exposure analysis highlights the need for targeted resilience measures to protect both residential areas and the natural coastal systems that provide critical flood protection. This hotspot also includes portions of the Florida Keys Overseas Heritage Trail, which is an important recreational asset (Priority Level 3). The vulnerability of local roads, residential properties, and natural resources underscores the importance of implementing a comprehensive flood mitigation strategy in this area.

For additional information regarding specific assets within Stillwright Point and other prioritized hot spots, please refer to Appendix G, which contains further details on asset vulnerabilities and project prioritizations.

Recommendations

- 1. Residential Property Floodproofing and Elevation:** Many homes within Stillwright Point are located in flood-prone areas, with the potential for inundation from both present-day rainfall and future sea-level rise. Floodproofing strategies, such as installing water-resistant barriers, elevating homes, and upgrading to flood-resistant building materials, are essential to protect residential properties. Where possible, raising homes to meet or exceed base flood elevation levels will provide long-term protection against SLR and storm surge impacts.
- 2. Drainage System Upgrades for Local Roads:** The local access roads in Stillwright Point are at high risk of becoming impassable during heavy rainfall, seasonal tidal flooding and storm surge events. Installing improved drainage systems, such as permeable pavements, expanded culverts, pumps, and stormwater retention areas, will mitigate the risk of road flooding. This ensures continued access to emergency services and daily functions, even during extreme weather events.
- 3. Stormwater Pump Station:** To alleviate local roadway flooding, the site could benefit from a stormwater pump station on the vacant parcels near the intersection of N Blackwater Ln and Stillwright Way. Additional connected stormwater networks along the low points of adjacent roadways could contribute to an accelerated drawdown of ponded water in areas more prone

to inundation. It should be noted the County has already acquired lands within Stillwright Point to contribute to stormwater retention and the location of a pump station in conjunction with other road elevation and pumping strategies. This project is also subject of a grant application submitted to DEP 9/1/24.

- 4. Shoreline Stabilization and Mangrove Restoration:** The coastal wetlands and mangrove forests in Stillwright Point serve as natural buffers against storm surges and wave action. Restoring degraded mangrove areas and reinforcing shorelines with living shoreline techniques will enhance the area's natural flood defenses. This strategy will protect both residential infrastructure and the region's valuable coastal ecosystems from erosion and inundation.
- 5. Resilience Enhancements to the Florida Keys Overseas Heritage Trail:** Sections of the Florida Keys Overseas Heritage Trail running through Stillwright Point are vulnerable to flooding and sea-level rise. Raising these trail sections or implementing stormwater management systems along the trail can prevent damage from recurrent flooding, ensuring that the trail remains a functional recreational and alternative transportation route. These improvements will also protect the trail's role as a critical evacuation route in times of emergency.
- 6. Real-Time Flood Monitoring and Early Warning Systems:** Given the susceptibility of the area to rainfall-induced flooding and storm surge, implementing real-time flood monitoring systems in Stillwright Point will allow for early detection and warning of flood risks. Sensor networks and communication systems can alert residents and emergency responders, improving preparedness and response times during flood events.
- 7. Long-Term SLR Adaptation Plans:** As sea-level rise projections extend beyond 2040, Stillwright Point will need a phased adaptation plan to address long-term vulnerabilities. This plan should include continuous reassessment of flood risks, the potential for managed retreat in areas facing chronic inundation, and ongoing investment in flood-resilient infrastructure and natural defenses. Ensuring that adaptation measures are integrated into local planning and zoning regulations will protect both the built and natural environments as conditions evolve over the coming decades.

Hot Spot 4: Key West International Airport

Figure 66 - Prioritized Hot Spots in Hot Spot 4



Key West International Airport is a critical transportation hub and a key asset for Monroe County, providing essential connectivity for residents, tourists, and emergency services. The airport includes vital infrastructure such as runways, taxiways, terminal buildings, the air traffic control tower, and maintenance facilities (Priority Level 5). Emergency response services, including the Key West International Airport Fire Department and staging areas for emergency operations, are also located within this hotspot. This critical infrastructure faces significant long-term threats from projected sea-level rise (SLR) and storm surge. Nearby assets, such as Roosevelt Boulevard, parking facilities, and sections of the Florida Keys Overseas Heritage Trail, are also vulnerable to flood risks. Utilities, including stormwater systems, and critical facilities like the Florida Highway Patrol (FHP) Substation and Salt Ponds Bunker Area, face similar risks.

Given the airport's role in regional transportation, emergency response, and economic activity, addressing these vulnerabilities is essential for maintaining long-term resilience. For more detailed information regarding the critical assets and prioritizations within this hotspot, please refer to Appendix G.

Recommendations

- **Runway and Taxiway Elevation and Reinforcement:** The airport's runways and taxiways are highly vulnerable to both storm surge and long-term sea-

level rise, which could disrupt operations during extreme weather events and eventually render them unusable if left unprotected. A major project would involve elevating the runways and taxiways above projected flood levels. This effort would require:

- Raising the runway surfaces to account for SLR projections by 2100, ensuring safe takeoff and landing during periods of high water.
 - Reinforcing the sub-base of the runways and taxiways with storm-resistant materials to withstand erosion and water saturation.
 - Incorporating advanced drainage systems underneath and adjacent to the runways to direct stormwater away from the tarmac and prevent standing water.
 - Ensuring the taxiways are similarly elevated and fortified to maintain continuous access between runways and terminal areas.
- **Flood Barriers and Coastal Defenses:** Protecting the airport from storm surge and tidal flooding requires a combination of gray infrastructure and nature-based solutions:
 - Construct a perimeter flood barrier system around the airport facilities to prevent storm surge and high tides from inundating critical areas. This could include seawalls or levees along the airport's coastal boundaries.
 - Explore the use of natural coastal defenses, such as restoring or reinforcing nearby salt marshes, coastal wetlands, and mangrove forests, to reduce the energy of storm surges and provide an additional buffer zone.
 - Install offshore breakwaters, jetties or submerged barriers to reduce wave action that could further damage the airport's infrastructure during storms.
- **Stormwater Management System Retrofits:** The existing stormwater infrastructure, including catch basins, drainage wells, and manholes, is likely inadequate to handle the future impacts of heavy rainfall, storm surge, and SLR. A retrofit of the stormwater system is recommended, including:
 - Upgrading and expanding the capacity of the stormwater network to quickly redirect water from paved surfaces such as runways, taxiways, and parking areas.
 - Installing advanced pumping stations that can handle large volumes of water during extreme events and prevent water from accumulating in low-lying areas.

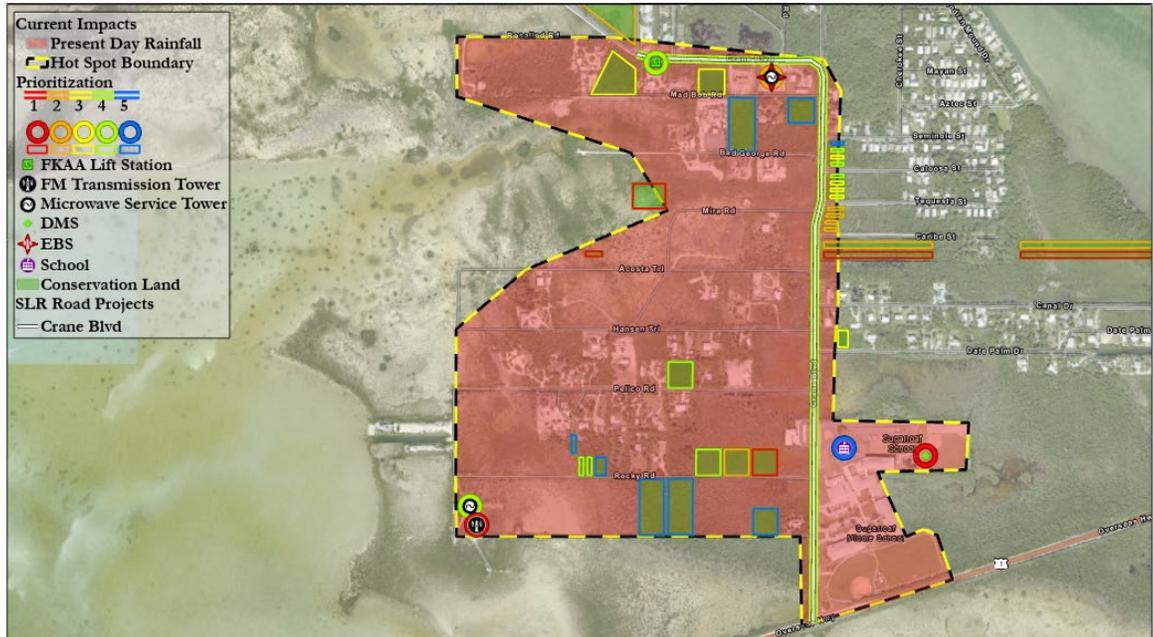
- Incorporating permeable surfaces in parking areas to reduce runoff and increase groundwater infiltration.
- Enhancing existing natural retention areas around the airport, such as salt ponds, to provide additional water storage during flood events.
- **Utility Infrastructure Resilience:** Utilities serving the airport, including electrical substations, the stormwater line works, and the FHP Substation, must be protected from flooding to ensure continued operation. Mitigation measures for these critical systems should include:
 - Elevating or floodproofing electrical and communication equipment to prevent disruptions during storm events. This can involve placing substations on raised platforms or inside flood-resistant enclosures.
 - Ensuring that backup power systems are in place for critical operations, including air traffic control, emergency services, and passenger processing facilities.
 - Improving the resilience of the stormwater line works by reinforcing drainage infrastructure and ensuring it can handle projected increases in rainfall and water levels.
- **Resilience Enhancements for Roosevelt Boulevard and Florida Keys Overseas Heritage Trail:** Roosevelt Boulevard, a primary access road to the airport, is vulnerable to flooding and must be elevated to ensure continuous access to the airport, especially during emergencies. Proposed mitigation projects include:
 - Elevating key sections of Roosevelt Boulevard to prevent flooding from both storm surge and rainfall events.
 - Adding culverts or underpasses at low-lying areas along the road to enhance drainage and reduce the likelihood of road closures.
 - Implementing resilience measures along sections of the Florida Keys Overseas Heritage Trail to maintain its functionality as an alternative transportation route and as an important recreational resource. This may involve raising trail segments or installing stormwater management systems along the trail to prevent flood damage.
- **Emergency Response Staging Area Enhancements:** The airport's fire department and emergency response staging areas must remain operational during storm events to provide crucial services. Potential projects to ensure these areas remain functional include:
 - Hardening of critical facilities, such as the fire station, to ensure they can withstand hurricane-force winds, flooding, and storm surge.

- Installing flood barriers or relocating staging areas to higher ground to prevent inundation during extreme weather.
- Equipping the staging areas with redundant power sources, including generators or renewable energy options, to ensure continuous operation during power outages.
- **Long-Term SLR Adaptation and Monitoring:** The airport faces ongoing risks from rising sea levels beyond 2040. Developing a long-term adaptation plan that incorporates monitoring and flexibility for future modifications is critical. This plan should include:
 - Routine assessments of the structural integrity of the elevated infrastructure and the effectiveness of the installed flood barriers and drainage systems.
 - Continuous monitoring of sea-level rise and storm surge trends using real-time sensors and data analytics to adjust future adaptation measures as needed.
 - Planning for additional elevation or relocation of facilities if SLR projections indicate further risks, ensuring that long-term airport operations remain viable even under changing climate conditions.

Implementing these resilience projects will safeguard Key West International Airport's role as a critical transportation and emergency service hub, ensuring that it continues to serve Monroe County and the surrounding region in the face of increasing climate threats.

Hot Spot 5: Sugarloaf Key

Figure 67 - Prioritized Assets in Hot Spot 5



Sugarloaf Key is a key area in Monroe County, facing significant risks from both present-day rainfall and future sea-level rise (SLR) projections. The hotspot contains several vital assets, including Sugarloaf Elementary/Middle School, critical infrastructure like the FKAA Lift Station (USKI-S02), FM Transmission Tower, Microwave Service Tower, Debris Management Site (DMS), and the Emergency Broadcast System (EBS). The Overseas Highway (U.S. Route 1) and various local access roads also serve as essential infrastructure vulnerable to SLR and storm surge impacts. The area also features natural resources such as coastal ecosystems, wetlands, and conservation lands that contribute to the area's environmental resilience but are similarly exposed to climate risks.

Given these critical assets, protecting the educational, utility, and transportation infrastructure in Sugarloaf Key is essential for community safety and continuity of services. The following recommendations aim to enhance the resilience of these key assets, ensuring that the community remains functional and prepared for both immediate and long-term flooding challenges. Some of these assets may fall under the responsibility of other entities for long term resilience including the School District or FKAA. For additional information regarding specific assets within this hotspot, refer to Appendix G, which contains further details on asset vulnerabilities and prioritization.

Recommendations

1. Elevation and Drainage Improvements for Sugarloaf Elementary/Middle School

- Sugarloaf Elementary/Middle School serves as both an educational facility and a potential emergency shelter during extreme weather. However, the school's low-lying location makes it susceptible to flooding from rainfall and future sea-level rise.
- Recommendation:
 - Elevate the school structure to ensure it remains functional during flood events and resilient to future sea-level rise.
 - Install advanced drainage systems on campus, including drainage basins and permeable surfaces, to manage heavy rainfall and prevent water accumulation.
 - Develop green infrastructure solutions, such as rain gardens, to naturally absorb excess rainwater and reduce the need for mechanical pumping systems.
 - These interventions will ensure continued educational operations while also maintaining the facility's emergency shelter capabilities during extreme weather events.

2. Hardening of FKAA Lift Station and Critical Infrastructure

- The FKAA Lift Station (USKI-S02) and other communication infrastructure, such as the FM Transmission Tower, Microwave Service Tower, and EBS, are essential for utility services and emergency communication during storms. Protecting these assets from flood risks is crucial for maintaining community connectivity.
- Recommendation:
 - Elevate the lift station and communication towers above projected flood levels and floodproof them to prevent damage from saltwater intrusion.
 - Install reinforced flood barriers and backup generators to ensure continuous utility and communication services during storms and power outages.
 - Implement monitoring systems to detect potential failures and allow for proactive maintenance, minimizing service interruptions during critical periods.

3. Debris Management Site (DMS) Resilience Improvements

- The Debris Management Site (DMS) plays a key role in post-disaster recovery operations by handling storm debris. However, the site itself is vulnerable to flooding, which could hinder recovery efforts.
- Recommendation:
 - Reinforce the site against flooding by constructing elevated access roads, ensuring that the site remains accessible for trucks and machinery during floods.
 - Install flood mitigation measures such as raised berms or retaining walls to protect the site from storm surges.
 - Add covered storage areas to protect equipment and debris-processing facilities from water damage, ensuring that recovery operations can proceed without delay after storms.

4. Elevation of Crane Boulevard and Local Roads

- Crane Boulevard and other local access roads are vital for daily transport and emergency evacuations. These roads are currently vulnerable to flooding from heavy rainfall and SLR.
- Recommendation:
 - Elevate Crane Boulevard and flood-prone local roads to ensure they remain passable during extreme weather conditions.
 - Install improved drainage systems, including culverts, bioswales, pumps, and permeable pavement, to manage stormwater runoff and prevent road closures.
 - Implement flood barriers or gates at key points to protect road infrastructure from storm surge impacts, ensuring continuous transportation access for residents and emergency services.

5. Restoration of Coastal Wetlands and Natural Barriers

- Coastal wetlands and natural barriers serve as critical defenses against storm surges and flooding. Protecting and restoring these ecosystems can enhance the flood resilience of Sugarloaf Key.
- Recommendation:
 - Restore and reinforce mangrove forests and coastal wetlands to create natural buffers that absorb floodwaters and reduce the impact of storm surges.

- Implement living shorelines to stabilize erosion-prone areas and improve the ability of natural habitats to absorb excess water.
- Establish conservation zones to protect sensitive ecosystems from development and enhance their flood protection functions.

6. Real-Time Flood Monitoring and Early Warning Systems

- Given the flood risks facing Sugarloaf Key, installing real-time flood monitoring systems and early warning sensors will be crucial for emergency preparedness and timely evacuations.
- Recommendation:
 - Deploy a network of flood sensors throughout Sugarloaf Key, especially near vulnerable assets such as the school, lift station, and DMS, to monitor water levels and provide real-time alerts.
 - Integrate flood forecasts with Monroe County's emergency management systems to provide early warnings and ensure residents are informed of impending flood risks.
 - Implement adaptive traffic management systems that can reroute vehicles away from flood-prone roads, ensuring safe and efficient evacuations during extreme weather events.

The implementation of these targeted projects will significantly enhance the resilience of Sugarloaf Key's critical infrastructure and natural resources, ensuring that the community remains functional and safe in the face of increasing climate threats. Long-term adaptation strategies, such as the elevation of infrastructure and restoration of natural barriers, will help mitigate the impacts of sea-level rise and storm surge. For further information on the prioritized assets and vulnerabilities within Sugarloaf Key, refer to Appendix G.

Hot Spot 6: Pigeon Key

Figure 68 - Prioritized Asset in Hot Spot 6



Pigeon Key is an island with historically significant structures in Monroe County, located within the Florida Keys. Once a work camp for the Florida East Coast Railway, Pigeon Key now serves as both a tourist attraction and an educational facility. Its early 20th-century structures, many of which are listed on the National Register of Historic Places, make it an important cultural and historical site. In addition, Pigeon Key hosts a marine science educational center, supporting students and researchers, and is accessible via the old Seven Mile Bridge, a critical component of the Florida Keys Overseas Heritage Trail. This trail serves as a recreational asset and an alternative transportation route, crossing Pigeon Key and linking it to other parts of the Keys. The surrounding marine ecosystems and limited terrestrial habitats also add environmental significance to the area.

Due to its low-lying topography, Pigeon Key is highly vulnerable to present-day sea-level rise (SLR) and projected climate impacts by 2040. The island's critical historical, cultural, and educational resources face significant risks from future sea-level rise and coastal flooding. Safeguarding these unique assets requires targeted interventions. For further details regarding specific assets within this hot spot and other prioritized locations, please refer to Appendix G, which contains additional asset information, including vulnerability ratings and project prioritizations.

Recommendations

1. Elevation and Floodproofing of Historical Structures

- Pigeon Key’s historical buildings are vulnerable to flooding and storm surge due to their proximity to the shoreline and low elevation. Protecting these structures is essential to preserving the island's cultural heritage. Due to facilities’ historical designations, the regulatory and approval process for building adaptations may be more complex than non-designated structures.
- Recommendation:
 - Elevate the foundations of historical buildings to protect them from floodwaters, ensuring the structures remain intact during storm events.
 - Floodproof the exterior and interior of buildings by installing barriers, waterproof materials, and other protective measures, such as raising electrical systems above projected flood levels.
 - Implement routine structural assessments to maintain the long-term integrity of the buildings, factoring in future SLR projections to ensure that flood-proofing strategies remain effective.

2. Shoreline Protection and Erosion Control

- Pigeon Key’s shoreline is at risk of erosion due to storm surges and rising sea levels, which could lead to habitat loss and threaten the structural integrity of island infrastructure.
- Recommendation:
 - Construct living shorelines and restore mangrove ecosystems to stabilize the island's perimeter and reduce erosion. These natural barriers will help absorb wave energy and protect the island from storm impacts.
 - Install rock revetments, living shorelines or seawalls in areas experiencing significant erosion to prevent further shoreline degradation. This hybrid approach will combine gray and green infrastructure to enhance the island's resilience.
 - Monitor shoreline changes regularly to assess the effectiveness of the installed erosion control measures and adjust as necessary to ensure long-term stability.

3. Resilience Upgrades to the Old Seven Mile Bridge

- The old Seven Mile Bridge provides the only access route to Pigeon Key, making it a critical transportation asset. However, it is vulnerable to the impacts of sea-level rise, storm surge, and coastal flooding, which could make the bridge impassable in the future.
- Recommendation:
 - Reinforce vulnerable sections of the bridge to ensure continued access to the island. This will involve raising the bridge deck to accommodate higher tidal levels and strengthening the structural integrity of the bridge piers to withstand stronger storm surges.
 - Upgrade drainage systems along the bridge to prevent water accumulation on the deck during heavy rainfall or high tide events.
 - Ensure that the bridge remains safe for both vehicles and pedestrians by incorporating materials that can withstand long-term exposure to saltwater and corrosion.

4. Enhancements to the Florida Keys Overseas Heritage Trail

- The Florida Keys Overseas Heritage Trail is an important recreational and alternative transportation route that crosses Pigeon Key. Portions of the trail are susceptible to flooding and SLR, which could disrupt public access to the island.
- Recommendation:
 - Elevate portions of the Heritage Trail that are vulnerable to flooding to ensure continuous access for pedestrians and cyclists, even during high-water events.
 - Install stormwater management systems along the trail, including culverts and permeable surfaces, to manage water runoff and prevent trail erosion.
 - Incorporate green infrastructure, such as bioswales and rain gardens, to help absorb excess rainwater and reduce pressure on the drainage systems.

5. Protection of Marine Ecosystems and Terrestrial Habitats

- Pigeon Key's surrounding marine ecosystems and limited terrestrial habitats are valuable environmental resources, providing natural flood

buffers and supporting biodiversity. However, these ecosystems are increasingly threatened by rising sea levels, storm surges, and erosion.

- Recommendation:
 - Restore and enhance nearby seagrass beds and coral reefs to act as natural flood buffers, reducing wave energy and protecting the island’s coastline from storm impacts.
 - Monitor the health of these ecosystems over time, using adaptive management strategies to ensure that they continue to function as effective flood mitigation systems in the face of changing climate conditions.

6. Emergency Flood Monitoring and Early Warning Systems

- Due to its isolation and vulnerability to SLR and storm surges, Pigeon Key requires real-time flood monitoring and early warning systems to ensure the safety of residents, visitors, and researchers.
- Recommendation:
 - Deploy flood sensors around the island and along the Seven Mile Bridge to monitor rising water levels and detect potential flood threats in real time.
 - Integrate flood forecasts with Monroe County’s emergency management systems to provide timely warnings to Pigeon Key’s residents and visitors, enabling safe evacuations and preparedness measures.
 - Establish automated alerts and communication systems to notify the public and emergency services of impending flood risks, ensuring that evacuation routes remain accessible.

These recommendations aim to preserve Pigeon Key's cultural, environmental, and transportation assets while addressing the immediate and long-term threats posed by SLR and coastal flooding. Implementing these measures will help ensure the island remains resilient, allowing it to continue serving as a vital historical and educational site for future generations. For additional information on prioritized assets and detailed project recommendations, please refer to Appendix G.

Hot Spot 7: Summerland Key

Figure 69 - Prioritized Assets in Hot Spot 7



Summerland Key is a vital area within Monroe County that faces long-term impacts from sea-level rise (SLR), projected for 2070 and 2100. This key supports critical transportation infrastructure such as the Overseas Highway (U.S. Route 1), various Monroe County Bridges, the Florida Keys Overseas Heritage Trail, and local roads including West Shore Drive and East Shore Drive (Priority Level 5). These transportation assets are essential for daily commutes, tourism, and emergency evacuations, but they are highly vulnerable to SLR and storm surge.

Summerland Key also contains utilities and critical facilities, including multiple FKAA Lift Stations (SKI-501 through SKI-511), the Summerland Key Transmission Station (SKTS), Summerland Pump Station, water facilities, and a Microwave Service Tower (Priority Level 5). The Debris Management Site (DMS) is essential for emergency response, especially following storm events, but faces considerable flood risks.

The area is home to residential and commercial zones, such as the Mobile Home Park at 24986 Overseas Highway, which is particularly at risk (Priority Level 4-5). Several private marinas, including Blanche Bergin Marina Park, Sea Boots Charter Fishing, and Summerland Cove, represent vulnerable marine infrastructure (Priority Level 3-4). Community facilities, such as the Summerland Airfield and E Shore Drive Site, are also threatened by rising sea levels and storm surges.

The region's natural resources, including coastal ecosystems, nearshore marine

habitats, and conservation lands, are vital for protecting against erosion and flooding. However, the key's low-lying topography and proximity to the coast heighten its vulnerability to the impacts of climate change. Addressing the vulnerabilities of Summerland Key's diverse infrastructure, residential, commercial, and natural resources is essential for safeguarding the community's functionality and environmental integrity. For additional details regarding specific assets within this hotspot and other prioritized locations, please refer to Appendix G, which contains further asset information and prioritizations.

Recommendations

1. Elevation and Reinforcement of the Overseas Highway and Local Roads

As the primary evacuation route and critical transportation corridor, the Overseas Highway (U.S. Route 1) is vulnerable to SLR and storm surge, particularly within Summerland Key. Any adaptation of US-1 will have to be led by FDOT. Local roads, including West Shore Drive and East Shore Drive, face similar risks.

- Recommendation:
 - Elevate critical segments of the Overseas Highway and local roads to ensure year-round functionality, particularly in areas projected to experience frequent flooding by 2070-2100.
- Incorporate SLR-adapted designs such as elevated roadbeds and causeways to allow for safe passage during storm events and tidal flooding.
- Implement advanced drainage systems, including permeable pavement and expanded culverts, to manage surface runoff and prevent road submersion.

2. Hardening of FCAA Lift Stations and Utility Infrastructure

Several critical utilities, including FCAA Lift Stations (SKI-501 through SKI-511), the Summerland Key Transmission Station (SKTS), and water facilities, are vital for maintaining public health and safety. These utilities are vulnerable to saltwater intrusion, flooding, and storm surge.

- Recommendation:
 - Elevate and floodproof the FCAA Lift Stations and transmission station to protect against rising sea levels and storm surge impacts. This includes integrating waterproof materials and reinforced flood barriers.

Install backup power generators at key utility sites to ensure service continuity during outages and storm events.

- Monitor for saltwater intrusion in water facilities, implementing reverse osmosis technology or other water treatment systems to ensure the water supply remains safe.

3. Resilience Enhancements for the Debris Management Site (DMS)

- The Debris Management Site (DMS) is essential for post-disaster recovery operations but is at risk of becoming inaccessible or inoperable due to flood events.
- Recommendation:
 - Elevate access roads leading to the DMS, ensuring that emergency response vehicles can reach the site even during flood conditions.
 - Install perimeter flood barriers and raised berms to protect the site from floodwaters and storm surge.
 - Enhance storage and processing areas with waterproof covers and reinforced infrastructure to prevent damage to debris management equipment.

4. Floodproofing and Elevation of Residential and Commercial Properties

- Summerland Key contains a variety of residential and commercial zones, including a Mobile Home Park and properties along the Overseas Highway, all of which are highly vulnerable to SLR and storm surge.
- Recommendation:
 - Encourage homeowners and businesses to elevate properties or implement floodproofing measures, such as installing flood barriers, using water-resistant materials, and upgrading drainage systems to protect against tidal flooding.
 - Promote the voluntary buyout of properties most vulnerable to chronic flooding and SLR, especially in Priority Level 4-5 zones.

5. Coastal Restoration and Natural Flood Barriers

- Coastal ecosystems and conservation lands surrounding Summerland Key play an essential role in buffering against storm surges and tidal flooding. However, these natural systems are at risk of degradation due to SLR and increased erosion.

- Recommendation:
 - Restore and protect coastal wetlands and mangrove forests to enhance the island's natural resilience to flooding and storm surges.
 - Implement living shorelines along vulnerable coastal zones to stabilize eroding shorelines and reduce wave energy.

6. Resilience Upgrades for Marine Infrastructure

- Private marinas such as Blanche Bergin Marina Park and Summerland Cove serve as important economic and recreational assets but are vulnerable to SLR and storm surge.
- Recommendation:
 - Property owners should reinforce marina facilities to protect against tidal flooding and storm surges, including raising dock heights and reinforcing marina infrastructure with saltwater-resistant materials.
 - Property owners should install storm barriers or floating dock systems that adjust with changing water levels, ensuring continued functionality during high tides or storm events.

7. Real-Time Flood Monitoring and Early Warning Systems

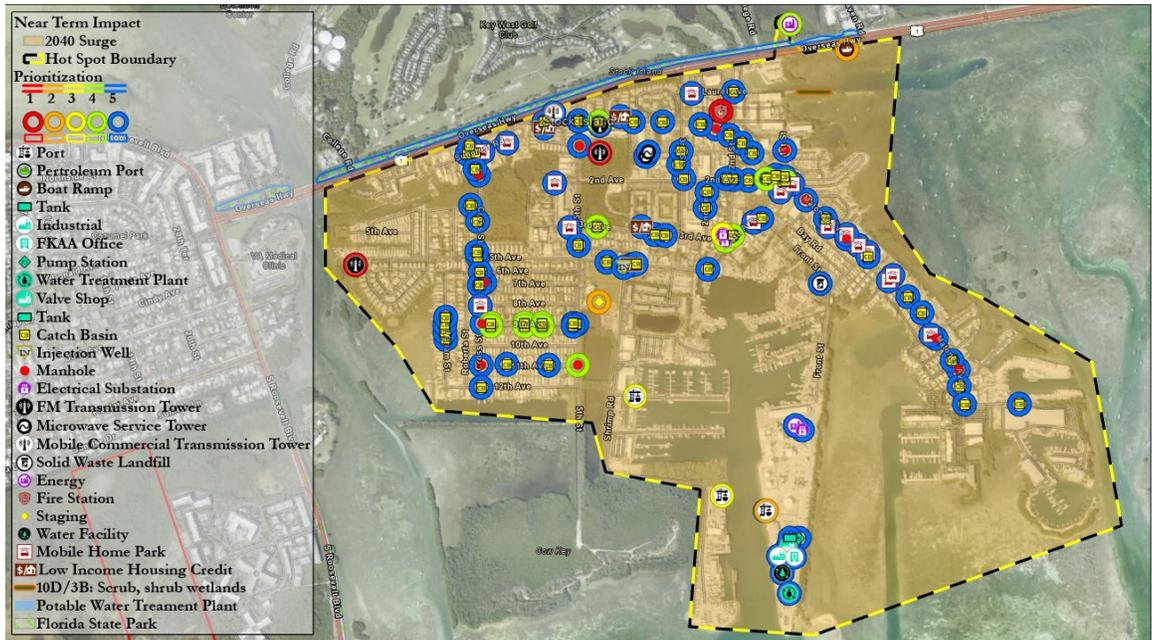
- Given the vulnerability of Summerland Key to SLR and flooding, implementing real-time flood monitoring systems will ensure timely responses to impending risks.
- Recommendation:
 - Deploy flood sensors around critical infrastructure, residential areas, and along Overseas Highway to provide real-time data on rising water levels and potential flood risks.
 - Integrate early warning systems with Monroe County's emergency management network to alert residents and local businesses of impending flood events, ensuring timely evacuations or protective measures.

Summerland Key is home to a range of critical assets, including transportation routes, utility systems, residential and commercial areas, and natural resources. Each of these assets is essential to maintaining the key's functionality and economic resilience. Implementing these targeted recommendations will enhance the area's ability to withstand sea-level rise, storm surge, and flooding, ensuring that

Summerland Key remains a safe and vibrant community. For additional details regarding asset prioritization and specific projects, please refer to Appendix G.

Hot Spot 8: Stock Island

Figure 70 - Prioritized Assets in Hot Spot 8



Stock Island is a critical area facing near-term impacts from storm surge projected for 2040. The island contains a wide range of vital assets, including critical infrastructure, industrial and commercial facilities, residential areas, and natural resources. Due to its low-lying topography and coastal proximity, Stock Island is highly vulnerable to both storm surge and sea-level rise (SLR), putting its infrastructure and environment at significant risk.

Key infrastructure includes water treatment plants, energy generation facilities, communication towers, and utility structures. These assets are crucial for maintaining the island’s functionality and are highly vulnerable to flooding and storm surge, as highlighted on the map.

Industrial and commercial areas on Stock Island include various manufacturing, processing, and storage facilities that support the local economy. These critical industrial zones are particularly vulnerable to storm surge impacts, which could disrupt operations and cause economic losses.

Stock Island’s residential neighborhoods—including mobile home parks, low-income housing, and other residential communities—are also at risk from flooding

and storm surge, as indicated on the map. Protecting these homes is essential to maintaining the island's housing stability and ensuring the safety of its residents.

The island's marine infrastructure, such as marinas, boat docks, and fishing facilities, plays a critical role in the local economy. However, the coastal nature of these assets leaves them exposed to storm surge and potential damage from rising sea levels.

Transportation infrastructure, such as the Overseas Highway, local access roads, and the Florida Keys Overseas Heritage Trail, serves as essential routes for daily operations and emergency evacuations. The island's road network is particularly vulnerable to flooding, which could disrupt connectivity and hinder evacuation efforts during extreme weather events.

In addition to its built environment, Stock Island includes natural resources such as coastal ecosystems, wetlands, and conservation lands. These ecosystems are vital for flood protection, serving as natural buffers against storm surges and erosion. However, they are also at risk from the impacts of rising sea levels.

Without intervention, Stock Island faces severe disruptions to its critical services, economic activities, housing, and environmental resources. For more detailed information about the specific assets and projects within this hotspot, please refer to Appendix G. Similar to other hot spots, some critical assets within this hot spot are not owned and controlled by Monroe County and are privately owned or owned/maintained by other agencies or entities.

Recommendations

1. Floodproofing of Critical Utility and Energy Infrastructure

- Protect the FKA RO Plant, Desalting Plant, Keys Energy Services Generating Plant, and other critical utility facilities from storm surge and flooding.
- Recommendation:
 - Elevate critical utility structures, such as electrical substations and water treatment plants, above projected flood levels for 2040 storm surge scenarios.
 - Implement flood barriers and reinforced construction around these facilities to prevent damage from high water levels.
 - Install backup generators and emergency power systems to ensure utility services remain operational during storm events.

2. Resilience Enhancements for Industrial and Commercial Facilities

- Encourage property owners to strengthen the flood resilience of industrial and commercial assets, including the Port of Key West, Stock Island Construction Office, and Bama Sea Products.
- Recommendation:
 - Property owners should elevate or retrofit industrial buildings with floodproofing materials to withstand saltwater exposure and prevent interior damage.
 - Implement drainage and stormwater management systems in industrial zones to prevent standing water and reduce the risk of water damage to equipment and facilities.
 - Install flood gates or barriers at key access points to industrial areas to prevent floodwaters from reaching critical operations.

3. Floodproofing and Elevation of Residential Areas

- Protect vulnerable residential areas, including mobile home parks, RV parks, and low-income housing, from storm surge and flooding.
- Recommendations for private property owners:
 - Elevate or relocate vulnerable mobile homes and RVs to higher ground, where feasible, to reduce exposure to storm surge.
 - Retrofit homes with floodproofing measures, including elevated foundations, flood barriers, and water-resistant materials to minimize flood damage.
 - Consider voluntary buyout programs for properties most at risk of chronic flooding, allowing for managed retreat in highly vulnerable areas.

4. Private Marine Infrastructure Resilience Projects

- Property owners should protect key marine infrastructure, including marinas, docks, and commercial fishing facilities, from future flood risks.
- Recommendation for private property owners:
 - Elevate and reinforce marina docks and related infrastructure to protect against storm surge and rising water levels.

Install floating dock systems that can adjust to changing water levels, ensuring that marinas remain operational during high tides and storm events.

- Protect shoreline areas around marinas with natural defenses, such as mangrove restoration or living shorelines, to absorb wave energy and reduce erosion.

5. Transportation and Road Elevation Projects

- FDOT should ensure the Overseas Highway (U.S. Route 1) and local roads remain functional during flood events and future SLR scenarios.

- Recommendation:

FDOT should elevate sections of the Overseas Highway and local roads that are most vulnerable to storm surge and flooding, particularly around key residential and commercial zones.

Upgrade road drainage systems by installing culverts, permeable pavement, and bioswales to manage stormwater runoff and prevent road flooding.

- Install storm surge barriers at key points along coastal roads to protect transportation infrastructure from direct flood impacts.

6. Resilience Enhancements for Community Facilities and Commercial Areas

- Protect community facilities and commercial businesses, such as Coconut Grove, from flooding and storm surge.

- Recommendation:

Elevate or retrofit community centers and commercial areas with flood-resistant materials and drainage systems to ensure their continued functionality during storm events.

- Implement green infrastructure solutions around commercial areas to manage stormwater and reduce the risk of localized flooding.

7. Natural Flood Defenses and Coastal Restoration

- Protect and restore coastal ecosystems, wetlands, and conservation lands to act as natural buffers against storm surge and flooding.

- Recommendation:
 - Restore and protect mangrove forests and coastal wetlands to enhance their ability to absorb floodwaters and mitigate storm surge impacts.
 - Establish living shorelines along vulnerable coastal areas to prevent erosion and provide long-term flood protection.
 - Implement conservation measures to prevent further development in flood-prone coastal zones, preserving these areas as natural flood barriers.

8. Real-Time Flood Monitoring and Early Warning Systems

- Install flood monitoring systems and early warning networks to provide real-time data and alerts during storm events.
- Recommendation:
 - Deploy sensor networks to monitor flood levels around critical infrastructure, residential areas, and transportation routes.
 - Integrate flood forecasting systems with Monroe County’s emergency management systems to provide advanced warnings and improve response times for evacuations and flood preparations.
 - Ensure that flood alerts are communicated effectively to both residents and businesses, allowing for timely protective measures.

Stock Island’s range of critical infrastructure (some privately owned and maintained), industrial zones, residential areas, and natural ecosystems makes it highly vulnerable to near-term storm surge and long-term SLR impacts. By implementing these targeted resilience projects, Stock Island’s essential assets can be protected, ensuring the continued delivery of vital services and safeguarding housing and economic activity. These efforts will also contribute to the environmental sustainability of the island’s coastal ecosystems. For additional details regarding specific assets within this hotspot and other prioritized locations, please refer to Appendix G.

Hot Spot 9: Cudjoe Key

Figure 71 - Prioritized Assets in Hot Spot 9



Cudjoe Key is an important area within Monroe County that faces mid-term impacts from sea-level rise (SLR) projected for 2070. The key contains a variety of critical infrastructure, including several Florida Keys Aqueduct Authority (FKAA) Lift Stations, an electrical substation, and emergency services like the Cudjoe Key Fire Station. The key's low-lying topography and proximity to the coast make these assets vulnerable to rising sea levels and flooding, which pose significant risks to both property and critical services.

Cudjoe Key's transportation infrastructure, including the Overseas Highway (U.S. Route 1), local access roads, and the Florida Keys Overseas Heritage Trail, plays an essential role in daily connectivity and emergency evacuations. Flooding or damage to these transportation routes could disrupt access for residents, tourists, and emergency responders.

The key's residential areas, including mobile home parks and neighborhoods, are also vulnerable. Homes, particularly those located within low-lying zones, face risks of property damage from flooding, while displacement could become a major issue in the long term if proactive measures are not taken.

Additionally, Cudjoe Key is home to valuable natural resources, including coastal ecosystems and conservation lands. These natural features act as buffers against storm surges and erosion but are increasingly threatened by rising water levels. Their

degradation would not only harm the environment but also diminish the island's natural flood defenses.

For additional details regarding the specific assets and project prioritizations within this hotspot, please refer to Appendix G, which contains further asset vulnerability assessments and proposed projects.

Recommendations

1. Resilience Improvements for FKAA Lift Stations and Electrical Substation

- FKAA should retrofit and elevate lift stations and electrical substations to protect them from flooding and saltwater intrusion.
- Recommendation:
 - Elevate the FKAA lift stations and substation above projected flood levels to ensure continued operation during extreme weather events.
 - Retrofit critical infrastructure with floodproof materials and protective enclosures to prevent damage from saltwater corrosion.
 - Install backup power systems to maintain operational capacity during power outages caused by storm events.

2. Floodproofing and Elevation of Cudjoe Key Fire Station #11

- Protect and elevate Fire Station #11 to maintain emergency response capacity during flooding or storm surge events.
- Recommendation:
 - Elevate the fire station building and surrounding access roads to ensure the facility remains accessible and operational during flood conditions.
 - Install flood barriers around the fire station to protect critical emergency vehicles and equipment.
 - Ensure that backup power and communication systems are available to maintain emergency response functions during power outages.

3. Road Elevation and Drainage Enhancements for the Overseas Highway and Local Roads

- FDOT should elevate sections of the Overseas Highway and key local roads to maintain access and improve flood resilience.
- Recommendation:
 - Raise sections of the Overseas Highway and critical local roads prone to flooding, ensuring that evacuation routes and daily transportation remain functional.
 - Install upgraded drainage systems, including permeable pavements, culverts, and stormwater retention areas, to reduce the risk of road closures during heavy rain and storm events.
 - Implement storm barriers along vulnerable road sections to protect against storm surge and rising sea levels.

4. Residential Property Floodproofing and Elevation

- Floodproof and elevate homes in vulnerable residential areas, particularly mobile home parks and neighborhoods located in low-lying areas.
- Recommendation:
 - Encourage homeowners to elevate homes and install floodproofing measures to protect against property damage from rising waters and storm surge.
 - Promote voluntary buyouts in high-risk areas, particularly within mobile home parks, to allow for managed retreat if necessary.
 - Retrofit existing homes with water-resistant building materials, flood barriers, and backflow preventers to reduce the risk of flooding and minimize damage.

5. Restoration of Coastal Ecosystems and Conservation Areas

- Restore and protect coastal ecosystems and conservation lands to maintain their natural flood defenses.
- Recommendation:
 - Restore degraded mangrove forests and coastal wetlands to enhance their ability to absorb storm surges and reduce erosion.
 - Implement living shorelines to protect against rising sea levels and stabilize vulnerable coastal areas.

- Preserve and expand conservation zones to ensure natural buffers remain intact and continue to provide essential ecosystem services.

6. Real-Time Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems and early warning sensors throughout Cudjoe Key.
- Recommendation:
 - Deploy sensor networks across the key, focusing on vulnerable assets like lift stations, the fire station, and residential areas, to monitor flood levels and provide real-time data to residents and emergency responders.
 - Integrate the monitoring system with the county's emergency management system to trigger automated alerts and improve preparedness for upcoming storm events.
 - Ensure that the community is well-informed about evacuation routes and flood risks through early warning systems and regular updates.

Long-Term Adaptation Strategies

To safeguard the long-term resilience of Cudjoe Key, it is critical to develop a phased adaptation plan that addresses future sea-level rise projections and climate change impacts:

- **Continuous Monitoring:** Implement a monitoring system to track changes in flood risks and assess the effectiveness of the installed infrastructure over time.
- **Flexibility in Infrastructure:** Ensure that road elevation and utility upgrades are designed with flexibility in mind, allowing for future modifications as sea-level rise projections evolve.
- **Community Engagement:** Involve residents and local businesses in planning and adaptation efforts by providing education on floodproofing, insurance options, and resilience measures. This will help ensure that adaptation efforts reflect the needs and priorities of the community.

By implementing these targeted projects and long-term strategies, Cudjoe Key can strengthen its resilience to rising sea levels and protect both its critical infrastructure and natural resources from the impacts of climate change. For further details on asset prioritization and specific project recommendations, refer to Appendix G.

Hot Spot 10: Long Key

Figure 72 - Prioritized Assets in Hot Spot 10



Long Key is a vulnerable area within Monroe County that faces near-term impacts from increased rainfall projected for 2040. Its low-lying topography and proximity to the coast heighten the risks of flooding and associated challenges. Critical infrastructure in this hot spot includes wastewater treatment facilities, multiple Florida Keys Aqueduct Authority (FKAA) lift stations, and vital transportation links such as the Overseas Highway (U.S. Route 1). The key also features community assets like the Long Key Transfer Station and microwave service towers, which are essential for communication. It should be noted that the County has received grant funds to develop a living shoreline along the shoreline of the Transfer Station.

Natural resources in this area, such as Long Key State Park, coastal wetlands, and Long Key Lake, also face risks due to increased precipitation and potential flooding. These natural assets serve as vital recreational and ecological resources, but they are vulnerable to degradation, which could have cascading effects on both the environment and local infrastructure.

For more detailed asset information and prioritizations within this hot spot, please refer to Appendix G.

Recommendations

1. Resilience Improvements for Wastewater Treatment and FKAA Lift

Stations

- FCAA should retrofit and floodproof the Layton Wastewater Treatment Plant (WWTP) and associated FCAA lift stations to ensure continuous service during heavy rainfall and flood events.
- Recommendation:
 - Elevate critical components of the wastewater treatment plant and lift stations to protect them from floodwaters.
 - Install flood barriers and protective enclosures around key infrastructure to prevent saltwater intrusion and damage from storm events.
 - Equip these facilities with backup power systems to maintain operational capacity during power outages caused by extreme weather.

2. Drainage and Flood Protection for Transportation Infrastructure

- FDOT should enhance the flood resilience of the Overseas Highway and local access roads to ensure continuous connectivity during heavy rainfall and flood events.
- Recommendation:
 - Elevate sections of the Overseas Highway and critical local roads prone to flooding, ensuring that evacuation routes and daily transportation remain functional.
 - Upgrade drainage systems along these roads, incorporating permeable pavement, culverts, and stormwater retention areas to handle increased surface water from heavy rainfall.
 - Implement storm barriers along vulnerable road sections to protect against both rainfall-induced flooding and potential storm surges.

3. Floodproofing of Long Key Transfer Station and Communication Infrastructure

- Protect and elevate the Long Key Transfer Station and nearby microwave service towers to maintain essential waste management and communication functions.
- Recommendation:
 - Floodproof the Long Key Transfer Station by elevating key facilities

and installing flood barriers to ensure waste management services continue during extreme weather events.

- Retrofit the microwave service towers with flood-resistant enclosures and elevated platforms to protect against flooding, ensuring uninterrupted communications during storm events.

4. Protection and Restoration of Natural Resources and Recreational Areas

- Restore and enhance Long Key State Park, coastal wetlands, and Long Key Lake to maintain natural flood defenses and ecological integrity.

- Recommendation:

Implement wetland restoration projects to enhance the natural flood-absorbing capacity of coastal ecosystems, reducing the impact of flooding on nearby infrastructure.

Restore and protect mangrove forests along the coastline to act as natural barriers against storm surge and wave action.

- Enhance Long Key State Park by incorporating nature-based solutions such as living shorelines, which can stabilize coastal areas and mitigate erosion.

5. Real-Time Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems and early warning sensors throughout Long Key to provide advanced notice of flooding risks.

- Recommendation:

Deploy flood sensors near vulnerable assets, such as wastewater treatment plants, lift stations, and transportation infrastructure, to provide real-time data on water levels and potential flood risks.

Integrate flood monitoring systems with Monroe County's emergency management platform to ensure timely alerts and enable coordinated responses to flood events.

- Ensure that residents and stakeholders are informed of real-time flood risks through automated early warning systems and community education.

6. Living Shoreline at Long Key Transfer Station

- Continue implementation of the living shoreline project at the Long Key Transfer Station.

- Recommendation:
 - Design and construct a living shoreline to protect the Transfer Station from flooding and erosion.
 - Incorporate native vegetation and natural materials to enhance ecosystem services and improve resilience.
 - Monitor the effectiveness of the living shoreline and adapt the design as needed based on performance and changing conditions.

Long-Term Resilience Strategies

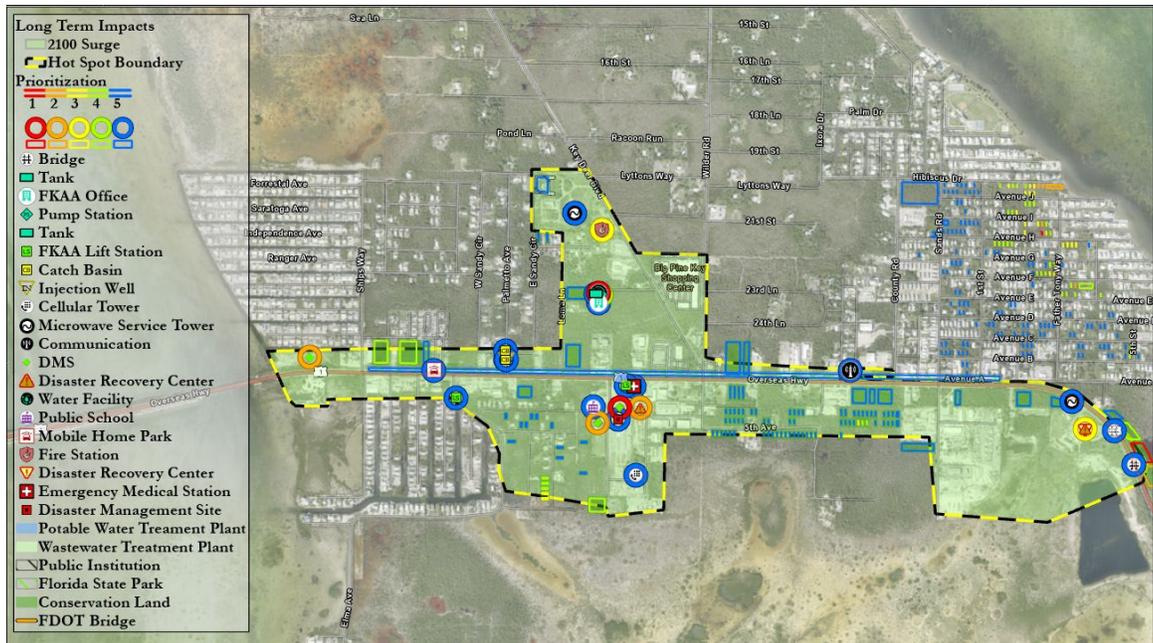
To address the ongoing challenges of rising rainfall and flood risks, Long Key requires phased adaptation strategies:

- **Continuous Monitoring:** Establish a long-term monitoring plan to track the effectiveness of flood protection measures and adapt infrastructure as conditions change.
- **Flexible Infrastructure Design:** Ensure that transportation, utility, and community infrastructure improvements are designed to accommodate future adjustments based on updated flood projections.
- **Community Engagement:** Engage local stakeholders, businesses, and residents in flood resilience planning through education and workshops focused on floodproofing techniques and adaptation strategies.

By implementing these recommended resilience measures, Long Key can better protect its critical infrastructure, natural resources, and community assets from the near-term impacts of increased rainfall and flooding. For further details on asset prioritization and specific project recommendations, please refer to Appendix G.

Hot Spot 11: Big Pine Overseas Highway Area

Figure 73 - Prioritized Assets in Hot Spot 11



Big Pine Key is a critical area at risk from long-term impacts of storm surge. This hotspot contains essential infrastructure that supports daily life, emergency response, and regional connectivity. Assets at risk include water and wastewater treatment facilities, such as the Big Pine Pump Station and Florida Keys Aqueduct Authority (FKAA) facilities, and critical communications infrastructure like cellular towers and microwave service towers.

Additionally, the area is home to vital community services and emergency facilities, including the Big Pine Key Volunteer Fire Department, ambulance services, a Disaster Recovery Center, and educational institutions like Big Pine Academy. The hotspot also includes transportation infrastructure such as Overseas Highway (U.S. Route 1) owned by FDOT, which is essential for local and regional traffic, Key Deer Boulevard, and Watson Boulevard.

Privately-owned residential areas and commercial centers, such as the Big Pine Shopping Center, Big Pine Flea Market, and mobile home parks, are also vulnerable. Natural and recreational resources, including conservation lands and Big Pine Community Park, face risks from rising sea levels and storm surge. Additionally, utility infrastructure, such as the Big Pine Wastewater Maintenance Shop and Ships Way Debris Site, are threatened by flooding and inundation due to the area's low-lying topography and coastal proximity.

For more detailed asset information and prioritization within this hotspot, please refer to Appendix G.

Recommendations

1. Elevation and Floodproofing of Water and Wastewater Treatment Facilities

- FCAA should retrofit and elevate critical wastewater facilities, including the Big Pine Pump Station and FCAA Lift Stations, to maintain water treatment operations during storm surges and flooding.
- Recommendation:
 - Elevate essential components of the pump stations and lift stations above projected flood levels to prevent stormwater intrusion.
 - Install flood barriers and protective enclosures around facilities to mitigate risks from saltwater intrusion and heavy rainfall.
 - Ensure facilities are equipped with backup power systems and emergency generators to maintain service continuity during extreme weather events.

2. Resilience Improvements for Communication and Emergency Infrastructure

- Protect and reinforce the cellular towers, microwave service towers, and emergency response facilities, including the Big Pine Key Volunteer Fire Department and Disaster Recovery Center, to ensure continuous operation during flood events.
- Recommendation:
 - Elevate and floodproof communication towers and critical equipment to prevent service disruptions during storms.
 - Reinforce fire stations, ambulance facilities, and emergency centers to ensure they can withstand the impacts of storm surge and flooding.
 - Install monitoring systems to assess real-time flood conditions, allowing emergency personnel to respond quickly during events.

3. Drainage and Flood Protection for Transportation Infrastructure

- FDOT should enhance the flood resilience of Overseas Highway, Key Deer Boulevard, and other critical access roads to ensure continuous

transportation and evacuation capabilities during flood events.

- Recommendation:

Elevate vulnerable road sections to ensure that they remain functional during storm surges and extreme rainfall events.

Implement improved stormwater management systems, including permeable pavement, culverts, and swales, to handle surface water runoff and reduce road flooding.

- Install flood barriers and storm gates along critical roadways to protect against storm surge.

4. Floodproofing Residential and Commercial Areas

- Private property owners should improve the flood resilience of residential neighborhoods, mobile home parks, and commercial centers such as the Big Pine Shopping Center to reduce property damage and displacement.

- Recommendation:

Encourage floodproofing for homes and commercial properties by installing elevated foundations, flood-resistant materials, and backflow prevention systems.

Implement voluntary buyout programs for properties in the highest-risk areas to allow for managed retreat in zones that will become increasingly difficult to protect from rising sea levels.

- Retrofit mobile home parks with raised infrastructure and reinforced flood barriers to reduce risks for low-income residents.

5. Natural Resource Protection and Restoration

- Restore and enhance coastal wetlands, conservation lands, and natural resources, including the Big Pine Community Park, to improve the island's natural flood defenses.

- Recommendation:

Implement wetland restoration projects to absorb floodwaters and provide natural buffers against storm surge and rising seas.

Restore mangrove forests and other coastal habitats to stabilize shorelines and protect infrastructure from wave action and erosion.

- Enhance recreational spaces like the Big Pine Community Park by incorporating nature-based solutions to reduce flood risks while preserving the park's ecological and recreational functions.

6. Real-Time Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems and early warning sensors across Big Pine Key to provide advanced notice of flooding risks and improve emergency response efforts.
- Recommendation:
 - Deploy flood sensors near critical infrastructure such as water treatment plants, communication towers, and transportation routes to provide real-time data on rising water levels.
 - Integrate monitoring systems with Monroe County's emergency management platform to ensure timely alerts and enable coordinated responses.
 - Implement early warning systems to notify residents, businesses, and emergency services of impending flood risks.

Long-Term Resilience Strategies

To address the ongoing risks from rising sea levels and future storm surges, Big Pine Key requires a comprehensive, phased adaptation approach:

- **Routine Monitoring:** Establish long-term monitoring programs to assess the performance of installed flood protection measures and infrastructure resilience.
- **Flexible Infrastructure Design:** Ensure that new projects are designed with the flexibility to accommodate future modifications as sea-level rise projections and environmental conditions evolve.
- **Community Engagement and Education:** Engage residents, businesses, and stakeholders in resilience planning efforts, providing education on floodproofing techniques, emergency preparedness, and long-term adaptation strategies.

By implementing these recommendations, Big Pine Key can better withstand storm surge, sea-level rise, and flooding, ensuring the long-term protection of its critical infrastructure, community assets, and natural resources. For more detailed information on specific assets and project prioritizations, please refer to Appendix G.

Hot Spot 12: Flagler Avenue in Key West

Figure 74 - Prioritized Assets in Hot Spot 12



Flagler Avenue in Key West is a critical transportation corridor that faces near-term risks from storm surge as projected for 2040 and long-term sea-level rise by 2100. Spanning approximately one mile from White Street to Palm Avenue, this vital thoroughfare serves as a connector for local businesses, shops, residential areas, and essential services like ambulances, fire services, and police. Given its low elevation and its importance for daily operations and emergency response, Flagler Avenue's exposure to flooding and storm surges poses significant risks to the functionality of the community.

In addition to its transportation function, critical infrastructure running beneath and alongside Flagler Avenue, such as electrical lines, water supply, sewage systems, and communications infrastructure, is also vulnerable to flood damage and inundation. Ensuring that these assets remain operational during extreme weather events is key to maintaining service continuity and protecting public safety.

For detailed asset information and prioritization within this hotspot, please refer to Appendix G.

Recommendations

1. Elevation and Floodproofing of Flagler Avenue

- The County is in the process of elevating and retrofitting Flagler Avenue to ensure continuous access during extreme weather events, particularly for emergency services and public transportation.
- Recommendation:
 - Elevate road sections in areas prone to flooding to reduce the risk of submersion during storm surges and high tides. This will protect Flagler Avenue from becoming impassable, maintaining connectivity for emergency response vehicles and daily traffic.
 - Install flood barriers or storm gates along vulnerable sections of the avenue to mitigate the impact of storm surges.

2. Upgrading Stormwater Management Systems

- Improve stormwater drainage systems along Flagler Avenue to handle heavy rainfall and mitigate surface water accumulation.
- Recommendation:
 - Expand drainage capacity by installing larger culverts, permeable pavements, and swales to direct excess water away from the road surface and into safe retention areas.
 - Install pumps where necessary to actively remove water from low-lying sections of the avenue during heavy rainfall events.

3. Floodproofing Utility and Communication Lines

- Protect critical infrastructure, such as electrical lines, water pipes, sewage systems, and communication cables, that run along and beneath Flagler Avenue from flood damage and saltwater intrusion.
- Recommendation:
 - Elevate utility infrastructure, such as electrical transformers and communication junction boxes, above projected flood levels.
 - Waterproof underground infrastructure, including water and sewage pipes, to prevent saltwater corrosion and intrusion during storm events.
 - Ensure backup power systems are in place for critical utilities along Flagler Avenue, ensuring service continuity even during

extended flood events or power outages.

4. Enhancing Resilience for Adjacent Properties

- Private property owners should consider floodproofing and adaptation measures for local businesses, shops, and residences located along Flagler Avenue to protect property and prevent displacement.
- Recommendation:
 - Provide incentives for property owners to install flood barriers, elevate structures, and adopt flood-resistant building materials.
 - Encourage businesses and homeowners to participate in floodproofing programs, such as installing backflow preventers and reinforcing doors and windows against water intrusion.
 - Implement voluntary buyout programs for properties in the most flood-prone areas along Flagler Avenue to facilitate future managed retreat if necessary.

5. Emergency Preparedness and Response Systems

- Strengthen the emergency response capabilities along Flagler Avenue to ensure that residents and businesses remain protected during extreme weather events.
- Recommendation:
 - Deploy real-time flood monitoring systems to provide up-to-date data on water levels and storm surge risks, allowing emergency responders to anticipate and address flood impacts.
 - Upgrade traffic management systems to ensure continuous access for emergency vehicles during storm surges and flooding events.
 - Install early warning systems that alert residents and businesses along Flagler Avenue of impending storm surges or flood events, allowing them to prepare and evacuate if necessary.

Long-Term Adaptation Strategies

To address the long-term risks from rising sea levels and future storm surges, Flagler Avenue will need a comprehensive, phased adaptation approach:

- **Regular Monitoring:** Establish a long-term monitoring system to assess the

effectiveness of flood protection measures and make adjustments based on changing climate conditions.

- **Flexible Design:** Ensure that road elevation and stormwater management projects are designed with the flexibility to accommodate further modifications as sea-level rise projections evolve.
- **Community Engagement:** Engage local businesses, residents, and stakeholders in resilience planning efforts, providing education on floodproofing, emergency preparedness, and long-term adaptation strategies.

By implementing these targeted recommendations, Flagler Avenue can be more resilient to storm surges and near-term flooding risks, ensuring the long-term functionality of this critical corridor. For further details on prioritized assets and vulnerabilities, please refer to Appendix G.

Hot Spot 13: Duck Key

Figure 75 - Prioritized Assets in Hot Spot 13



Duck Key is highly vulnerable to mid-term impacts from storm surge and sea-level rise, projected for 2070. Its low-lying topography and coastal proximity place critical infrastructure, residential areas, and natural resources at significant risk. The key includes essential water infrastructure, such as the Duck Key Wastewater Treatment Plant, Reclaim Production Well, multiple Reclaim Pump Stations, and Florida Keys Aqueduct Authority (FKAA) Lift Stations. In addition, the area contains important

marine facilities, resorts, and residential neighborhoods, all of which are exposed to flooding hazards.

Key transportation infrastructure like FDOT's Overseas Highway (U.S. Route 1), associated bridges, local roads, and the Florida Keys Overseas Heritage Trail face significant vulnerability from storm surge, which could disrupt connectivity and access to essential services. Natural resources, including coastal ecosystems and nearshore marine habitats, are also under threat from environmental changes, emphasizing the need for comprehensive adaptation strategies.

For further details regarding specific assets and project prioritization in this hotspot, please refer to Appendix G.

Recommendations

1. Elevation and Floodproofing of Wastewater Infrastructure

- Elevate and floodproof critical FKAA wastewater facilities to protect against storm surge and flooding, ensuring continued operation and preventing contamination.

- Recommendation:

FKAA should consider elevating the Duck Key Wastewater Treatment Plant and associated Reclaim Pump Stations to account for projected 2070 storm surge levels, reducing the risk of submersion.

Floodproof the treatment plant and lift stations by installing barriers, using flood-resistant materials, and ensuring backup power systems are available to maintain operations during extreme weather events.

- Enhance drainage systems around these facilities to quickly remove stormwater and prevent pooling around critical infrastructure.

2. Protection of Residential and Resort Areas

- Private property owners should implement flood resilience measures in residential areas and resort accommodations to safeguard property and ensure continued functionality during and after storm events.

- Recommendation:

Floodproof residential homes and resort facilities, particularly those located in low-lying areas along Harbour Drive, Bimini Drive, and near Hawks Cay Resort. Encourage the use of flood

barriers, elevated foundations, and water-resistant building materials.

Promote voluntary buyouts or relocation programs for properties at highest risk of repetitive flooding, facilitating long-term managed retreat if necessary.

- Encourage resort facilities to install temporary flood barriers and upgrade their drainage systems to mitigate flood impacts during storm surge events.

3. Reinforcement and Elevation of Transportation Infrastructure

- Protect critical transportation routes, including the FDOT's Overseas Highway, local roads, and bridges, from storm surge and sea-level rise to maintain access and connectivity during extreme weather.

- Recommendation:

Elevate low-lying sections of the Overseas Highway and local roads to ensure they remain above flood levels, preventing them from becoming impassable during storms.

Reinforce the bridge that connects Duck Key to the Overseas Highway, ensuring it can withstand future storm surges and coastal erosion.

- Improve drainage systems along roadways and install culverts or flood gates to manage stormwater and prevent road closures due to flooding.

4. Restoration of Coastal Ecosystems

- Enhance the resilience of coastal ecosystems and nearshore marine habitats through restoration efforts, using nature-based solutions to protect both built and natural assets.

- Recommendation:

Restore mangrove forests and coastal wetlands around Duck Key to create natural barriers that absorb storm surge and reduce wave energy, helping to protect residential areas and infrastructure.

- Implement living shorelines and other shoreline resiliency projects along the most vulnerable sections of the coast to stabilize erosion-prone areas, reduce flooding, and provide long-term protection for nearby properties.

5. Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems and early warning sensors to enhance community preparedness and ensure timely evacuation in the event of a flood.
- Recommendation:
 - Deploy sensor networks throughout Duck Key to monitor water levels and storm surge in real-time, providing critical data for emergency responders and residents.
 - Integrate flood monitoring systems with emergency management systems to trigger early warnings and ensure rapid response during extreme weather events.
 - Implement adaptive traffic management systems that redirect vehicles away from flood-prone areas and maintain safe evacuation routes.

6. Breakwater Restoration Project

- Implement a breakwater restoration project to enhance coastal protection for Duck Key.
- Recommendation:
 - Restore and reinforce existing breakwaters to reduce wave energy and mitigate storm surge impacts.
 - Incorporate nature-based solutions where possible to enhance ecological benefits.
 - Monitor the effectiveness of the restored breakwaters and adjust the design if necessary.

Long-Term Adaptation Strategies

To address future risks from rising sea levels and storm surge, a phased adaptation approach is essential for Duck Key:

- **Monitoring and Evaluation:** Regularly assess the effectiveness of flood protection measures and infrastructure resilience, making necessary adjustments as climate conditions evolve.
- **Community Engagement:** Involve residents, businesses, and stakeholders in flood resilience efforts, providing education on floodproofing techniques and preparing for future climate impacts.
- **Flexible Infrastructure Design:** Ensure that infrastructure projects, including

road elevation and wastewater system improvements, are adaptable to accommodate further modifications as sea-level rise projections increase over time.

By implementing these resilience measures, Duck Key can enhance its ability to withstand mid-term storm surge risks, ensuring the continued safety, functionality, and environmental integrity of this important area. For additional details on asset vulnerabilities and specific recommendations, refer to Appendix G.

Hot Spot 14: The Avenues, Big Pine Key

Figure 76 - Prioritized Assets in Hot Spot 14



The Avenues area of Big Pine Key is expected to face significant near-term impacts from sea-level rise projected for 2040. This area includes numerous residential avenues, consisting of mobile home parks, trailer communities, and private homes along Avenues A through H. These communities are especially vulnerable due to the high concentration of mobile homes and trailers, which are more susceptible to flooding and storm surge impacts.

The region is home to essential critical infrastructure, including Florida Keys Aqueduct Authority (FKAA) lift stations and an electrical substation, all of which are at high risk of being compromised by flooding. In addition, recreational facilities, including parts of the Seahorse Campground and the Florida Keys Overseas Heritage Trail, are also present and face potential damage from rising water levels. Critical transportation infrastructure, such as FDOT’s Overseas Highway (U.S. Route 1) and

the local network of streets connecting Avenues A through H, serves as a vital corridor for daily activities and emergency response and must be protected.

For further details regarding specific assets within this hotspot and other prioritized locations, refer to Appendix G, which contains additional information about assets, vulnerability ratings, and project prioritizations.

Recommendations

1. Floodproofing and Elevation for Mobile Homes and Trailer Communities

- Private property owners should implement floodproofing and elevation measures for mobile homes and trailers located in vulnerable areas along Avenues A through H to protect against near-term flood risks.
- Recommendation:
 - Encourage homeowners to install elevated foundations or stilts for homes in the highest-risk areas.
 - Implement flood barriers, elevated utilities, and water-resistant materials in mobile home parks to reduce damage from floodwaters.
 - Offer voluntary relocation programs for homeowners in the most flood-prone locations to move to safer areas within or outside of Big Pine Key.

2. Resilience Improvements for FCAA Lift Stations and Electrical Substation

- Enhance the resilience of the Florida Keys Aqueduct Authority (FCAA) lift stations and the area's electrical substation to prevent service disruptions and infrastructure damage.
- Recommendation:
 - Elevate lift stations (e.g., BPKS-LS35, BPKS-LS6, BPKS-LS7, BPKS-LS8, BPKS-LS9, and BPKS-LS10) to keep them above projected flood levels, ensuring they remain operational during storm events.
 - Floodproof the electrical substation by elevating key components and installing protective barriers to mitigate flood damage and prevent widespread power outages.
 - Install backup power systems such as generators or solar-powered systems for critical facilities, ensuring continuity of service in the event of a power outage.

3. Roadway Elevation and Drainage Enhancements

- Elevate and improve the drainage systems along Avenues A through H and surrounding roadways to prevent road closures during flood events and ensure continued access for residents and emergency services. It should be noted that the County is implementing a road elevation project using awarded grant funds in the Avenues.
- Recommendation:
 - Elevate low-lying sections of the streets and road network to prevent inundation during heavy rainfall and storm surge events.
 - Install improved drainage systems, such as permeable pavements, swales, and culverts, to manage stormwater runoff and prevent standing water along roadways.
 - Implement flood barriers at key road intersections prone to flooding to protect critical access routes.

4. Enhancement of Recreational and Natural Areas

- Implement measures to protect recreational areas, including the Seahorse Campground and the Florida Keys Overseas Heritage Trail, and restore natural ecosystems that serve as flood buffers.
- Recommendation:
 - Elevate and floodproof key sections of the Florida Keys Overseas Heritage Trail to ensure the trail remains accessible for recreation and as a transportation alternative during extreme weather events.
 - Restore coastal ecosystems, including mangroves and wetlands, to enhance natural flood defense systems. These ecosystems act as natural barriers that reduce storm surge and flooding impacts.
 - Ensure conservation lands adjacent to the Avenues area are protected, maintaining their ecological function as floodwater buffers and wildlife habitats.

5. Community Preparedness and Flood Monitoring Systems

- Strengthen community preparedness and install real-time flood monitoring systems to ensure timely response and early warnings during flood events.

- Recommendation:
 - Deploy sensor networks in the Avenues area to monitor water levels and provide real-time alerts to residents and emergency services during storm surge or heavy rainfall.
 - Implement a community engagement program that educates residents on floodproofing techniques, evacuation plans, and emergency preparedness.
 - Integrate the monitoring system with Monroe County's emergency response systems to improve coordination and ensure rapid deployment of resources during floods.

Long-Term Adaptation Strategies

In addition to near-term interventions, long-term resilience planning for the Avenues area must consider the evolving risks of sea-level rise beyond 2040. Key strategies include:

- **Continuous Monitoring and Maintenance:** Establish a program for regular inspections and updates to flood defenses, lift stations, and road infrastructure to ensure they continue functioning as conditions change.
- **Flexible Infrastructure Design:** Incorporate flexible design elements in new infrastructure projects, allowing for future elevation or relocation as sea levels rise.
- **Community Involvement:** Engage residents and local stakeholders in planning discussions to align infrastructure improvements with community needs and priorities.

By implementing these recommendations, the Avenues area of Big Pine Key will be better equipped to withstand the near-term risks of sea-level rise and storm surge while enhancing the community's long-term resilience. For additional details on asset vulnerabilities and project prioritization, refer to Appendix G.

Hot Spot 15: Conch Key

Figure 77 - Prioritized Assets in Hot Spot 15



Conch Key, a small island in the Florida Keys, is currently facing significant impacts from present-day rainfall. The island's low-lying topography and close proximity to the coast make it particularly vulnerable to flooding, which is further exacerbated by the limited drainage systems in place. This flooding poses challenges to both daily life and the long-term sustainability of the island.

The key contains critical infrastructure at high risk, including the Florida Keys Aqueduct Authority (FKAA) Lift Stations, the Conch Key Volunteer Fire Department Station 17, several microwave service towers, and the Florida Keys Electric Cooperative (FKEC) Recloser. These assets are vital to the island's functionality but are highly susceptible to damage from flooding. Transportation infrastructure, including the Overseas Highway (FDOT's U.S. Route 1), the Conch Key Boat Ramp, and the local road network, also faces significant flood risks, which could lead to isolation during extreme weather events.

Residential areas, including the Conch Trailer Park, Coral Key Village, and homes along Seaview Avenue, are at risk of property damage and flooding that could affect the safety and well-being of the residents. Marine facilities like the Bay View Inn and Marina and Coral Key Fisheries are also vulnerable, threatening local economic activities tied to marine operations. Additionally, the natural resources on Conch

Key, including coastal ecosystems and marine habitats, face potential degradation from flooding and environmental changes.

For further details regarding specific assets within this hot spot and other prioritized locations, please refer to Appendix G, which contains additional asset information, vulnerability ratings, and project prioritizations.

Recommendations

1. Enhanced Drainage Systems and Trench Drain Improvements

- Improve existing drainage infrastructure, including trench drains, to handle heavy rainfall and reduce standing water, which causes frequent flooding in residential and commercial areas.
- Recommendation:
 - Upgrade the existing trench drain system and install additional drainage basins where needed to quickly remove surface water during rain events.
 - Incorporate permeable pavements in residential streets and driveways to allow rainwater to be absorbed more efficiently.
 - Integrate pump stations to actively manage water levels during peak rain periods, ensuring the trench drain system is not overwhelmed.

2. Floodproofing of Critical Infrastructure

- Protect critical assets, including the FCAA Lift Stations and Conch Key Fire Department Station, from flooding by implementing floodproofing measures to ensure uninterrupted services during heavy rainfall events.
- Recommendation:
 - Elevate and floodproof the FCAA Lift Stations and other key infrastructure, using waterproof materials and elevating critical components above flood levels.
 - Install back-up power systems such as solar or generator-powered systems to maintain functionality during power outages caused by flooding.
 - Reinforce the Conch Key Fire Station with flood barriers to ensure the continued operation of emergency services.

3. Road Elevation and Improved Access to U.S. Route 1

- Elevate low-lying local roads and improve connections to U.S. Route 1 to ensure continued transportation access during flood events. It should be noted that the County is implementing a road elevation project currently in Conch Key with awarded grant funds.
- Recommendation:
 - Elevate sections of Conch Key's local road network, particularly the roads most susceptible to flooding, to prevent road closures during storms or heavy rainfall.
 - Enhance road connections to U.S. Route 1 by raising access points and incorporating additional drainage systems along these key corridors.
 - Install flood barriers at vulnerable points along the Overseas Highway to maintain access during extreme weather events.

4. Floodproofing of Residential and Commercial Areas

- Private property owners should implement floodproofing measures for residential communities and marine facilities to protect properties from flood damage and maintain community safety.
- Recommendation:
 - Encourage homeowners to adopt elevated foundations, install water-resistant materials, and add flood barriers around homes and businesses, particularly in areas like the Conch Trailer Park and Coral Key Village.
 - Promote the use of floodproofing technologies such as backflow prevention systems in residential areas to minimize damage to properties and infrastructure.
 - Offer incentives for voluntary buyouts for residents in the highest-risk areas, encouraging relocation to safer zones on the island or nearby areas.

5. Marine Infrastructure Resilience

- Private property owners should strengthen and protect marine infrastructure, including boat ramps, marinas, and marine-dependent businesses, from the impacts of flooding and storm surge.

- Recommendation:
 - Reinforce the Conch Key Boat Ramp and surrounding marinas to ensure they remain functional and safe during flood events.
 - Install flood barriers and raise critical areas of marine businesses to protect valuable assets like Coral Key Fisheries and other marine-dependent businesses.
 - Implement breakwater systems to reduce wave energy and prevent damage to nearshore infrastructure during storm events.

6. Real-Time Flood Monitoring and Early Warning Systems

- Deploy real-time flood monitoring systems to provide early warnings during flood events, allowing for better preparation and response by residents and emergency services.
- Recommendation:
 - Install flood sensors and water-level monitoring systems around Conch Key, particularly near critical infrastructure and low-lying residential areas.
 - Integrate these monitoring systems into Monroe County's emergency management platform to provide real-time data and alerts to residents, ensuring timely evacuations and preventive measures.
 - Establish automated flood warning systems that notify residents and local authorities of rising water levels and potential risks.

Long-Term Adaptation Strategies

In addition to immediate interventions, Conch Key must plan for long-term resilience against the growing risks of sea-level rise and extreme weather. Key strategies include:

- **Ongoing Maintenance:** Ensure regular inspections of drainage systems, critical infrastructure, and transportation routes to ensure that they continue to function effectively.
- **Flexible Adaptation Plans:** Develop infrastructure with flexibility in mind, allowing for future elevation or enhancement as sea levels rise and flood risks increase.

- **Community Engagement and Preparedness:** Involve residents and business owners in resilience efforts, ensuring they are informed about floodproofing measures and emergency preparedness plans.

By implementing these recommendations, Conch Key can enhance its resilience to flooding, protect critical infrastructure, and safeguard both community safety and the local economy in the face of increasing climate challenges. For more information, please refer to Appendix G for asset-specific details and project prioritizations.

Hot Spot 16: North Key Largo

Figure 78 - Prioritized Assets in Hot Spot 16



The northern section of Key Largo is highly vulnerable to near-term sea-level rise (SLR) projected for 2040. The area includes dense residential communities, commercial zones, and critical infrastructure, all of which face significant risks from flooding, storm surges, and rising seas.

The stormwater management network—comprising drainage systems like catch basins and manholes—is vulnerable to being overwhelmed by inundation, which could impact the functionality of local and regional drainage during extreme weather. Key transportation routes, including portions of the Overseas Highway (U.S. Route 1) and adjacent local roads, play a vital role in maintaining regional connectivity, but they are also exposed to rising water levels and flooding risks. In addition, essential

community services, commercial facilities, and utility infrastructure, such as electrical substations and communication towers, are in this flood-prone zone.

The region's residential neighborhoods and commercial areas face the combined threats of property damage, flooding, and isolation during major weather events. Additionally, natural resources, including state parks, coastal ecosystems, and conservation lands, are at risk of degradation from flooding, undermining both the local environment and economic activities like tourism. These factors underscore the urgency of strengthening resilience and adaptation measures in this vulnerable section of Key Largo.

Recommendations

1. Stormwater Management and Drainage Enhancements

- Upgrade the existing stormwater management system to ensure it can manage the increased runoff and prevent frequent flooding in key residential and commercial areas.
- Recommendation:
 - Expand and upgrade drainage infrastructure, including publicly managed catch basins and manholes, to enhance capacity and mitigate flood risks in low-lying areas.
 - Install permeable pavement and rain gardens in public spaces to absorb stormwater and reduce surface runoff, relieving pressure on existing drainage systems.
 - Consider the installation of pumping stations in flood-prone areas to actively manage and redirect floodwaters during heavy rain events.

2. Road Elevation and Flood-Resilient Transportation Access

- Ensure that key transportation routes, such as FDOT's U.S. Route 1 and local roads, remain accessible during storm events by elevating vulnerable road sections.
- Recommendation:
 - Elevate sections of U.S. Route 1 and other publicly maintained roads in vulnerable areas to protect against flooding and ensure continuous access during storm surges.
 - Integrate culverts and causeways to maintain natural water flow under elevated roadways, reducing the risk of water buildup and road submersion.

- Install flood barriers or temporary closures at low-lying road sections to protect key access routes from inundation during extreme weather.

3. Floodproofing of Critical Infrastructure

- Protect key publicly managed infrastructure, such as electrical substations, pumping stations, and utility networks, from damage during flood events.
- Recommendation:
 - Floodproof publicly owned facilities by elevating critical components and installing flood barriers around essential infrastructure such as pumping stations and electrical substations.
 - Equip facilities with real-time flood monitoring systems to provide advance warnings and ensure emergency response teams can protect vulnerable infrastructure.
 - Implement backup power systems in these facilities to maintain service continuity during storm-induced power outages.

4. Residential and Commercial Floodproofing Initiatives

- Private property owners should implement targeted floodproofing measures for residential neighborhoods and commercial districts vulnerable to flooding.
- Recommendation:
 - Provide incentives for property owners to elevate homes and commercial buildings, install flood barriers, and retrofit structures with water-resistant materials to prevent water intrusion.
 - Promote community engagement programs that educate homeowners on floodproofing techniques and encourage the adoption of resilient design in new developments.
 - Explore voluntary buyout programs for properties in areas of chronic flooding, allowing for the conversion of high-risk zones into natural flood buffers or open spaces.

5. Conservation and Natural Infrastructure Restoration

- Restore and enhance natural flood barriers, such as coastal wetlands, mangroves, and other green infrastructure, to bolster flood resilience.
- Recommendation:
 - Restore and expand publicly managed mangrove forests and wetlands in conservation areas to reduce storm surge impacts and absorb excess water during flood events.
 - Implement living shorelines where feasible to stabilize vulnerable coastal zones and prevent erosion, reducing the need for hard infrastructure solutions.
 - Integrate nature-based defenses with existing infrastructure to create a multi-layered flood protection system for the community and surrounding ecosystems.

These recommendations are designed to enhance the overall resilience of North Key Largo by protecting critical infrastructure, ensuring safe and accessible transportation, and mitigating flood risks through comprehensive stormwater management and floodproofing initiatives. For more details on the prioritized assets and specific adaptation projects in this area, refer to Appendix G.

Hot Spot 17: Marathon Airport

Prioritized Assets in Hot Spot 17

Figure 79 -



The Marathon Airport area is vulnerable to near-term impacts from storm surge, projected for 2040. The area encompasses vital transportation and infrastructure components, including the Marathon Airport (with its runways, terminals, and support facilities), utility networks, and public safety services. As a central hub in the Florida Keys, the resilience of Marathon Airport and its surrounding infrastructure is crucial for regional connectivity and emergency response.

Key transportation networks like the Florida Keys Overseas Heritage Trail and local roads provide access to the airport and support the movement of people and goods. Emergency services such as the Marathon Fire Rescue Station and a Disaster Management Site are crucial assets located within the vulnerable zone. The area's utility infrastructure, including components of the Marathon Stormwater Line and electrical distribution systems, is vital for maintaining public services and ensuring community resilience.

Additionally, the Marathon area contains significant residential neighborhoods, commercial zones, tourism hubs, and natural resources like coastal ecosystems and marine habitats, all of which are susceptible to the impacts of storm surges and rising seas.

Key residential neighborhoods, commercial corridor, and hazardous waste facility immediately east of the airport exhibit topographic characteristics that increase risk for flooding. These areas abut drainage infrastructure primarily intended for exfiltration including 107th St Gulf, 109th St Gulf, and 1st Ave Gulf.

Recommendations

1. Runway Elevation and Flood Resilience at Marathon Airport

- Elevate the airport runways and enhance the flood resilience of critical airport facilities to prevent disruption during storm surges and flooding.
- Recommendation:
 - Elevate sections of the runway to withstand projected storm surge levels and ensure the airport remains operational during and after extreme weather events.
 - Install storm-resistant materials and flood barriers around key airport facilities, including terminals and control towers, to safeguard critical aviation infrastructure from water damage.
 - Enhance drainage systems along the runway, including inlets and manholes, to prevent water accumulation during heavy rainfall and flooding events.

2. Stormwater System Upgrades

- Upgrade the stormwater management system to handle the increased risk of storm surge and flooding, focusing on maintaining functionality during extreme weather. For lower lying areas, establishing hydraulic connections to the coastal outfalls through a connected stormwater network would decrease risk of localized flooding due to limited infiltration capacity of existing exfiltration systems.
- Recommendation:
 - Acquire and implement a wet detention facility off of 109th St Gulf and connect to coastal outfall through an outlet control structure, storm pipe network, and backflow prevention valve.
 - Connect existing storm water inlets along 3rd Ave Gulf to the coastal outfall to alleviate roadway inundation along 4th Ave Gulf, 3rd Ave Gulf, 2nd Ave Gulf and 107th St Gulf.
 - Propose stormwater inlet and associated pipe connection in the low point of the commercial parking lot. The pipe network shall connect to existing structures along 1st Ave Gulf and tie into the coastal canal outfall.
 - Expand drainage capacity by upgrading publicly managed stormwater wells, inlets, outfalls, and other critical components of the Marathon Stormwater Line to manage increased water volumes.
 - Implement floodproofing measures such as constructing flood walls or elevating key stormwater infrastructure in the lowest-lying areas.
 - Install smart monitoring systems to track water levels in the stormwater network and provide early warnings to public works and emergency services.

3. Public and Emergency Service Facility Protection

- Protect public and emergency service facilities, such as Marathon Fire Rescue Station 14 and the Disaster Management Site, from flooding to maintain emergency response capabilities during extreme weather events.
- Recommendation:
 - Floodproof critical public service buildings by elevating structures, installing flood barriers, and retrofitting facilities with water-

resistant materials to prevent disruption of emergency services.

Establish backup power systems and emergency response plans to ensure that these services remain operational during power outages and flooding.

- Install real-time monitoring systems to provide early warnings for the potential closure of roads or other key access points, allowing for rerouted emergency response if necessary.

4. Utility Infrastructure Resilience

- Protect and reinforce the electrical grid and utility systems, such as the FKEC Recloser, to maintain power distribution and public services during extreme weather.

- Recommendation:

Elevate electrical utility infrastructure, such as reclosers and substations, above projected flood levels to prevent water damage.

Retrofit the Marathon Stormwater Line and utility access points with floodproof materials to enhance their longevity and functionality during storm events.

- Integrate backup power systems for critical utility services, ensuring continuous operation during extended power outages.

5. Elevation and Drainage Improvements for Local Roads

- Elevate local roads and enhance drainage to ensure continuous access to the airport and surrounding neighborhoods during extreme weather events.

- Recommendation:

Elevate low-lying road sections, such as those around Aviation Boulevard and other key access routes to the airport, to prevent road closures due to flooding.

Upgrade road drainage systems by installing curb inlets, ditch bottom inlets, and culverts to manage water runoff and reduce standing water on roadways.

- Integrate permeable pavement where appropriate to reduce the amount of surface runoff and improve overall drainage efficiency.

6. Natural Resource Restoration and Coastal Protection

- Restore and reinforce coastal ecosystems and green infrastructure to enhance flood resilience and protect natural habitats in the Marathon Airport area.
- Recommendation:
 - Restore mangroves and coastal wetlands near the airport to act as natural buffers, reducing the impact of storm surges and absorbing excess water.
 - Implement living shoreline projects to stabilize eroding areas along the coast, helping to prevent further land loss and maintain natural defenses.
 - Designate vulnerable natural areas for conservation and protection, reducing human development in high-risk zones.

These recommendations aim to enhance the resilience of the Marathon Airport and surrounding infrastructure by safeguarding critical facilities, improving stormwater management, and protecting both built and natural environments. For additional details on prioritized assets and specific projects, refer to Appendix G.

Hot Spot 18: North Big Pine Key

Figure 80 - Prioritized Assets in Hot Spot 18



North Big Pine Key faces significant mid-term impacts from sea-level rise (SLR) projected for 2070. This hotspot includes key infrastructure supporting local residential areas, conservation lands, and transportation networks, all of which are vulnerable to future flooding and storm surge risks. The island's unique natural habitats, including conservation lands home to endangered species like the Key Deer, underscore the need for adaptive measures to protect both human and ecological resources from the impacts of rising seas and storm surges.

For detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Elevation and Floodproofing of Key Utility Infrastructure

- Retrofit and elevate essential utility services, including publicly maintained Florida Keys Aqueduct Authority (FKAA) lift stations, to mitigate flood risks and ensure continuous operation.
- Recommendation:
 - Elevate the FKAA lift stations and critical components to account for projected 2070 sea-level rise.
 - Floodproof facilities using barriers, waterproof materials, and backup power systems to maintain service during storm events.

2. Bridge and Road Elevation along Key Deer Boulevard

- Elevate transportation infrastructure, including bridges and roads such as Key Deer Boulevard, to maintain connectivity during flood events and support emergency response efforts.
- Recommendation:
 - Elevate key road sections and Monroe County bridges to prevent inundation and road closures.
 - Enhance drainage along elevated roadways by integrating culverts and other flood management systems.

3. Natural Resource Protection and Restoration

- Implement conservation and restoration projects to strengthen natural flood defenses and protect habitats at risk from rising sea levels and storm surge.

- Recommendation:
 - Restore mangroves and wetlands to provide natural flood barriers, stabilizing shorelines and absorbing storm surges.
 - Expand conservation lands to reduce development pressure on vulnerable ecosystems and promote biodiversity resilience.

4. Floodproofing of Residential Neighborhoods

- Encourage the floodproofing of residential areas along low-lying streets such as Eden Pines Colony, ensuring homes and infrastructure are protected from future flood risks.
- Recommendation:
 - Promote the use of elevated foundations, flood barriers, and other flood-resistant construction techniques in residential developments.
 - Consider implementing a voluntary buyout program for properties in the most flood-prone areas to allow for managed retreat.

5. Stormwater Management and Drainage Improvements

- Enhance stormwater management systems to handle increased runoff and prevent frequent flooding in low-lying residential areas.
- Recommendation:
 - Upgrade public drainage infrastructure, such as installing additional permeable surfaces, culverts, and swales to manage stormwater runoff efficiently.
 - Implement real-time monitoring systems to manage flood levels and provide data for effective stormwater management.

Long-Term Adaptation Strategies

- **Routine Monitoring:** Establish a long-term monitoring program to assess the performance of flood protection measures and adjust based on changing environmental conditions.
- **Flexible Design:** Ensure that infrastructure projects can be adapted as SLR projections evolve.
- **Community Engagement:** Involve residents in the planning and implementation of resilience strategies, offering education on floodproofing and emergency preparedness.

By following these phased recommendations, North Big Pine Key will be better equipped to withstand the impacts of mid-term sea-level rise, safeguarding both its human and ecological resources. For specific asset details and prioritization, please refer to Appendix G.

Hot Spot 19: Middle Key Largo

Figure 81 - Prioritized Assets in Hot Spot 19



Middle Key Largo is projected to face significant mid-term impacts from storm surge by 2070. The area is home to critical infrastructure, including emergency services like fire stations and ambulance services, vital utilities such as the Rock Harbor Distribution Pump Station, and essential communication systems. The region’s stormwater management infrastructure and transportation networks are particularly vulnerable due to the low-lying topography and coastal proximity.

For detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Elevation and Floodproofing of Emergency Services and Utility Infrastructure

- Retrofit and elevate emergency service facilities and utility systems, including fire stations, the ambulance service center, and key utilities, to maintain functionality during storm surges.

- Recommendation:
 - Elevate emergency service buildings and utility infrastructure above projected flood levels to ensure continued operations.
 - Floodproof the facilities by installing barriers and using waterproof materials to prevent water damage.
 - Equip these facilities with backup power systems to ensure continuous service during extreme weather events.

2. Stormwater Management and Drainage Enhancements

- Upgrade the stormwater drainage systems, including trench drains and other public stormwater infrastructure, to manage the increased flood risks from storm surges.
- Recommendation:
 - Install additional drainage systems, such as permeable pavements, to manage stormwater effectively.
 - Enhance public drainage infrastructure to prevent overflow and flooding during peak storm events.
 - Implement real-time flood monitoring systems to ensure timely response and drainage adjustments during storms.

3. Resilience Improvements for Transportation Infrastructure

- Protect essential transportation routes, such as FDOT's Overseas Highway and local roads like Ocean Bay Drive, from flooding and storm surge to ensure connectivity for emergency services and residents.
- Recommendation:
 - Elevate vulnerable sections of the Overseas Highway and local roads to keep them functional during storms and flooding.
 - Integrate culverts and storm barriers into key roadways to protect against inundation and maintain access.
 - Upgrade public transportation networks by incorporating permeable pavements and swales to manage floodwaters.

4. Floodproofing Commercial and Residential Properties

- Private property owners should implement flood resilience measures for commercial and residential properties in low-lying zones, including

condominium complexes and marine-related businesses, to reduce damage during storm surge events.

- Recommendation:

- Encourage the use of elevated foundations, flood barriers, and waterproofing materials in commercial and residential areas.

- Promote voluntary buyouts or relocation for properties in the highest-risk zones.

- Offer incentives for property owners to adopt flood-resistant designs and retrofitting.

5. Natural Resource Protection and Restoration

- Enhance natural flood defenses by restoring coastal ecosystems and recreational areas, including the Florida Keys Overseas Heritage Trail and John Pennekamp Coral Reef State Park, to mitigate storm surge impacts.

- Recommendation:

- Restore and expand mangroves and wetlands to provide natural buffers against storm surge and reduce wave energy.

- Implement living shoreline projects to protect eroding coastlines and enhance natural flood barriers.

- Protect conservation lands and recreational areas to preserve their ecological function and resilience to climate impacts.

6. Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems to provide early warnings and improve emergency response for residents and businesses in Middle Key Largo.

- Recommendation:

- Deploy flood sensors around critical infrastructure and flood-prone areas to track water levels and issue timely alerts.

- Integrate monitoring systems with emergency management platforms to improve coordination during storm events.

- Install early warning systems to notify residents and businesses of incoming flood risks.

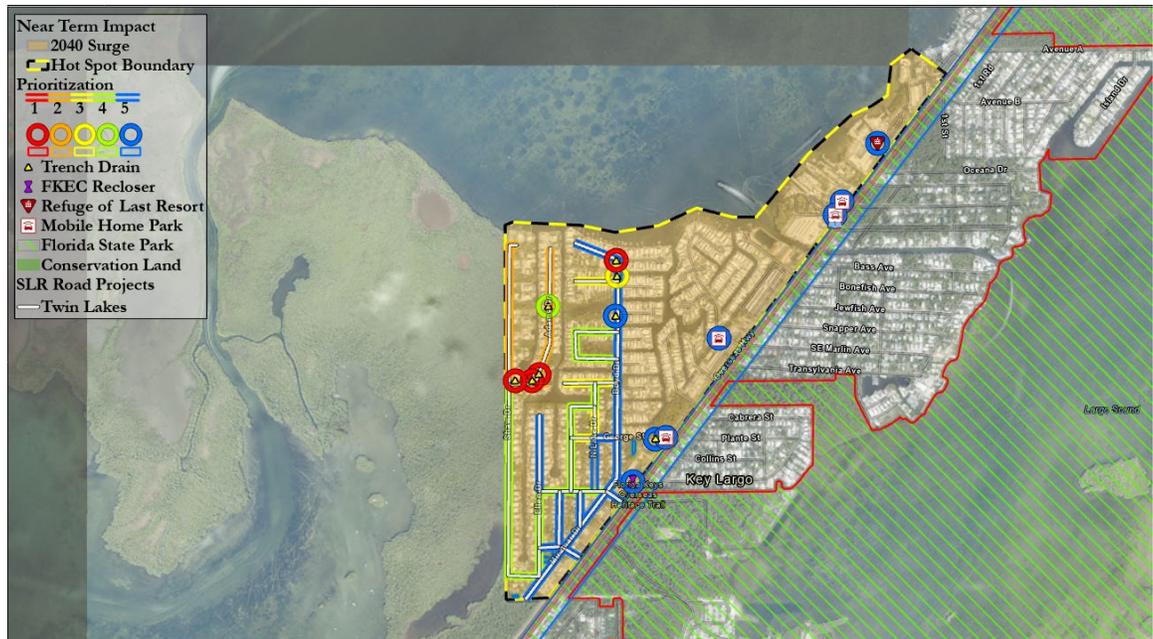
Long-Term Adaptation Strategies

- **Routine Monitoring:** Establish ongoing monitoring programs to evaluate the performance of flood protection measures and make necessary adjustments as conditions evolve.
- **Flexible Design:** Ensure infrastructure designs incorporate flexibility for future elevation or modification based on updated sea-level rise projections.
- **Community Engagement:** Work closely with residents, businesses, and stakeholders to promote resilience planning and community preparedness for future climate impacts.

By implementing these recommendations, Middle Key Largo can improve its resilience to mid-term storm surge and flood risks, safeguarding critical infrastructure, community assets, and the local environment. For further details on specific assets and project prioritization, please refer to Appendix G.

Hot Spot 20: Twin Lakes, Key Largo

Figure 82 - Prioritized Assets in Hot Spot 20



The Twin Lakes area in Key Largo is projected to experience significant near-term impacts from storm surge by 2040. This hotspot includes vulnerable residential areas, including mobile home parks, critical tourism and hospitality infrastructure, and essential transportation networks. The area's low-lying topography increases its susceptibility to flooding and storm surges, which pose risks to community well-being and local businesses.

For detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Road Elevation and Floodproofing for SLR Road Projects

- Elevate and floodproof critical roadways, such as Adams Drive, Crane Street, Ocean Drive and Caloosa Street, as part of the Twin Lakes Sea-Level Rise (SLR) Road Project to maintain connectivity during storm surge events.
- Recommendation:
 - Enhance stormwater drainage systems with permeable pavement and culverts to handle increased water flow during storm events.

- Install flood barriers at strategic locations along roadways to prevent storm surge from overtopping critical routes.

2. Floodproofing of Critical Utility Infrastructure

- Protect and reinforce publicly managed infrastructure, including the FKEC Recloser and trench drains, to prevent flood damage and ensure continuity of utility services during extreme weather events.
- Recommendation:
 - Elevate and waterproof essential utility systems, including electrical reclosers and stormwater drainage components, to reduce the risk of damage during storm surge.
 - Install backup power systems at critical facilities to maintain service continuity in the event of power outages.
 - Implement monitoring systems to track floodwater levels and respond quickly to any disruptions in utility services.

3. Enhancements for Residential and Commercial Flood Resilience

- Private property owners should implement floodproofing measures for residential communities, mobile home parks, and commercial properties, such as resorts and marinas, to reduce property damage and displacement risks.
- Recommendation:
 - Encourage floodproofing for homes and businesses by elevating structures, installing flood barriers, and retrofitting properties with water-resistant materials.
 - Promote voluntary buyout or relocation programs for the most at-risk properties in the Twin Lakes area, prioritizing vulnerable mobile home parks.
 - Provide incentives for local businesses to adopt resilient building practices, including elevating foundations and implementing flood-resistant designs.

4. Restoration and Protection of Natural Resources

- Restore and protect natural resources, such as coastal ecosystems and conservation lands near John Pennekamp Coral Reef State Park, to improve flood resilience and support environmental preservation.

- Recommendation:
 - Restore mangroves, wetlands, and other coastal habitats to act as natural flood barriers, reducing the impact of storm surge and protecting inland areas.
 - Implement living shorelines along vulnerable sections of the coastline to prevent erosion and enhance natural flood defenses.
 - Designate conservation areas for ongoing protection and restoration, reducing development in high-risk flood zones.

5. Real-Time Flood Monitoring and Early Warning Systems

- Install flood monitoring systems and early warning sensors to provide real-time data on flood risks and ensure timely response and evacuation when necessary.
- Recommendation:
 - Deploy sensor networks throughout the Twin Lakes area to monitor water levels and storm surges, enabling rapid response from emergency services.
 - Integrate monitoring systems with Monroe County's emergency management platform to issue timely warnings to residents, businesses, and emergency responders.
 - Implement early warning systems that provide alerts to vulnerable populations in the event of incoming storms or flooding.

Long-Term Adaptation Strategies

- **Routine Monitoring:** Establish long-term programs for monitoring flood defense performance, ensuring that infrastructure remains effective as sea levels rise.
- **Flexible Design:** Design infrastructure projects, such as road elevations and floodproofing, with the flexibility to accommodate future modifications based on evolving climate projections.
- **Community Engagement:** Engage residents, businesses, and stakeholders in resilience planning efforts, promoting education on floodproofing, preparedness, and long-term adaptation strategies.

By implementing these recommendations, the Twin Lakes area of Key Largo can improve its resilience to storm surge, protecting critical infrastructure, residential

communities, and natural resources. For further details on specific assets and project prioritizations, please refer to Appendix G.

Hot Spot 21: Orange Blossom/Harry Harris Park, Tavernier Key

Figure 83 - Prioritized Assets in Hot Spot 21



The Orange Blossom/Harry Harris Park area of Tavernier is currently facing significant impacts from present-day rainfall, primarily affecting low-lying residential areas, recreational facilities, and critical infrastructure. Without intervention, the risk of flooding and disruption will continue to grow, posing challenges to the local community and economy.

For detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Drainage System Upgrades for Residential and Commercial Areas

- Upgrade existing drainage systems to manage present-day rainfall and reduce the risk of flooding in low-lying residential neighborhoods and commercial zones.

- Recommendation:
 - Expand the trench drain and stormwater system capacity to ensure adequate drainage in flood-prone areas like mobile home parks and condominiums.
 - Incorporate permeable pavement and bioswales into residential areas to absorb excess water and mitigate the effects of heavy rainfall.
 - Install pumping stations in key locations to remove water from low-lying areas during peak rainfall events.

2. Floodproofing of Critical Community and Disaster Management Facilities

- Implement floodproofing measures for critical infrastructure, including the Orange Blossom Debris Management Site (DMS), which is essential for disaster recovery operations.
- Recommendation:
 - Elevate critical components of the DMS and other essential facilities to ensure continued functionality during and after flood events.
 - Install protective barriers and floodproof structures at key facilities to safeguard equipment and operational capacity.
 - Equip the DMS with backup power and drainage systems to maintain operations during extended rainfall events or power outages.

3. Road Elevation and Connectivity Improvements for Evacuation Routes

- Elevate and enhance transportation infrastructure, particularly FDOT's U.S. Route 1 and local access roads, to ensure continued connectivity and safe evacuation during flood events.
- Recommendation:
 - Elevate sections of the Overseas Highway and key local roads such as Arbor Lane and Coconut Drive to protect against road closures caused by flooding.
 - Install improved drainage systems, including culverts and permeable pavements, along roads to handle increased water flow and prevent standing water.

- Implement flood barriers or temporary closures along low-lying evacuation routes to protect against storm surge and heavy rainfall.

4. Flood Resilience for Marine and Recreational Facilities

- Private property owners should enhance the flood resilience of marine facilities, such as marinas and Harry Harris Park, to protect critical tourism infrastructure and community recreational areas.

- Recommendation:

Elevate marine infrastructure, including boat ramps and docks, to withstand present-day and future flood risks, ensuring continued access for recreational and commercial activities.

Floodproof recreational facilities like Harry Harris Park by installing barriers, improving drainage systems, and using water-resistant materials for key structures.

Install breakwaters or other protective coastal infrastructure to mitigate the effects of storm surge and coastal flooding on these facilities.

- Provide additional stormwater retention storage capacity in low lying areas including a retention area east of E Beach Rd and another adjacent to the basketball court. Stormwater retention areas shall be piped to the coastal outfall with a backflow prevention valve.

5. Protection of Natural Resources and Conservation Lands

- Restore and protect vulnerable coastal ecosystems, including adjacent conservation lands and natural habitats, to provide natural flood barriers and enhance environmental resilience.

- Recommendation:

Restore wetlands and coastal ecosystems to absorb floodwaters and reduce the impact of storm surges on inland areas.

Implement living shorelines and mangrove restoration projects to stabilize vulnerable shorelines and prevent erosion, protecting both natural resources and nearby infrastructure.

- Designate conservation lands for long-term protection and reduce human encroachment in high-risk flood zones to maintain their ecological function as flood buffers.

6. Real-Time Flood Monitoring and Early Warning Systems

- Deploy real-time flood monitoring systems and early warning sensors across the Tavernier area to provide timely alerts during flood events and improve community preparedness.
- Recommendation:
 - Install sensor networks to monitor water levels and storm surge risks, providing real-time data for emergency responders and the local community.
 - Integrate the monitoring system with Monroe County's emergency management platform to issue alerts to residents, enabling early action and evacuation if necessary.
 - Establish automated flood warning systems for low-lying residential areas and essential facilities to mitigate the impacts of sudden flood events.

7. Breakwater Restoration and Park Improvements

- Implement a breakwater/living shoreline restoration project and enhance Harry Harris Park to improve flood resilience and recreational value.
- Recommendation
 - Restore and reinforce existing breakwaters to protect the park and surrounding areas from storm surge and erosion.
 - Integrate park improvements with flood resilience measures, such as elevated structures and improved drainage systems.
 - Enhance recreational facilities while incorporating flood-resistant designs and materials.

Long-Term Adaptation Strategies

- **Routine Monitoring and Maintenance:** Establish a long-term maintenance plan for the upgraded drainage systems and floodproofed infrastructure to ensure ongoing performance and functionality.
- **Flexible Infrastructure Design:** Design all future infrastructure upgrades with the flexibility to accommodate rising sea levels and increased rainfall projections, allowing for future modifications.
- **Community Engagement and Preparedness:** Engage local residents, businesses, and stakeholders in resilience planning and preparedness, promoting floodproofing techniques and emergency evacuation plans.

By implementing these targeted recommendations, the Tavernier area can be more resilient to flooding from present-day rainfall and future storm events, ensuring the continued safety and functionality of critical infrastructure, residential areas, and natural resources. For further details on specific assets and prioritization, please refer to Appendix G.

Hot Spot 22: Ocean Reef, Key Largo

Figure 84 - Prioritized Assets in Hot Spot 22



The Ocean Reef area in Key Largo is an exclusive and vital community, which faces significant long-term impacts from sea-level rise. Critical infrastructure, emergency services, transportation, and natural resources are all at risk due to the region's coastal location and low-lying topography.

For more detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Floodproofing of Water Treatment and Utility Infrastructure

- Protect key water treatment facilities, including the Reverse Osmosis Treatment Plant and Ocean Reef Distribution Pump Station, along with utility infrastructure such as the FKEC Substation, from rising sea levels and potential storm surge.

- Recommendation:
 - Elevate essential components of the water treatment and distribution systems to prevent flood damage and maintain safe drinking water access during extreme weather.
 - Floodproof the FKEC Substation and install protective enclosures for key electrical and communications infrastructure, including cellular towers and FM transmission towers, to prevent disruptions.
 - Ensure all facilities are equipped with backup power systems to guarantee continuous service during emergencies.

2. Enhancement of Emergency Services and Security Infrastructure

- Strengthen flood resilience for emergency services such as the Ocean Reef Club Fire Station #26, the Ocean Reef Main Security Station, and other critical community safety infrastructure.
- Recommendation:
 - Elevate and retrofit emergency response facilities to prevent flood damage and ensure continuous operation during storm events or rising water levels.
 - Install flood barriers and reinforce structural components of emergency and security infrastructure to protect against sea-level rise and storm surges.
 - Deploy real-time monitoring systems to provide early flood warnings and allow emergency personnel to prepare and respond swiftly.

3. Elevation and Protection of Transportation Infrastructure

- Protect the transportation infrastructure that supports connectivity within and access to the Ocean Reef community, including the Ocean Reef Club Airport, Anchor Drive, and Card Sound Road.
- Recommendation:
 - Elevate low-lying sections of key roadways and runways to ensure continuous functionality in the face of rising sea levels and flood risks.
 - Improve stormwater management systems along roads and around the airport by installing permeable pavements and enhancing drainage to reduce floodwater accumulation.

- Implement flood gates and barriers at vulnerable points along Card Sound Road to protect this crucial access route from inundation during extreme weather events.

4. Residential and Recreational Facility Floodproofing

- Private property owners should implement floodproofing and adaptation measures for residential properties, recreational facilities like the Card Sound Golf Club, and community amenities such as the Ocean Reef Club Marina and Angelfish Cay Condominium.
- Recommendation:
 - Encourage homeowners and property managers to elevate structures, install flood barriers, and use water-resistant materials to protect against future flooding.
 - Promote the use of nature-based solutions, such as living shorelines, to stabilize coastal areas and reduce erosion risks near residential and recreational facilities.
 - Retrofit marinas and boat docks to withstand storm surges and rising sea levels, ensuring they remain operational during and after extreme weather events.

5. Adaptation of Community Facilities and Service Sites

- Protect and adapt essential community service facilities, such as The Academy at Ocean Reef, the Ocean Reef Storeroom, and the Ocean Reef Debris Site, to ensure they continue to serve the community during and after extreme weather events.
- Recommendation:
 - Floodproof critical community facilities by elevating structures, using flood-resistant materials, and installing protective barriers around key service sites.
 - Equip debris management sites with flood mitigation measures to prevent contamination or service disruption during storm events.
 - Install backup power systems for essential community services to maintain operations during power outages.

6. Restoration and Protection of Natural Resources

- Implement measures to protect and restore natural resources, including the John Pennekamp Coral Reef State Park, coastal

ecosystems, and wetlands, to mitigate the effects of sea-level rise and storm surge.

- Recommendation:

- Restore wetlands and mangrove forests to act as natural buffers, absorbing floodwaters and reducing the impact of storm surges on inland areas.

- Enhance shoreline protection using living shorelines and nature-based solutions to stabilize vulnerable areas and reduce erosion.

- Integrate conservation efforts into flood mitigation strategies to ensure the long-term sustainability of natural habitats and recreational spaces.

Long-Term Adaptation Strategies

- **Routine Monitoring and Evaluation:** Establish long-term monitoring programs to track the performance of flood protection measures and make necessary adjustments as sea levels continue to rise.
- **Flexible Infrastructure Design:** Ensure that all infrastructure projects are designed with flexibility, allowing for future adaptations or elevations as new sea-level rise projections emerge.
- **Community Engagement and Preparedness:** Engage residents and stakeholders in resilience planning efforts, providing education on floodproofing techniques, emergency preparedness, and long-term adaptation strategies.

By implementing these recommendations, Ocean Reef can enhance its resilience to the long-term impacts of sea-level rise and storm surges, ensuring the continued safety and functionality of its critical infrastructure, community facilities, and natural resources. For further details on asset prioritization and specific projects, please refer to Appendix G.

Hot Spot 23: Winston Waterways, Key Largo

Figure 85 - Prioritized Assets in Hot Spot 23



Winston Waterways in Key Largo faces significant near-term impacts from sea-level rise projected for 2040. This low-lying area includes essential transportation infrastructure, residential communities, and recreational areas, all highly vulnerable to flooding due to its coastal proximity and topography. The densely populated Winston Waterways residential neighborhood, including key streets such as Calleja Road, Palm Drive, Lime Drive, and Mahogany Drive, is at risk of being inundated by rising sea levels and storm surges, potentially cutting off access to homes. Critical infrastructure, such as the Florida Keys Overseas Heritage Trail and the Overseas Highway (U.S. Route 1), is also at risk, threatening both recreational activities and evacuation routes. Existing drainage systems may be overwhelmed by increased rainfall and rising waters, exacerbating localized flooding.

Additionally, nearby recreational and natural resources, including John Pennekamp Coral Reef State Park and surrounding mangrove ecosystems, are vulnerable to long-term impacts from sea-level rise. These natural assets provide essential flood protection and recreational value, but the encroaching water levels threaten the integrity of the ecosystems and the region's tourism. The balance between protecting human assets and preserving natural habitats will be critical for ensuring long-term resilience.

For more detailed asset information and prioritization, please refer to Appendix G.

Recommendations

1. Floodproofing and Elevation of Residential Streets and Properties

- Improve the flood resilience of residential streets and private property owners should fortify properties in Winston Waterways to reduce the risks posed by sea-level rise and storm surges.
- Recommendation:
 - Elevate key roads such as Calleja Road, Palm Drive, Lime Drive, and Mahogany Drive to maintain access during flood events and ensure that residents are not isolated.
 - Encourage homeowners to implement floodproofing measures such as elevated foundations, flood barriers, and water-resistant materials to protect homes from inundation.
 - Implement voluntary relocation programs for homeowners in the highest-risk areas to allow for managed retreat in zones that will become increasingly difficult to protect from rising sea levels.

2. Stormwater Drainage System Improvements

- Enhance the stormwater drainage systems in Winston Waterways to manage increased rainfall and mitigate localized flooding.
- Recommendation:
 - Upgrade existing drainage infrastructure to increase capacity, particularly in low-lying areas where stormwater accumulation is most problematic.
 - Install permeable pavements, bioswales, and additional culverts to help direct floodwaters away from residential areas and into safe retention zones.
 - Integrate pump stations into flood-prone areas to actively manage water levels during peak rain periods and prevent drainage system overload.

3. Protection of Transportation Infrastructure

- Protect critical transportation infrastructure, including the Overseas Highway and the Florida Keys Overseas Heritage Trail, from sea-level rise and storm surges to ensure continuous connectivity and access to the region.

- Recommendation:
 - Elevate vulnerable sections of FDOT’s Overseas Highway and key local streets to prevent submersion during storm surges and high tides, maintaining evacuation routes and daily traffic flow.
 - Improve stormwater management systems along the highway and trail by installing larger drainage culverts and raising embankments to divert water away from transportation corridors.
 - Install temporary or permanent flood barriers along critical transportation routes to protect against storm surges and ensure safe passage during extreme weather events.

4. Natural Habitat Restoration and Coastal Protection

- Restore and protect the surrounding natural habitats, such as mangroves and wetlands near John Pennekamp Coral Reef State Park, to enhance natural flood defenses and preserve recreational and tourism value.
- Recommendation:
 - Restore and expand mangrove forests and coastal wetlands to act as natural buffers against storm surges and provide long-term protection for both human and natural assets.
 - Implement living shorelines along vulnerable coastal areas to stabilize erosion-prone zones, reduce wave energy, and protect inland properties.
 - Enhance conservation efforts to preserve local ecosystems that support tourism and recreational activities, while also reducing the risk of environmental degradation from rising sea levels.

5. Community Preparedness and Early Warning Systems

- Strengthen the community's preparedness for flood risks and install real-time monitoring systems to provide early warnings for potential flood events.
- Recommendation:
 - Install flood monitoring sensors throughout the Winston Waterways neighborhood, particularly in low-lying areas and near critical infrastructure, to provide real-time data on water levels and rising sea levels.

Develop a comprehensive community engagement program to educate residents about floodproofing techniques, emergency preparedness, and evacuation procedures.

- Integrate flood warning systems with Monroe County's emergency management platform to ensure timely alerts for residents, businesses, and emergency personnel, allowing for quicker responses during flood events.

Long-Term Adaptation Strategies

- **Routine Monitoring and Infrastructure Flexibility:** Establish long-term monitoring programs to assess the effectiveness of flood protection measures and ensure that future infrastructure projects are designed with flexibility, allowing for modifications as sea-level rise projections evolve.
- **Community Engagement and Managed Retreat:** Engage residents in planning for long-term resilience, providing options for managed retreat in the most vulnerable areas where flood protection may become unsustainable over time.
- **Nature-Based Solutions:** Prioritize nature-based solutions, such as wetland restoration and mangrove expansion, to bolster natural flood defenses and reduce the need for hard infrastructure in certain areas.

By implementing these targeted recommendations, Winston Waterways can improve its resilience to near-term sea-level rise and storm surges, ensuring the long-term safety of its residents, infrastructure, and natural resources. For further details on specific asset prioritization and projects, please refer to Appendix G.

Recommendations

1. Floodproofing and Elevation of Water Management Facilities

- FCAA should protect critical water and wastewater facilities from the impacts of increased rainfall by elevating and floodproofing essential components of the FCAA Pump Station and FCAA Admin/Pump Station.
- Recommendation:
 - Elevate key components of water management facilities above projected flood levels to prevent damage from stormwater intrusion.
 - Install flood barriers and protective enclosures around pump stations to mitigate risks from heavy rainfall and saltwater intrusion.
 - Ensure backup power systems are in place to maintain water services during and after storm events.

2. Resilience Improvements for Emergency Services and Healthcare Facilities

- Enhance the resilience of emergency response and healthcare facilities, including Fire/EMS Station #22 and working with Mariner's Hospital, to ensure continuous operation during flood events.
- Recommendation:
 - Work with Mariner's Hospital to implement floodproofing projects and floodproof EMS Station #22 by elevating structures and installing flood barriers to protect against rain-driven flooding.
 - Equip facilities with emergency generators and backup power to maintain operational capacity during extended power outages.
 - Strengthen access routes for emergency vehicles by elevating key road sections around the hospital and fire station to ensure they remain functional during storm events.

3. Drainage System Enhancements for Transportation Infrastructure

- Improve the stormwater drainage systems along the Overseas Highway (FDOT's U.S. Route 1) and the Florida Keys Overseas Heritage Trail to handle increased rainfall and reduce flooding on critical transportation routes.

- Recommendation:
 - Upgrade the existing drainage infrastructure to increase capacity, ensuring that stormwater is efficiently removed from the roadway during and after heavy rain events.
 - Install additional culverts, bioswales, and permeable pavement where feasible to enhance water absorption and prevent pooling on road surfaces.
 - Implement flood barriers or storm gates at vulnerable sections of the highway to prevent road closures and maintain continuous access for emergency services and daily traffic.

4. Floodproofing Residential and Commercial Properties

- Private property owners should enhance the flood resilience of residential and commercial properties, including Harbour 92 Condominiums, Mangrove Marina, and other low-lying areas in Tavernier.
- Recommendation:
 - Encourage property owners to install elevated foundations, flood barriers, and water-resistant building materials to protect homes and businesses from flood damage.
 - Promote floodproofing techniques for critical commercial properties, especially marine facilities and businesses that rely on water access.
 - Implement voluntary buyout programs for the most flood-prone properties, allowing for managed retreat and the conversion of high-risk zones into open spaces or natural buffers.

5. Natural and Historic Resource Protection and Restoration

- Protect and restore natural resources and historical sites, such as the Old Tavernier School, Coconut Palm Inn, and surrounding conservation areas, to enhance flood resilience and preserve the community's cultural and environmental assets.
- Recommendation:
 - Restore and enhance coastal wetlands and mangrove habitats to serve as natural flood buffers, reducing the impact of rising water levels and absorbing stormwater runoff.

Implement nature-based flood defenses, such as living shorelines, to stabilize eroding areas and protect nearby properties from storm surges and heavy rainfall.

- Preserve historic sites by installing flood-resistant materials and structural reinforcements to prevent water damage and maintain their cultural significance.

6. Real-Time Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems across Tavernier to provide early warnings for flood events and improve emergency response efforts.

- Recommendation:

Deploy flood sensors near critical infrastructure, including water facilities, emergency services, and transportation routes, to provide real-time data on rising water levels.

Integrate these monitoring systems with the county's emergency management platform to ensure timely alerts and coordinated responses during flood events.

- Implement early warning systems to notify residents, businesses, and emergency personnel of impending flood risks, allowing for proactive measures and evacuations if necessary.

Long-Term Adaptation Strategies

To address ongoing risks from increased rainfall and future climate impacts, Tavernier requires a phased adaptation approach:

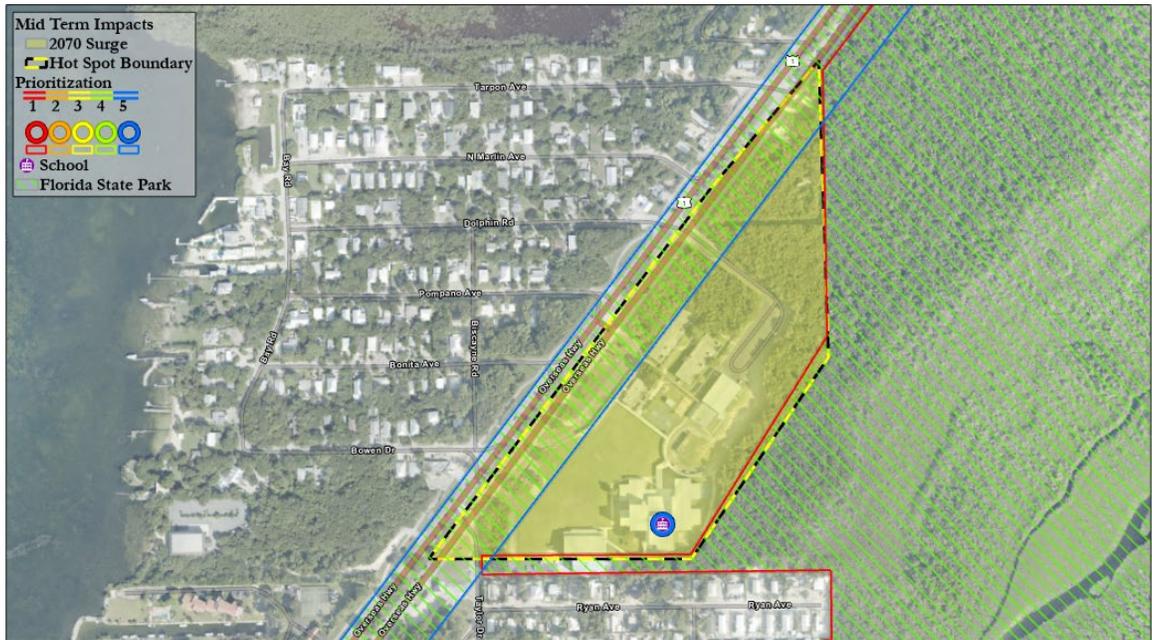
- **Routine Monitoring and Flexible Infrastructure Design:** Ensure that new infrastructure projects are designed with the flexibility to accommodate future modifications as climate conditions evolve.
- **Community Engagement and Education:** Engage residents, businesses, and stakeholders in resilience planning efforts, providing education on floodproofing techniques, emergency preparedness, and long-term adaptation strategies.
- **Nature-Based Solutions:** Prioritize nature-based solutions, such as wetland restoration and mangrove expansion, to bolster natural flood defenses and reduce reliance on hard infrastructure.

By implementing these targeted recommendations, Tavernier can improve its resilience to increased rainfall and storm events, protecting its critical infrastructure,

community assets, and natural resources. For more detailed information on specific asset prioritizations and projects, please refer to Appendix G.

Hot Spot 25: Elementary/Middle School, Key Largo

Figure 87 - Prioritized Assets in Hot Spot 25



This section of Key Largo is projected to face mid-term impacts from storm surge by 2070. It contains essential community infrastructure, most notably the Key Largo Elementary/Middle School, which serves both as an educational facility and a key emergency shelter during storms and floods. Given its critical role within the community, protecting the school from storm surge is a priority, especially due to its proximity to important natural and recreational assets like the Florida Keys Overseas Heritage Trail and nearby state parks.

In addition to educational infrastructure, the local transportation network is highly vulnerable to storm surge impacts. The Overseas Highway (U.S. Route 1), which runs parallel to the school, is a major access road for the area, providing vital connectivity between Key Largo and other parts of Monroe County. Local roads such as Pompano Avenue, Marlin Avenue, and Dolphin Road also play a crucial role in linking residential areas, the school, and emergency services. FDOT's Florida Keys Overseas Heritage Trail, which runs along the highway, not only offers recreational value but also serves as an alternative transportation route.

Natural resources surrounding the area, including the adjacent John Pennekamp Coral Reef State Park and nearby mangrove ecosystems, provide natural flood

defenses by buffering storm surges and absorbing floodwaters. These ecosystems are also essential habitats for wildlife and contribute to the community's overall resilience against climate impacts.

Recommendations

1. Elevation and Floodproofing of Key Largo Elementary/Middle School

- The School District should consider elevating and retrofitting the school building to ensure it remains a functional educational facility and emergency shelter during future storm surges and flood events.
- Recommendation:
 - Elevate critical areas of the school above projected storm surge levels, including classrooms, administrative areas, and the emergency shelter section.
 - Install flood barriers and waterproofing systems around vulnerable parts of the school to prevent water intrusion and ensure the building's structural integrity during extreme weather events.
 - Ensure the school is equipped with backup power systems and emergency generators to maintain essential services during and after storm events.

2. Improvement of Transportation and Access Routes

- Enhance the resilience of the local transportation network, particularly roads leading to the school and emergency routes, to ensure they remain functional during flood events.
- Recommendation:
 - Elevate low-lying sections of the Overseas Highway (FDOT's U.S. Route 1) and local roads, such as Pompano Avenue, Marlin Avenue, and Dolphin Road, to protect against future storm surges and prevent road closures.
 - Implement improved stormwater management systems along these roads, including culverts, swales, and permeable pavement, to handle surface water runoff and reduce road flooding.
 - Install flood barriers or storm gates along key access points to protect against storm surge impacts and ensure that emergency vehicles can access the school and surrounding areas.

3. Natural Resource Restoration and Protection

- Restore and enhance natural flood defenses, such as wetlands and mangrove ecosystems surrounding the school, to strengthen the area's resilience to storm surges and rising seas.
- Recommendation:
 - Restore mangrove forests and wetlands in the adjacent John Pennekamp Coral Reef State Park and nearby conservation lands to create natural buffers against storm surges.
 - Implement living shoreline projects along vulnerable sections of the coast to stabilize eroding areas and protect natural habitats.
 - Ensure ongoing conservation of these ecosystems by designating vulnerable areas for protection and limiting further development in flood-prone zones.

4. Real-Time Flood Monitoring and Early Warning Systems

- Install real-time flood monitoring systems to provide early warnings of flood risks and enable timely evacuations and emergency responses.
- Recommendation:
 - Deploy flood sensors around the school and critical infrastructure to monitor rising water levels in real-time.
 - Integrate the monitoring systems with Monroe County's emergency management platform to provide timely alerts to school administrators, emergency services, and residents.
 - Implement automated early warning systems to notify local residents and the school of impending storm surge or flood risks, allowing them to take necessary precautions.

5. Community Engagement and Education Programs

- Develop community education programs focused on flood resilience, including training for school staff and residents on emergency preparedness and floodproofing techniques.
- Recommendation:
 - Educate school staff and local residents on the importance of floodproofing measures, such as installing backflow prevention systems and using flood-resistant building materials.

Conduct regular emergency preparedness drills at the school, involving both students and community members, to ensure they are prepared to respond to flood events.

- Engage with the broader community to raise awareness about the risks of storm surge and the importance of maintaining natural flood defenses.

Long-Term Adaptation Strategies

To address future risks from rising sea levels and storm surge, the following long-term strategies are recommended:

- **Ongoing Monitoring and Flexible Infrastructure Design:** Ensure that infrastructure improvements, such as road elevation and school floodproofing, are adaptable to future climate conditions and rising sea levels.
- **Community Involvement and Education:** Continue to engage the community in resilience planning efforts, including workshops and training sessions on emergency preparedness, floodproofing, and long-term adaptation strategies.
- **Integration of Nature-Based Solutions:** Prioritize nature-based flood defenses, such as mangrove restoration and living shorelines, to complement built infrastructure and enhance long-term resilience.

By implementing these targeted recommendations, Key Largo Elementary/Middle School and its surrounding area can improve resilience against mid-term storm surge risks, ensuring the safety of students, residents, and critical infrastructure. For more detailed asset prioritizations and adaptation projects, please refer to Appendix G.

Habitat Change Due to Sea Level Rise

Monroe County's environmental health is crucial to its resilience against climate change. The following assessment explores the projected habitat changes resulting from sea-level rise, providing insights into ecological shifts and emerging vulnerabilities.

The Sea Level Affecting Marshes Model (SLAMM) was used to simulate long-term changes in tidal habitats, including saltwater marshes, mangroves, and other wetlands, under different sea-level rise scenarios. SLAMM integrates hydrologic functions and ecosystem parameters to forecast shifts based on current data from the Florida Fish & Wildlife Conservation Commission's Cooperative Land Cover Database (2019), a digital elevation model-derived slope raster, and other relevant inputs. The model quantifies changes in habitat and ecosystem functions, such as carbon sequestration, which is crucial for mitigating climate change.

This analysis compares the NOAA Intermediate-Low (NIL) and NOAA Intermediate-High (NIH) sea-level rise projections, highlighting the potential changes in Monroe County's ecosystems by 2100.

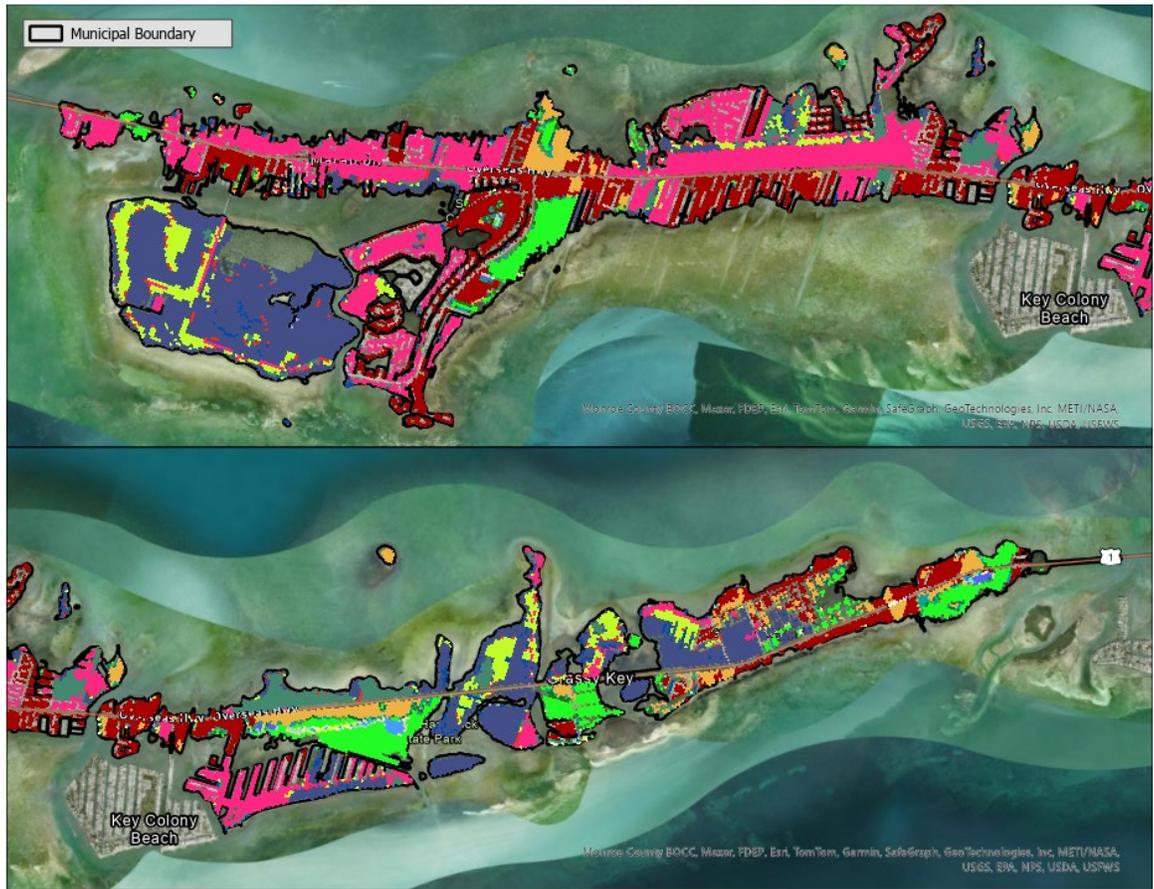
Figure 88 - SLAMM Map Legend

 Municipal Boundary	 Saltmarsh	 Estuarine Open Water
 Developed Dry Land	 Mangrove	 Tidal Creek
 Undeveloped Dry Land	 Estuarine Beach	 Open Ocean
 Nontidal Swamp	 Tidal Flat	 Flooded Dry Lands
 Cypress Swamp	 Ocean Beach	 Flooded Forest
 Inland Fresh Marsh	 Ocean Flat	
 Tidal Fresh Marsh	 Rocky Intertidal	
 Transitional Marsh	 Inland Open Water	

Figure 89 - NIH SLAMM Baseline Overview Map



Figure 90 - NIH SLAMM 2100 Map



Under the NOAA Intermediate-High Sea Level Rise Scenario, significant habitat changes are anticipated in Monroe County by the year 2100. These changes highlight the need for adaptive management strategies. Tables 20 and 21 show the sum of all changes by habitat type in hectares model wide. A negative value in the “Change from Present Day” in the last three columns represents a loss of that habitat type due to sea level rise for that scenario year. There is more loss associated with the NOAA Intermediate High sea level rise scenarios than the NOAA Intermediate Low scenarios.

Table 23 - Habitat Change under NOAA Intermediate-Low SLR Scenario

SLAMM Category	Present Day Hectares	2040 Hectares	2070 Hectares	2100 Hectares	Change from Present Day to 2040	Change from Present Day to 2070	Change from Present Day to 2100
Developed Dry Land	3109.47	2760.56	1920.74	1530.57	-11.22%	-38.23%	-50.78%
Undeveloped Dry Land	3808.71	2788.29	1463.60	1053.88	-26.79%	-61.57%	-72.33%
Swamp	9674.52	5520.92	1394.18	437.57	-42.93%	-85.59%	-95.48%
Cypress Swamp	10067.70	6383.48	1990.60	684.25	-36.59%	-80.23%	-93.20%
Inland-Fresh Marsh	35640.70	21731.65	10105.85	4751.56	-39.03%	-71.65%	-86.67%
Tidal-Fresh Marsh	1646.16	1189.36	177.85	59.45	-27.75%	-89.20%	-96.39%
Trans. Salt Marsh	10336.74	11543.71	12926.11	5459.21	11.68%	25.05%	-47.19%
Regularly-Flooded Marsh	1751.04	1133.96	110.90	51.01	-35.24%	-93.67%	-97.09%
Mangrove	121475.51	109995.32	32607.55	23144.93	-9.45%	-73.16%	-80.95%
Estuarine Beach	1309.11	1095.07	92.21	40.24	-16.35%	-92.96%	-96.93%
Tidal Flat	1595.07	1328.10	99.58	53.88	-16.74%	-93.76%	-96.62%
Ocean Beach	821.63	690.82	60.06	27.13	-15.92%	-92.69%	-96.70%
Ocean Flat	807.36	673.78	53.45	23.51	-16.55%	-93.38%	-97.09%
Rocky Intertidal	2643.93	2121.75	155.15	115.74	-19.75%	-94.13%	-95.62%
Inland Open Water	180.08	49.62	33.41	12.19	-72.45%	-81.45%	-93.23%
Riverine Tidal	397.14	126.91	4.13	1.10	-68.04%	-98.96%	-99.72%
Estuarine Open Water	21519.50	53344.89	152625.40	176602.77	147.89%	609.24%	720.66%
Tidal Creek	16.74	16.74	16.74	16.74	0.00%	0.00%	0.00%
Open Ocean	340.63	613.77	2038.50	2113.12	80.19%	498.45%	520.36%
Irreg.-Flooded Marsh	0.09	0	0	0	-100.00%	-100.00%	-100.00%
Inland Shore	0	0	0	0	0.00%	0.00%	0.00%
Tidal Swamp	0.18	0.18	0.18	0.18	0.00%	0.00%	0.00%
Flooded Developed Dry Land	51.51	400.42	1240.24	1630.41	677.36%	2307.77%	3065.23%
Flooded Forest	2041.80	5726.02	10118.90	11425.89	180.44%	395.59%	459.60%
Aggregated Non Tidal	6969.69	5949.27	4624.58	4214.86	-14.64%	-33.65%	-39.53%
Freshwater Non-Tidal	55382.93	33636.06	13490.62	5873.38	-39.27%	-75.64%	-89.39%

SLAMM Category	Present Day Hectares	2040 Hectares	2070 Hectares	2100 Hectares	Change from Present Day to 2040	Change from Present Day to 2070	Change from Present Day to 2100
Open Water	22454.09	54151.93	154718.18	178745.91	141.17%	589.04%	696.05%
Low Tidal	7177.10	5909.51	460.44	260.50	-17.66%	-93.58%	-96.37%
Saltmarsh	1751.04	1133.96	110.90	51.01	-35.24%	-93.67%	-97.09%
Transitional	133854.13	127265.05	55652.57	40030.03	-4.92%	-58.42%	-70.09%
Freshwater Tidal	1646.34	1189.54	178.03	59.63	-27.75%	-89.19%	-96.38%
GHG (10 ³ Kg)	0	-2458492	-4630073	-5348726	-	-	-

Table 24 - Habitat Change under NOAA Intermediate-High SLR Scenario

SLAMM Category	Present Day Hectares	2040 Hectares	2070 Hectares	2100 Hectares	Change from Present Day to 2040	Change from Present Day to 2070	Change from Present Day to 2100
Developed Dry Land	3109.47	2134.66	1214.03	1070.13	-31.35%	-60.96%	-65.58%
Undeveloped Dry Land	3808.71	1747.04	497.05	378.61	-54.13%	-86.95%	-90.06%
Swamp	9674.52	2308.56	51.76	50.94	-76.14%	-99.46%	-99.47%
Cypress Swamp	10067.70	3178.20	32.91	27.11	-68.43%	-99.67%	-99.73%
Inland-Fresh Marsh	35640.70	10958.87	103.71	97.20	-69.25%	-99.71%	-99.73%
Tidal-Fresh Marsh	1646.16	224.41	39.42	38.53	-86.37%	-97.61%	-97.66%
Trans. Salt Marsh	10336.74	24227.49	12673.37	33.27	134.38%	22.61%	-99.68%
Regularly-Flooded Marsh	1751.04	175.91	41.38	40.90	-89.95%	-97.64%	-97.66%
Mangrove	121475.51	38189.09	33558.84	20484.05	-68.56%	-72.37%	-83.14%
Estuarine Beach	1309.11	239.07	32.42	31.68	-81.74%	-97.52%	-97.58%
Tidal Flat	1595.07	436.78	48.85	47.52	-72.62%	-96.94%	-97.02%
Ocean Beach	821.63	138.76	25.99	23.49	-83.11%	-96.85%	-97.14%
Ocean Flat	807.36	129.76	20.56	20.07	-83.93%	-97.45%	-97.51%
Rocky Intertidal	2643.93	284.83	112.21	111.96	-89.23%	-95.76%	-95.77%
Inland Open Water	180.08	34.84	10.98	10.98	-80.65%	-93.90%	-93.90%
Riverine Tidal	397.14	10.13	0.24	0	-97.45%	-99.94%	-100.00%
Estuarine Open Water	21519.50	133090.33	164682.26	190524.97	518.46%	665.27%	785.36%

SLAMM Category	Present Day Hectares	2040 Hectares	2070 Hectares	2100 Hectares	Change from Present Day to 2040	Change from Present Day to 2070	Change from Present Day to 2100
Tidal Creek	16.74	16.74	16.74	16.74	0.00%	0.00%	0.00%
Open Ocean	340.63	1752.04	2040.91	2045.77	414.35%	499.16%	500.58%
Irreg.-Flooded Marsh	0.09	0	0	0	-100.00%	-100.00%	-100.00%
Inland Shore	0	0	0	0	0.00%	0.00%	0.00%
Tidal Swamp	0.18	0.18	0.18	0.18	0.00%	0.00%	0.00%
Flooded Developed Dry Land	51.51	1026.32	1946.95	2090.85	1892.47%	3679.75%	3959.11%
Flooded Forest	2041.80	8931.30	12084.56	12090.35	337.42%	491.86%	492.14%
Aggregated Non Tidal	6969.69	4908.02	3658.03	3539.59	-29.58%	-47.52%	-49.21%
Freshwater Non-Tidal	55382.93	16445.63	188.37	175.26	-70.31%	-99.66%	-99.68%
Open Water	22454.09	134904.09	166751.13	192598.46	500.80%	642.63%	757.74%
Low Tidal	7177.10	1229.20	240.02	234.72	-82.87%	-96.66%	-96.73%
Saltmarsh	1751.04	175.91	41.38	40.90	-89.95%	-97.64%	-97.66%
Transitional	133854.13	71347.88	58316.77	32607.67	-46.70%	-56.43%	-75.64%
Freshwater Tidal	1646.34	224.59	39.60	38.71	-86.36%	-97.59%	-97.65%
GHG (10 ³ Kg)	0	-2526898	-3177474	-2925468	-	-	-

Habitat Shifts and Projections

Under both sea-level rise scenarios, significant changes are expected in Monroe County’s habitats by 2100. These changes demand adaptive management strategies to minimize habitat loss and support the resilience of ecosystems. Below are some of the key findings based on SLAMM’s projections:

1. Decline in Marshes, Mangroves, and Tidal Habitats

- **Saltmarsh:** The extent of saltmarsh, currently 1,751 hectares, is projected to decrease to 51 hectares (NIL) and 41 hectares (NIH) by 2100, representing a decline of up to 97.66%.
- **Mangroves:** Mangroves, vital for biodiversity and coastal protection, are projected to shrink significantly from 121,475 hectares to 23,145 hectares (NIL) and 20,484 hectares (NIH), a reduction of up to 83.14%.
- **Tidal Flats:** Currently covering 1,595 hectares, tidal flats are expected to decline to 54 hectares (NIL) and 48 hectares (NIH) by 2100, a loss of up to 97.02%.

These declines pose significant threats to biodiversity, carbon sequestration, and storm surge protection. Mangroves are essential for mitigating coastal erosion and supporting marine life, and their reduction could have cascading ecological and economic impacts.

2. Dramatic Expansion of Flooded Forests

- **Flooded Forests:** Swamps, currently covering 2,042 hectares, are projected to increase to 11,426 hectares (NIL) and 12,090 hectares (NIH), reflecting a rise of up to 492%.

This transformation represents a shift from dry land to wetland ecosystems, altering local water filtration processes, habitat availability, and increasing risks of water pollution.

3. Significant Loss of Dry Land

- **Developed Dry Land:** Currently 3,109 hectares, developed land is expected to decrease to 1,531 hectares (NIL) and 1,070 hectares (NIH) by 2100, a reduction of up to 65.58%.
- **Undeveloped Dry Land:** This category, covering 3,809 hectares today, could shrink to just 1,054 hectares (NIL) and 379 hectares (NIH), a loss of up to 90.06%.

This extensive loss of dry land has serious implications for both natural habitats and human communities. It reduces available space for land-based species and human development, potentially leading to overcrowding of remaining habitats and intensifying competition for resources.

4. Substantial Expansion of Open Water

- **Open Ocean:** From 340 hectares today, open ocean areas could increase to 2,113 hectares (NIL) and 2,046 hectares (NIH), representing a dramatic rise of up to 500%.
- **Estuarine Open Water:** Covering 21,520 hectares at present, estuarine waters are projected to expand to 176,603 hectares (NIL) and 190,525 hectares (NIH) by 2100, an increase of up to 785%.

The expansion of open water areas will reshape Monroe County's coastal landscape. This shift will significantly impact estuarine ecosystems, which serve as nurseries for many marine species, while also disrupting human activities such as fishing, tourism, and coastal development.

NOAA Intermediate-Low (NIL) vs. NOAA Intermediate-High (NIH) Scenarios

The SLAMM modeling reveals that while both NIL and NIH scenarios predict substantial habitat changes by 2100, the NIH scenario shows far more severe impacts, with larger losses in marshes, mangroves, and dry land. Key differences between the scenarios include:

- Under the NIH scenario, salt marshes may shrink by 97.66%, compared to a 97.09% decline under the NIL scenario.
- Flooded forests are projected to increase by up to 492% under NIH, compared to 459% under NIL.
- Open ocean and estuarine waters could expand by 785% under NIH, significantly more than the 720% projected under NIL.

Adaptive Management Strategies

Given the significant ecological transformations predicted under both sea-level rise scenarios, Monroe County must adopt a proactive, adaptive approach to managing its natural resources. Key strategies include:

1. **Protecting and Restoring Mangroves and Marshes:** Preservation and restoration of mangroves and saltmarshes should be a top priority. These habitats provide essential flood protection, support biodiversity, and sequester carbon. Restoration projects that promote natural buffer zones and use nature-based solutions, such as living shorelines, can help mitigate habitat loss.
2. **Implementing Managed Retreat:** As dry lands are projected to shrink drastically, managed retreat from high-risk areas should be considered. Strategic relocation of infrastructure and human settlements from flood-prone areas can reduce future vulnerabilities and allow ecosystems to migrate inland naturally.
3. **Enhancing Wetland Conservation and Flooded Forest Management:** The significant expansion of flooded forests necessitates adaptive management to maintain biodiversity and water quality. Conservation efforts should focus on monitoring these ecosystems and promoting their resilience to changing conditions.
4. **Monitoring and Real-Time Adaptation:** Continuous monitoring of habitat changes and water levels is essential. Real-time data from flood sensors, satellite imagery, and drone technology should inform adaptive strategies to protect vulnerable ecosystems and adjust management plans as sea-level rise progresses.

5. **Incorporating Green Infrastructure:** Integrating green infrastructure, such as rain gardens, bioswales, and permeable pavements, into urban planning can mitigate the effects of habitat loss and increased flood risks. These systems can reduce runoff, support biodiversity, and improve water quality.

The habitat changes projected under sea-level rise scenarios for Monroe County indicate profound ecological shifts, particularly in wetlands, marshes, and mangroves. While the loss of critical habitats like saltmarshes and mangroves will reduce the county's resilience to storms and sea-level rise, there are opportunities to enhance conservation efforts, restore ecosystems, and implement adaptive management strategies. A comprehensive, forward-looking approach to habitat management can mitigate the impacts of sea-level rise and preserve the ecological and economic integrity of Monroe County. For detailed data on habitat projections, refer to Tables 23 and 24 and the corresponding maps (Figures 89 and 90) that illustrate the NOAA Intermediate-Low and Intermediate-High sea-level rise scenarios.

Shoreline Assessment

Monroe County, with its intricate geography encompassing the Florida Keys and numerous vital ecosystems, is at heightened risk from shoreline erosion, inland flooding, and high tide flooding (HTF) compounded by sea-level rise (SLR). The county's coastlines, flanked by mangrove forests, salt marshes, and coral reefs, are critical not only for the protection they provide but also for the biodiversity they support. However, these ecosystems are fragile and under growing threat from climate change, human development, and intensifying storm surges. SLR is expected to transform intertidal zones, pressuring these natural habitats and increasing risks to both human settlements and wildlife.

The degradation of these natural barriers would significantly weaken Monroe County's defense against erosion and flooding, with severe implications for biodiversity, including species like the Florida manatee (*Trichechus manatus*), Key deer (*Odocoileus virginianus clavium*), and Loggerhead sea turtles (*Caretta caretta*). These species rely on the stability and health of coastal ecosystems for food, shelter, and reproductive success. For instance, the inundation of turtle nesting beaches could reduce available habitat by up to 30% by 2040, jeopardizing the survival of key species.

Monroe County's mangrove forests, which line much of its coastline, are highly vulnerable to coastal squeeze—a process where rising seas push these habitats inland, but human infrastructure blocks their natural migration. Without space to expand landward, mangroves and other coastal ecosystems risk being submerged, reducing their capacity to:

- Sequester carbon, aiding in climate mitigation.

- Filter pollutants, contributing to water quality.
- Stabilize shorelines, protecting against erosion and storm surges.

Coral reefs, which buffer the shoreline by reducing wave energy, are also under threat from rising sea temperatures, causing coral bleaching. As reefs degrade, their ability to function as submerged breakwaters diminishes, leading to increased wave impact on shorelines and higher risks of flooding. Mangroves and salt marshes further play an essential role by retaining sediment, dissipating wave energy, and providing nurseries for numerous marine species. However, SLR and infrastructure barriers threaten to severely reduce these functions, making Monroe County more susceptible to storm events.

The Importance of Nature-Based Solutions

To safeguard both the natural and human environments, Monroe County should prioritize the restoration and conservation of living shorelines and coral reefs. Nature-based solutions (NBS) are increasingly recognized as the most sustainable and adaptive approach to mitigating coastal risks. By working with natural systems, these solutions offer resilience against SLR while enhancing biodiversity and ecosystem services.

Living Shorelines

Living shorelines use natural features such as mangroves, salt marshes, and seagrass beds to stabilize the coastline. These dynamic systems can evolve with environmental changes, offering both habitat restoration and protection from erosion. Key benefits include:

- **Erosion Control:** Mangrove and marsh root systems trap sediment, slowing the retreat of coastlines and maintaining habitat for wildlife.
- **Wave Energy Dissipation:** Dense vegetation absorbs wave energy, protecting infrastructure and reducing the likelihood of flooding.
- **Habitat Enhancement:** Living shorelines create essential habitats for marine life, birds, and fish nurseries, supporting biodiversity and enhancing local fisheries.

Coral and Oyster Reefs

Coral and oyster reefs act as natural breakwaters, reducing the energy of waves before they reach the shore. These reefs are particularly effective in Monroe County's shallow waters and provide a range of ecological benefits:

- **Wave Attenuation:** Reefs reduce wave height and energy, decreasing coastal erosion and protecting shorelines from storm surges.

- **Ecosystem Services:** Reefs enhance water quality by filtering pollutants and provide habitat for marine species, which in turn supports fisheries and boosts local economies.
- **Self-Sustaining:** As living structures, coral and oyster reefs can grow over time, making them more resilient to rising sea levels compared to traditional hard infrastructure.

Offshore Breakwaters

Offshore breakwaters can be strategically placed to deflect and reduce wave energy, working in concert with living shorelines to create a multi-layered coastal defense. When combined with other NBS, they offer robust protection for vulnerable areas:

- **Wave Deflection:** Breakwaters diminish the force of waves before they hit the shore, reducing erosion and flooding in high-risk areas.
- **Sediment Accretion:** Calmer inshore waters created by breakwaters promote the natural deposition of sediments, helping rebuild beaches and restore shoreline stability.

Data-Driven Shoreline Vulnerability Analysis

Using LiDAR (Light Detection and Ranging) data alongside detailed shoreline composition analysis, this assessment has identified four high-priority sites in Monroe County that are at risk of significant beach erosion, HTF, and inland flooding by 2040. These sites were analyzed for their topography, shoreline composition (e.g., natural vegetation, riprap, seawalls), and their vulnerability to storm surges, HTF, and projected SLR.

The integration of NOAA tide gauge data and historical tidal records provided a comprehensive understanding of the frequency and intensity of HTF expected at these sites by 2040. This data is critical for planning tailored interventions that will mitigate both current and future risks. Areas with natural vegetation such as mangroves were identified as having significant potential for nature-based interventions, while regions with seawalls or riprap were assessed for where these hard infrastructure solutions could be enhanced with natural elements.

Priority Areas for Shoreline Protection

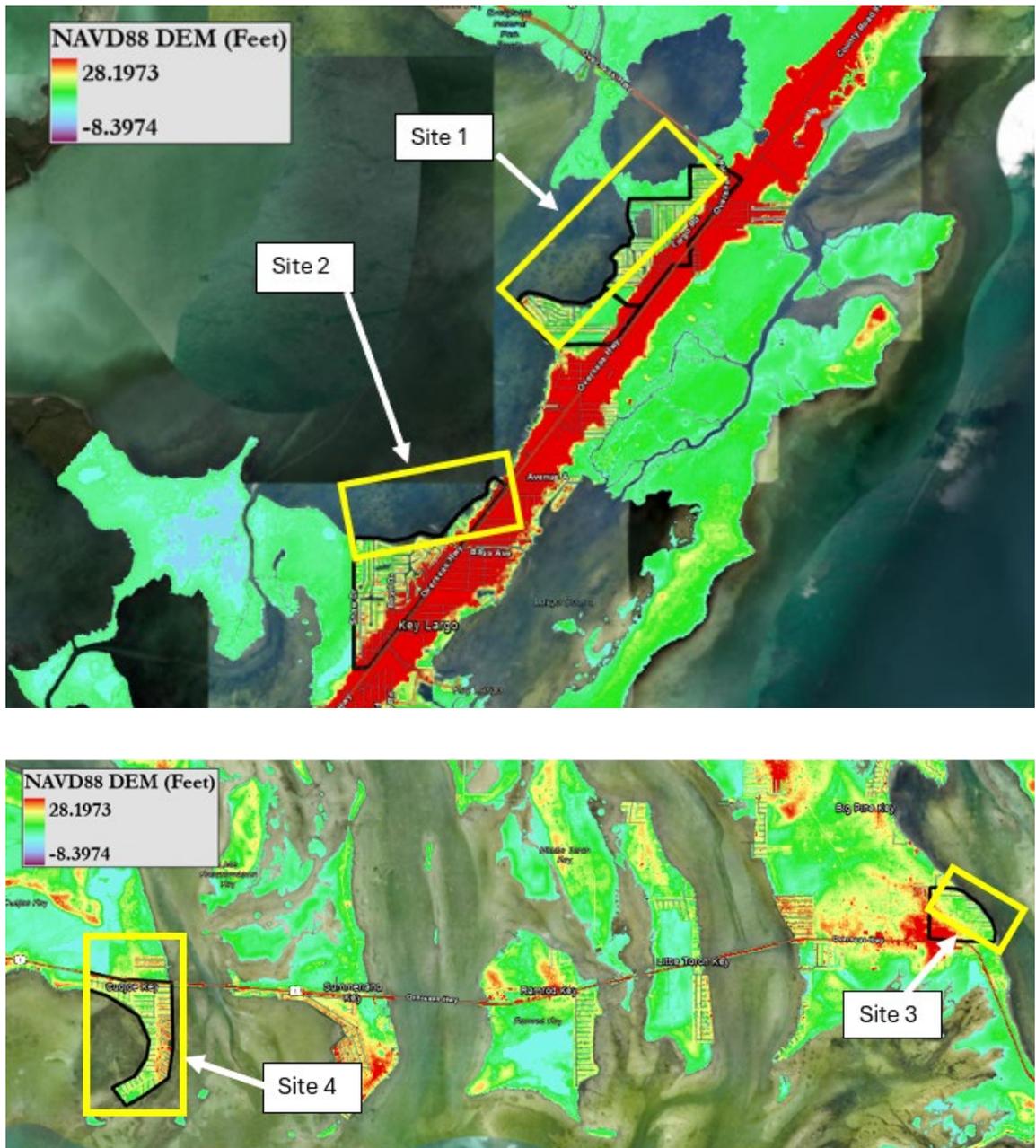
Four high-priority sites have been identified within Monroe County as facing substantial risks from coastal flooding and erosion by 2040. These sites were evaluated based on the following:

- Elevation data from LiDAR-generated DEMs.

- Shoreline composition and vulnerability to high tide flooding, storm surges, and future sea level rise (SLR).
- Opportunities for implementing living shorelines and other nature-based solutions.

Through these evaluations, a set of tailored recommendations was developed to both reduce flood impacts and stabilize vulnerable shorelines, promoting long-term resilience.

Figure 91 - Elevation Map of Shoreline Improvement Sites



Based on shoreline data provided by Monroe County and collected from the Florida Fish & Wildlife Conservation Commission (FWC), the project team determined the composition of the shoreline as either beach, seawalls, rip rap or vegetation. Identifying the composition of the shoreline in parallel with the shoreline's elevation and its susceptibility to storm events can assist in determining in which areas restoration projects or seawall improvement may be best suited. Shorelines comprised of beaches could benefit from the installation of natural vegetation on the

Figure 93 – Site 2 Shoreline Composition

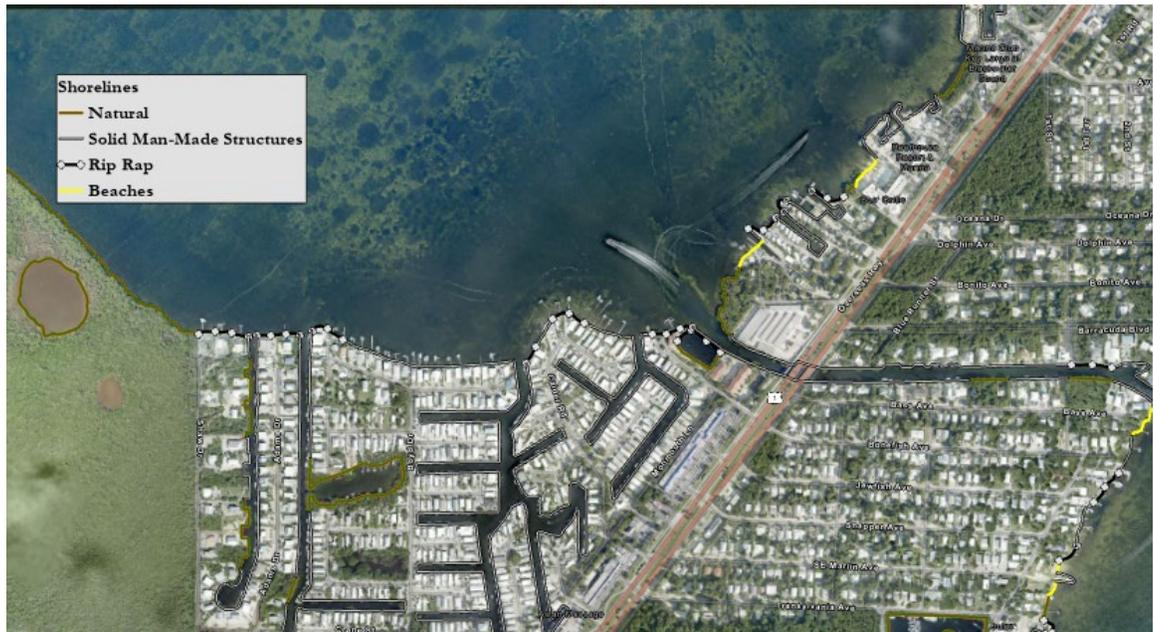


Figure 94 - Site 3 Shoreline Composition



Figure 96 - Site 1 Projected Tidal Flooding Frequency



Figure 98 - Site 3 Projected Tidal Flooding Frequency

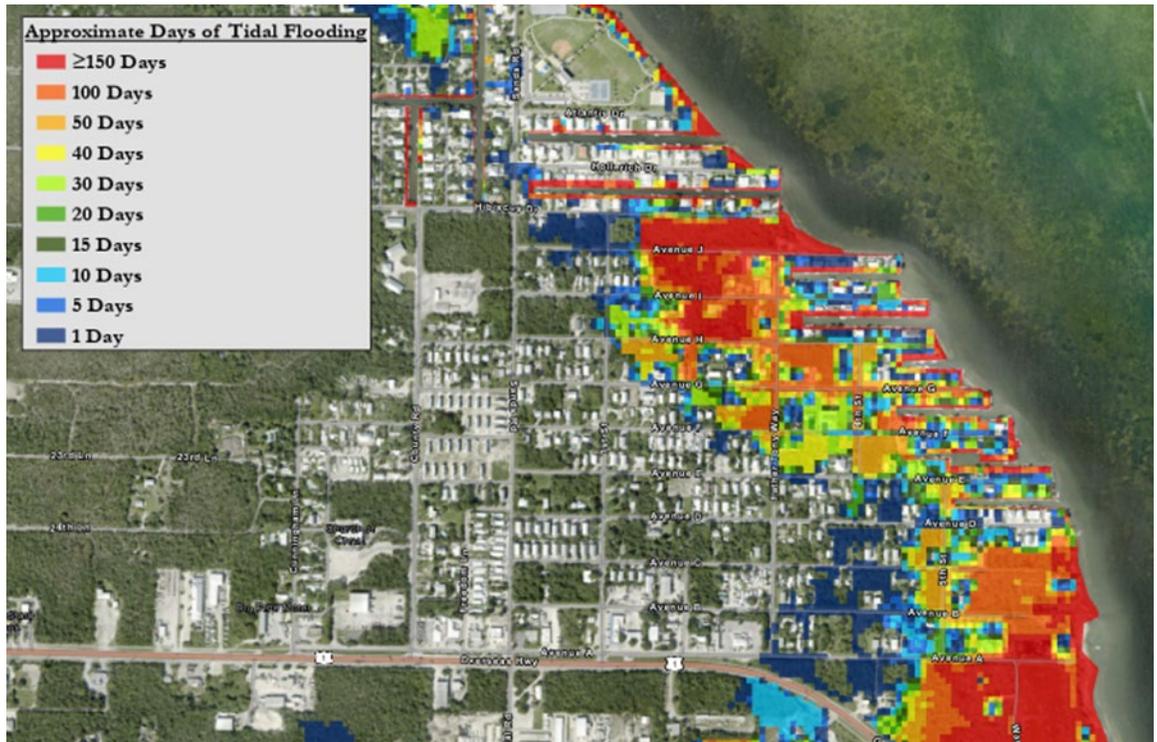


Figure 99 - Site 4 Projected Tidal Flooding Frequency



Based on the assessment of the data described above, the project team provides the following recommendations to improve the resiliency of the 4 identified sites.

Site 1: Key Largo Area 1

Figure 100 - Site 1 Proposed Shoreline Improvements



This high-density residential zone, projected to experience high tide flooding (HTF) over 150 days annually by 2040, relies heavily on riprap and seawalls. However, these structures alone are insufficient to protect against long-term sea-level rise and increased storm activity.

Recommendations:

- **Living Shoreline Installation:** By planting mangroves and establishing salt marshes in low-lying areas, the coastline can be stabilized, wave energy reduced, and erosion minimized. This natural buffer will complement the existing seawalls.
- **Oyster Reef Restoration:** Installing oyster reefs offshore will further reduce wave intensity and benefit local fisheries. Oyster reefs act as living barriers that grow over time, enhancing protection as sea levels rise.
- **Grey-to-Green Retrofits:** The existing seawalls can be retrofitted with nature-based elements, such as vegetated terraces or shelves. These retrofits support mangrove colonization and create habitat for marine life while

improving water quality through filtration. This hybrid approach will enhance the resilience of the built infrastructure.

- **Hybrid Breakwater Systems:** By constructing a combination of submerged reef breakwaters and living shorelines, the area will be shielded from rising seas while reducing reliance on hard infrastructure like seawalls. This strategy balances immediate protection with long-term adaptability to SLR.

Site 2: Key Largo Area 2

Figure 101 - Site 2 Proposed Shoreline Improvements



This site, a high-density residential area, is projected to experience HTF over 150 days per year by 2040. The existing shoreline consists of riprap and seawalls, which provide limited protection from tidal forces and wave action.

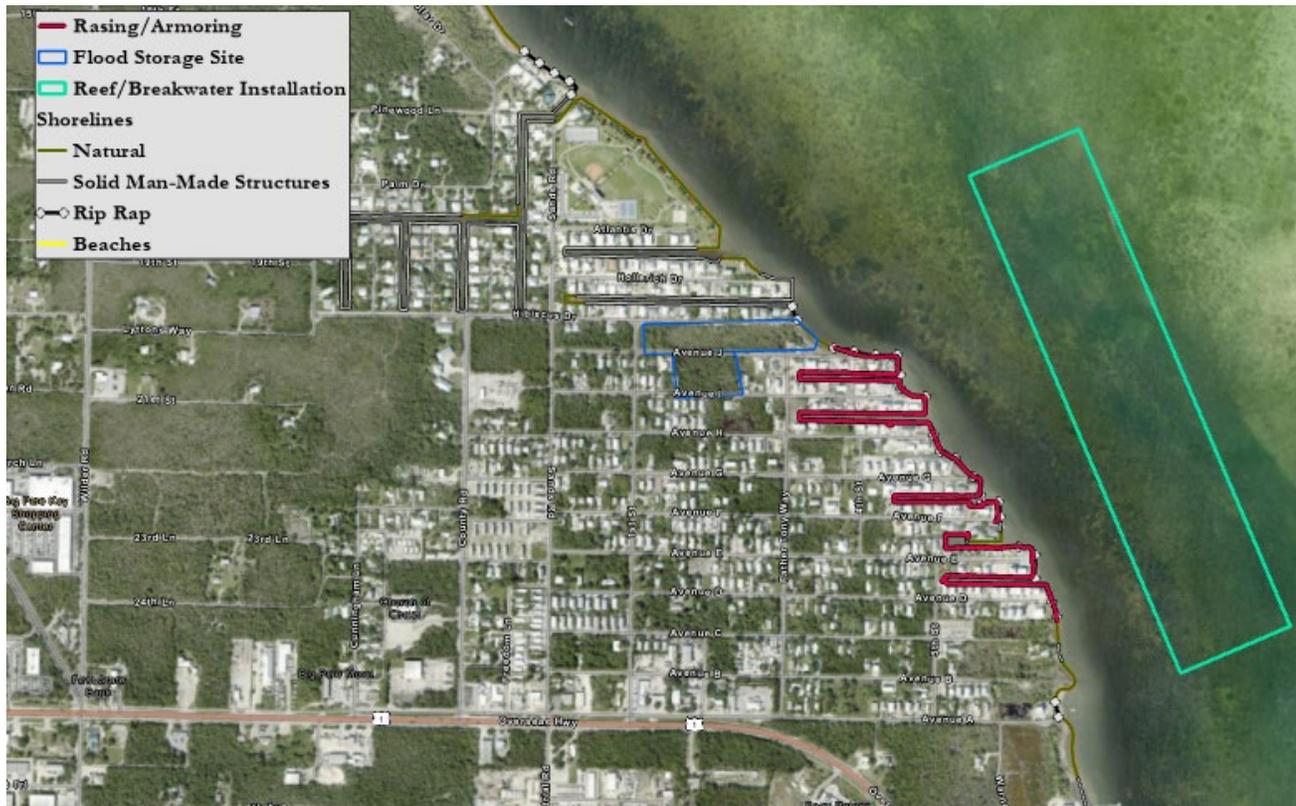
Recommendations:

- **Living Shoreline Installation:** Planting **mangroves** and establishing **salt marshes** in low-lying areas will help stabilize the coastline, protect against erosion, and reduce wave energy.

- **Oyster Reef Restoration:** Installing **oyster reefs** offshore will help reduce wave intensity while simultaneously enhancing local fisheries and water quality.
- **Hybrid Breakwater Systems:** Constructing a combination of submerged **reef breakwaters** and **living shorelines** will protect infrastructure from rising seas and increase resilience to storm surges.

Site 3: Big Pine Key

Figure 102 - Site 3 Proposed Shoreline Improvements



Big Pine Key, with its medium- to high-density residential areas, is highly vulnerable to tidal flooding, with projections of over 150 days of HTF annually by 2040. The area is characterized by a mix of natural vegetation, riprap, and seawalls.

Recommendations:

- **Mangrove Expansion and Salt Marsh Restoration:** Large portions of undeveloped land near the shoreline can be restored to salt marshes and mangroves, which would serve as natural flood buffers while sequestering carbon and supporting biodiversity.

- **Hybrid Breakwater Systems:** Incorporating submerged reefs with living shorelines will reduce wave energy before it reaches the shoreline, working synergistically with the existing grey infrastructure to provide layered protection.
- **Managed Retreat:** In high-risk areas where protection is not feasible, promoting voluntary buyouts and implementing managed retreat will allow nature-based solutions to take over, reducing long-term maintenance costs while restoring ecosystem health.

Site 4: Cudjoe Key

Figure 103 - Site 4 Proposed Shoreline Improvements



Cudjoe Key is a densely populated residential zone projected to experience HTF for up to 100 days per year by 2040. The existing shoreline consists of seawalls and riprap, which need both elevation and integration with nature-based solutions.

Recommendations:

- **Tidal Connections and Wetland Restoration:** Installing culverts between tidal channels and expanding wetland areas will improve water flow, reduce flood intensity, and enhance local ecosystems.
- **Coral and Oyster Reef Systems:** Constructing coral and oyster reefs offshore will provide critical wave attenuation, protecting infrastructure while promoting biodiversity and improving water quality.
- **Grey-to-Green Retrofits:** The seawalls and riprap in this area can be retrofitted with biogenic elements like perforated seawalls that allow water exchange, fostering the growth of marine vegetation and improving water quality. In addition, introducing green roofs or bio-barriers on existing riprap structures will promote biodiversity and strengthen shoreline defenses.
- **Elevated Seawalls and Armoring:** In the most vulnerable areas, raising and reinforcing seawalls will complement natural buffers, creating a layered defense against HTF and storm surges.

Long-Term Nature-Based Resilience Strategies

To ensure the sustainability and effectiveness of these shoreline interventions, the following long-term strategies are recommended: To ensure that Monroe County’s coastal defenses are sustainable and adaptive, the following long-term strategies should be implemented:

1. Phased Implementation and Monitoring

- Prioritize interventions in the most vulnerable areas, with continuous monitoring of HTF, SLR, and ecosystem health to make adaptive adjustments over time.

2. Community Engagement and Education

- Engage local communities in the benefits of nature-based solutions to garner support for conservation projects. Community stewardship is essential for the long-term success and maintenance of restored ecosystems.

3. Regional Collaboration and Funding

- Work with state and federal agencies to secure funding for large-scale nature-based infrastructure projects. Partnerships with NOAA, FEMA, and environmental NGOs can provide the financial and technical support necessary to scale up these efforts.

4. Grey-to-Green Retrofits

- Retrofits that blend traditional grey infrastructure with green solutions offer multiple benefits: improved flood protection, enhanced water quality, and increased biodiversity. By transforming seawalls and riprap with vegetated terraces, Monroe County can increase resilience and reduce reliance on hard defenses.

Through the adoption of nature-based solutions like living shorelines, coral and oyster reefs, and offshore breakwaters, Monroe County can significantly improve its resilience to high tide flooding, shoreline erosion, and the broader impacts of sea-level rise. These sustainable approaches not only provide essential flood protection but also restore and preserve vital ecosystems, promoting long-term resilience for both the natural environment and human communities.

Socioeconomic Vulnerability

A comprehensive vulnerability assessment encompasses not only physical factors but also socioeconomic considerations. These considerations reveal the increased risks faced by a community's most vulnerable communities. This section presents an analysis aimed at understanding the impact of flood vulnerability on the county's people. Spanning both urban and suburban communities, special attention is paid to identifying vulnerable populations. Those with limited resources or access to essential services require additional focus and call for special delineation of resources. Tailoring effective flood mitigation strategies specifically for these groups is critical. A census tract is a geographic region defined for population study. Census tracts are used in this analysis to identify particularly vulnerable populations within flooding hot spots.

Social Vulnerability Index

Monroe County consists of 26 census tracts, a detailed study of each area tract helps in identifying populations that are especially vulnerable to flood risk. Vulnerability is based on the overall composite ranking within the Social Vulnerability Index, where values of 50% (or .50) or greater are prioritized higher than lower values. Table 25 provides the census tracts within Monroe County that have a SVI Composite Index greater than 50%. Higher values indicate a higher susceptibility to flood-related adversities and other stressors. This detailed breakdown serves as a critical tool for prioritizing action and directing resources towards the most vulnerable sectors of the population. Ensuring that mitigation efforts are both efficient and equitable is crucial for protecting vulnerable communities.

Table 25 – Census Tracts in Monroe County with SVI Index Greater than 50%

Census Tract	Land Area (in square miles)	% Coverage by of Hot Spot
Census Tract 9704	4.3	74.3%
Census Tract 9707	2.7	77.7%
Census Tract 9710.02	3.9	61.5%
Census Tract 9711	1.6	77.9%
Census Tract 9712	1.5	86.0%
Census Tract 9713	2.1	94.6%
Census Tract 9714.01	5.8	72.3%
Census Tract 9717	7.4	58.8%
Census Tract 9718	1.5	89.8%
Census Tract 9719	1.0	87.7%
Census Tract 9721	1.6	58.5%
Census Tract 9724	0.3	70.6%
Census Tract 9727	25.0	68.6%
Census Tract 9728	0.5	60.3%

Figure 104 - Census Tracts with SVI Scores and Total Population (Upper Keys)

Dark blue to light blue indicates an SVI of 50% or higher

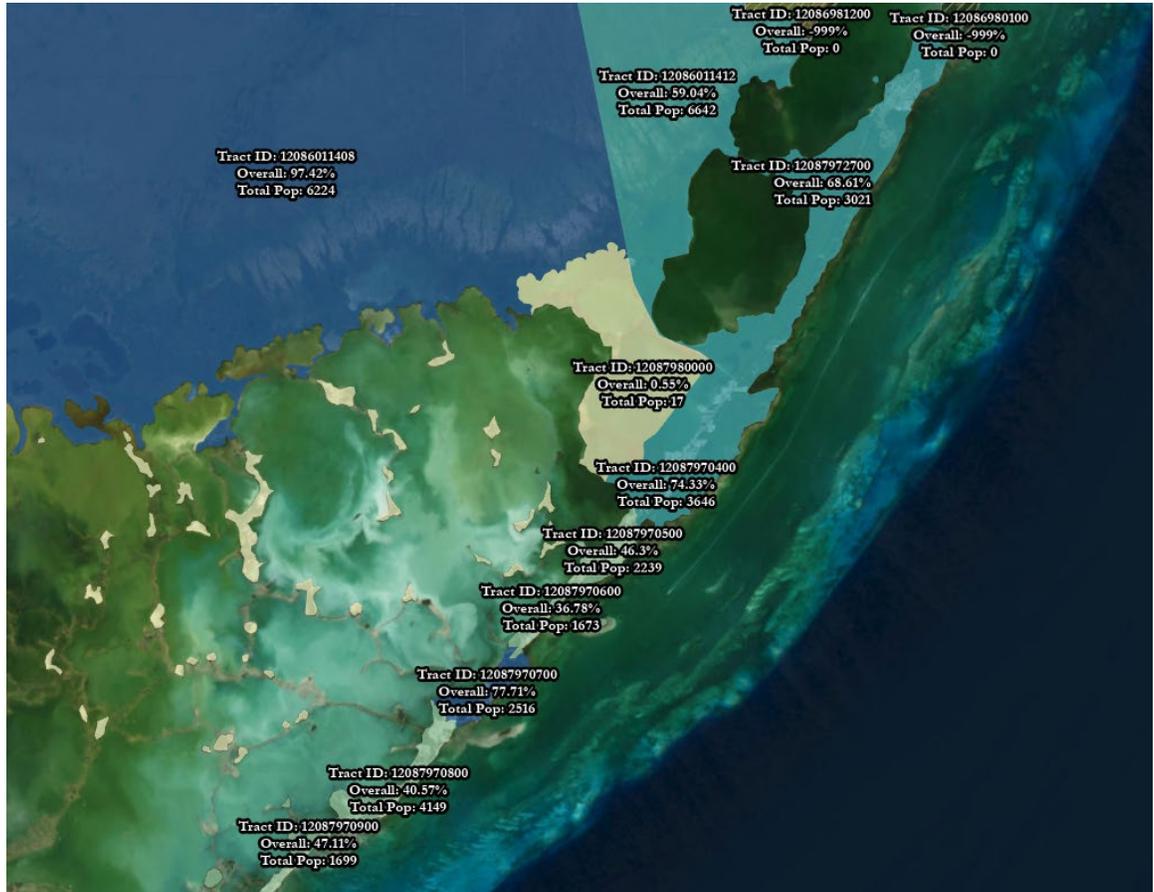


Figure 105 - Census Tracts with SVI Scores and Total Population (Middle/Lower Keys)

Dark blue to light blue indicates an SVI of 50% or higher



Figure 106 - Census Tracts with SVI Scores and Total Population (Key West and Stock Island)



Location Affordability Index

The Location Affordability Index (LAI) provides a comprehensive view of the cost burdens of housing and transportation on different household profiles and analyzes them to determine the true cost of living, not just in terms of rent and/or mortgages but also commuting and travel expenses. This index is a key factor when analyzing the vulnerability of a community. Metrics for each household profile identified within the analyzed census tracts are detailed below.

Figure 107 - Location Affordability within Monroe County (Upper Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.

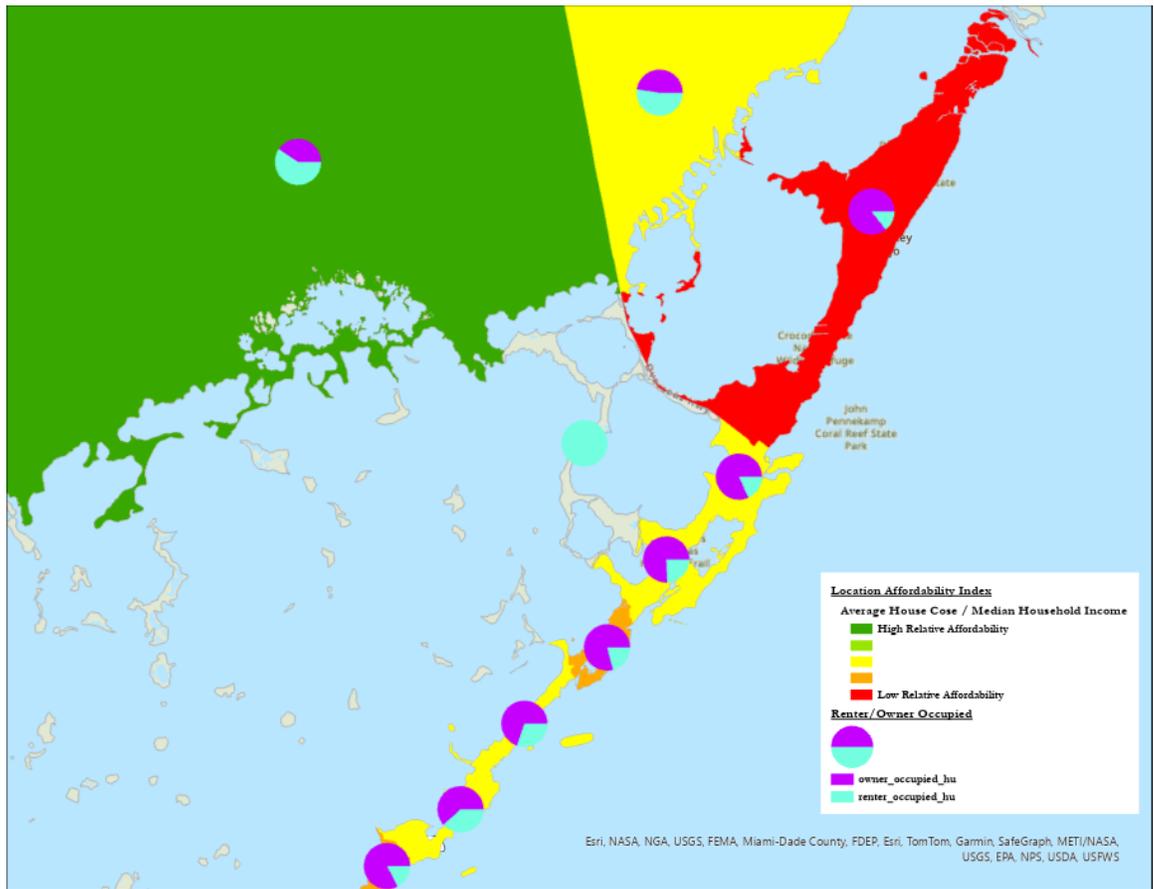


Figure 108 - Location Affordability within Monroe County (Middle Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.

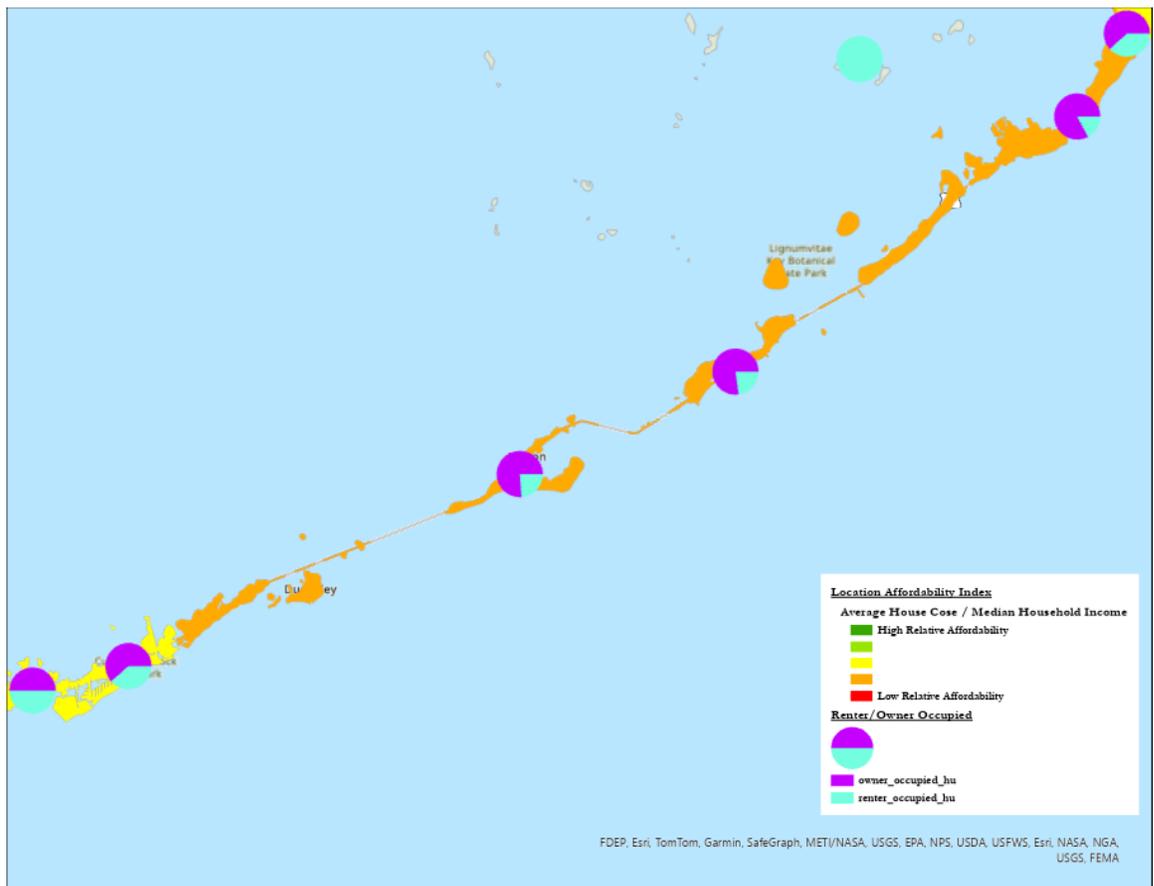


Figure 109 - Location Affordability within Monroe County (Lower Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.

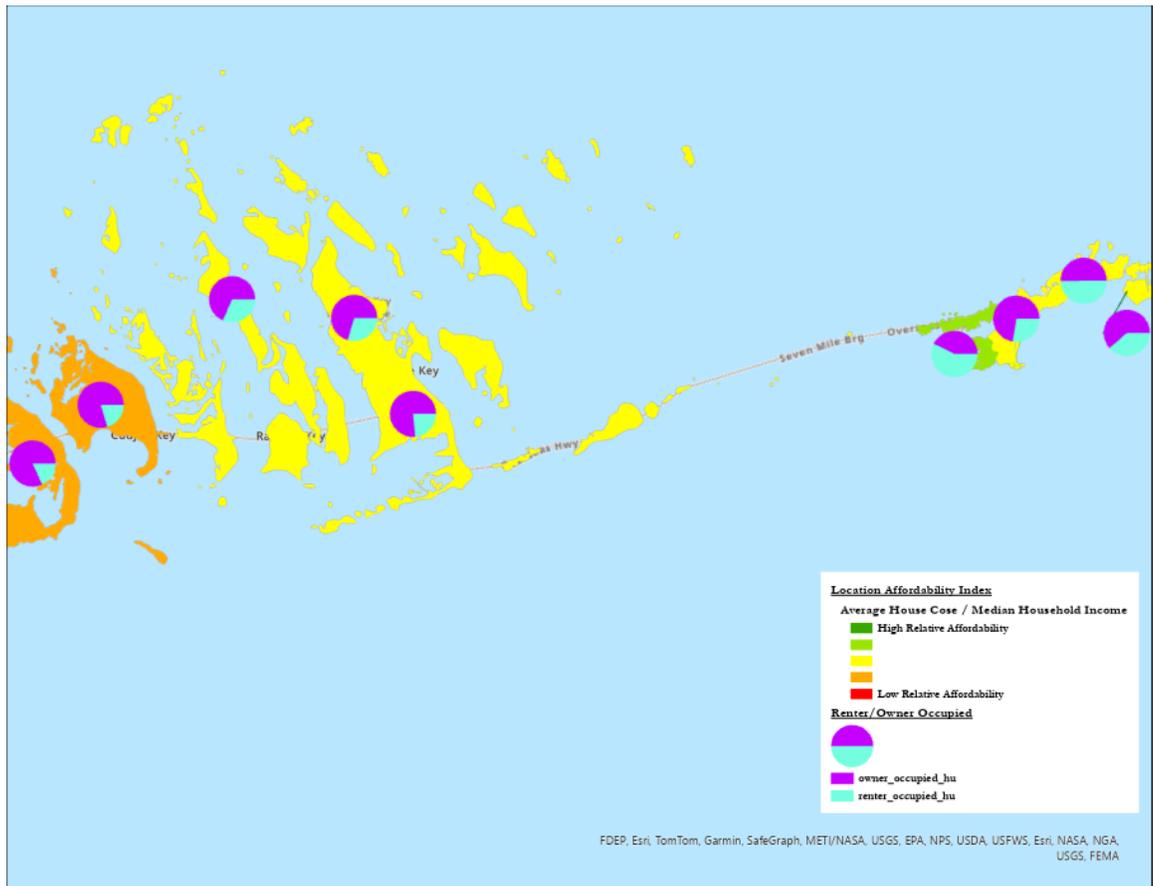
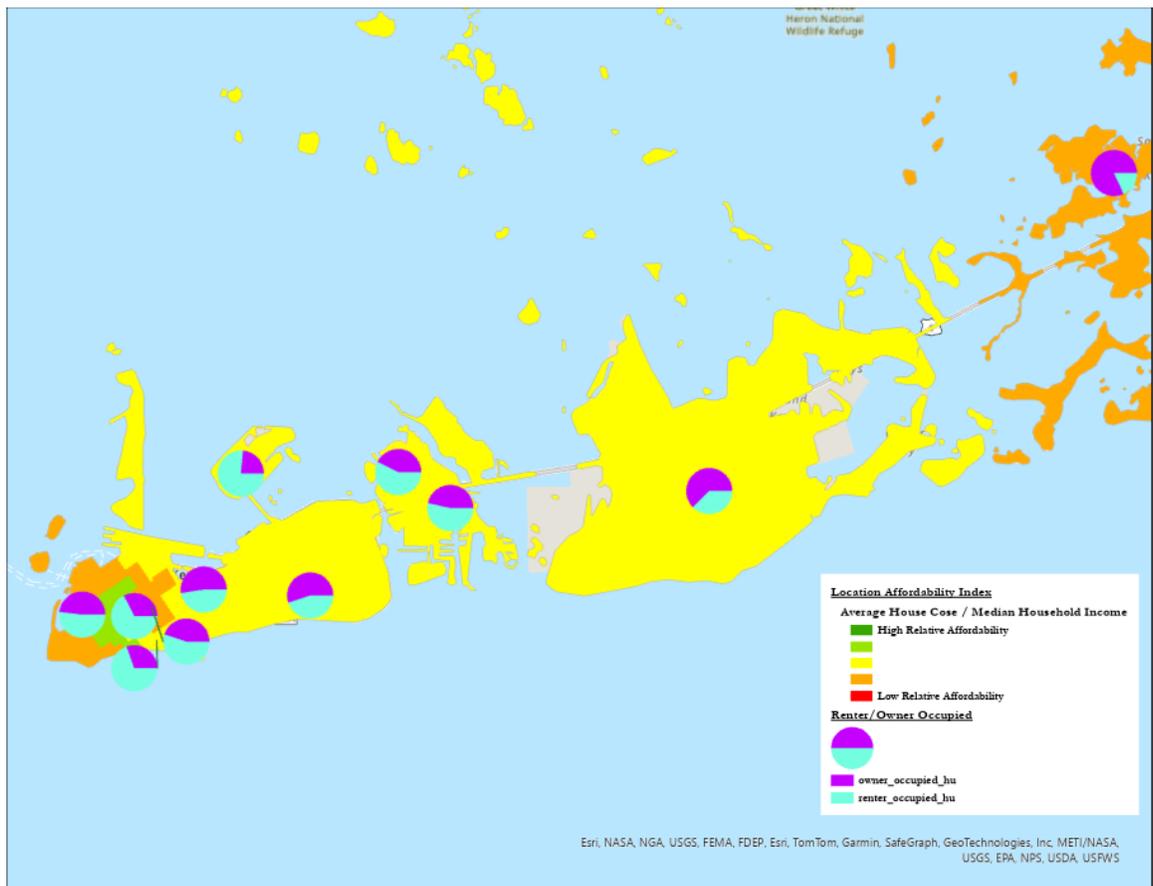


Figure 110 - Location Affordability within Monroe County (Lower Keys)

Green denotes areas where housing and transportation costs are more affordable, relative to income; red and orange signify areas where incomes are less sufficient to cover housing and transportation costs; yellow is in between. Pie chart overlays represent the ratio of total owner-occupied housing in blue and renter-occupied housing in purple.



Household Profiles

This 2024 Vulnerability Assessment for Monroe County introduces several household profiles to better understand the socioeconomic fabric of the county and tailor resilience strategies accordingly. Each profile encapsulates distinct economic realities, from those barely making ends meet to families enjoying financial stability.

Very Low-Income Individuals: These are residents at the lowest economic tier

within the community, earning significantly less than the majority. They represent the segment most in need of comprehensive support and intervention, reflecting profound financial challenges that necessitate targeted assistance programs to ensure their well-being and societal integration. This suggests significant economic challenges and a potential need for targeted financial assistance and social services to improve their quality of life and economic stability.

Working Individuals: This group includes a broad spectrum of the workforce, from those employed full-time to part-time across various sectors. Their economic situation is somewhat stable, yet precarious, marked by a delicate balance between earnings and expenditure that could be easily disrupted by unforeseen financial demands or economic downturns. This group likely includes a mix of full-time and part-time workers in various sectors, possibly facing moderate financial constraints with some disposable income but also vulnerabilities to economic downturns or unexpected expenses.

Retired Couples: Enjoying the fruits of their lifelong labor, retired couples generally occupy a more comfortable economic position, buoyed by pensions, savings, or other retirement benefits. While they are less vulnerable to immediate financial shocks, they may require support with healthcare and aging-related services to maintain their quality of life. This suggests that they likely have a stable source of retirement income, such as pensions or savings, positioning them relatively comfortably in terms of economic security. This group may have fewer financial vulnerabilities but could still require services geared towards healthcare and aging.

Single-Parent Families: Single parents navigate the complexities of raising children on a single income, a challenge compounded by the costs associated with childcare and education. This group's economic positioning, while not at the bottom, is fraught with unique pressures that call for policies aimed at easing their financial and caregiving burdens. Despite being in the middle-income bracket, the demands of single parenting, including childcare and educational expenses, can strain their financial resources, highlighting the need for supportive policies that address childcare, education, and healthcare.

Moderate Income Families: Representing a relatively comfortable middle ground in the economic spectrum, families in this category have a stable income that supports a decent standard of living. However, they are not immune to financial strains, particularly regarding housing, education, and healthcare expenses, underscoring the need for adaptable support systems.

Table 26 - LAI Household Profiles of Interest and their Median Household Income

Household Profile	Median Household Income for a Given Area (MHHI)
2. Very Low-Income Individual	National Poverty Line
3. Working Individual	50% of MHHI
5. Retired Couple	80% of MHHI
6. Single-Parent Family	50% of MHHI
7. Moderate-Income Family	80% of MHHI

Each of these profiles plays a crucial role in shaping Monroe County's approach to building a resilient and inclusive community. By acknowledging the diverse economic realities of its residents, the county can devise targeted strategies that not only address immediate vulnerabilities but also lay the groundwork for sustainable development and prosperity.

Policy, Land Use and Development

The process of conducting a vulnerability assessment generates an immense amount of data and analysis, but what the community does with those resources is even more important than the information itself. Key mechanisms through which a community can make better decisions based on the outcomes of a vulnerability assessment include its budget, infrastructure design, and land use/land development policies. Each of these examples is discussed in this section.

Budget Implications

This vulnerability assessment can help the City target investments into priority areas by focusing on the flooding hot spots identified. The flooding hot spots show current and increasing flood risk based on the type of flooding. For hot spots subject to tidal flooding, shoreline defense strategies might include seawall improvements, living shorelines, or controlling other tidal impacts through backflow prevention on stormwater outfalls. These strategies can help protect the critical assets identified in those hot spots, as well as the property and business owners relying on those assets for their day-to-day quality of life. Hot spots where rainfall is the primary driver of current and future flood risk are already known to be flood-prone areas, so any updated, more advanced hydrological modeling will serve as a further check and balance on stormwater improvement priorities. Accordingly, the County should

consider an update to its previous Stormwater Management Master Plan from 2001. Furthermore, prioritizing investments in flooding hot spot areas can maintain or improve stormwater levels of service defined with the County's Comprehensive Plan and Code and again assist in targeting investments to the areas that will be impacted the soonest. These prioritization strategies would essentially take place as part of the County's existing capital improvements and budgeting processes.

Infrastructure Design

When designing infrastructure in the County, there are two basic concepts: the actual design of a project and the level of service it provides. Excerpts related to these two concepts from the County's Development Standards in the Code and level of service in the Comprehensive Plan follow, leading into discussion of how the outcomes of this Vulnerability Assessment might be used to shape the County's policies moving forward. These sections form the basis of the County's current policies that consider flood risk. Given the information produced through the Vulnerability Assessment, next steps will include integrating the information learned from the VA process into this existing policy framework and consider new policies that can account for current and future flood risk. Flood conditions are changing. Future precipitation events are becoming more extreme, producing higher volumes of rainfall that will stretch the capabilities of existing drainage infrastructure. Current drainage patterns and operations will be compromised, as increasing tidal flooding downstream in coastal areas obstructs outfalls. The City should consider its existing levels of service for drainage and floodplain management and determine if they can be enhanced considering these new environmental conditions.

Stormwater

In the County's Code several provisions apply to stormwater management:

Section 114-3, Article I, Chapter 114 contains the provisions related to the County's Stormwater¹⁵ Management Program.

Sec. 114-3. - Surface Water Management Criteria.

(a) Intent. It is the intent of this section to establish guidelines and criteria for the safe management and disposal of stormwater runoff from developed areas that will minimize or eliminate any resultant adverse impacts on the surface water, groundwater, and other natural resources of the county. These guidelines consider the effects of sea level rise and encourage the use of low

¹⁵ Section 403.031(18), F.S. defines stormwater management systems as follows: "Stormwater management system" means a system designed and constructed or implemented to control discharges that are necessitated by rainfall events, incorporating methods to collect, convey, store, absorb, inhibit, treat, use, or reuse water to prevent or reduce flooding, overdrainage, environmental degradation and water pollution or otherwise affect the quantity and quality of discharges from the system.

impact development and new stormwater management approaches that eliminate off-property discharges. These procedures are intended to assist in protection of the vital water resources of the Florida Keys, including the reservoir of freshwater on Big Pine Key and the near shore waters of the Gulf of Mexico, Florida Bay and the Atlantic Ocean.

(b) Applicability. Projects discharging to impaired waters or to Outstanding Florida Waters (OFW) are subject to additional requirements for mitigation of pollutant loads. Single-family and duplex residences are required to observe best management practices (BMP's) as identified in the sections of the current edition of the County's Manual of Stormwater Management Practices clearly labeled as applicable to single-family and duplex residences and are subject only to the criteria, administrative procedures, and maintenance/retrofitting requirements identified in subsection (d) of this section and other applicable provisions of the Comprehensive Plan and this Land Development Code. All other applications for a county building permit are subject to all the criteria established in this section, except those identified in subsection (c). Except as specifically exempted in subsection (c) below, all development that is nonconforming to the surface water management criteria standards of this article shall be brought into compliance with the criteria of this Section 114-3.

(c) Exemptions. Notwithstanding any other provisions of this Land Development Code, the following activities are exempt from the requirements of this section, unless otherwise required by State or Federal Law:

(1) Maintenance work on existing mosquito drainage structures for public health and welfare purposes, provided that the activities do not increase peak discharge rate or pollution load;

(2) Routine maintenance and minor modification of existing impervious area other than single family and duplex residences provided it meets one of the following conditions:

a. The maintenance does not increase the existing impervious conditions of the site; or

b. The proposed maintenance is certified by a licensed engineer demonstrating that the maintenance will not increase the design peak discharge rate, volume pollution load of stormwater runoff, or impervious coverage of the site; or

c. The placement of a new structure does not change the designed peak discharge rate, volume or pollution load, or increase impervious coverage of site area of stormwater runoff from the site.

(3) Emergencies requiring immediate action to prevent material harm or danger to persons when obtaining a permit is impractical and would

cause undue hardship in protection of property from fire, violent storms, hurricanes, or other hazards. A report of the emergency action shall be made to the county administrator as soon as practicable. All emergency action shall also be temporary in nature and be reversed or appropriately remedied after the emergency has passed;

(4) Single-family and duplex residences built on individual lots that are part of an existing subdivision, provided a stormwater management system approved by the Monroe County Growth Management Division or South Florida Water Management District is in place, and is provided as part of the application materials;

(5) Maintenance, repair, or installation of underground or overhead utility facilities, such as, but not limited to, pipes, conduits and vaults, including replacing the ground surface with in-kind material or materials with similar runoff characteristics;

(6) Installation of a new or replacement of an existing public drainage system, public combined sewer, public sanitary sewer, or public water supply system;

(7) Road and parking lot maintenance limited to the following activities:

a. Pothole and square cut patching;

b. Overlaying existing asphalt or concrete or impervious brick pavement with asphalt or concrete without expanding the area of coverage;

c. Shoulder grading;

d. Reshaping or regrading drainage ditches;

e. Crack sealing; and

f. Vegetation maintenance.

(d) Single-family and duplex residences.

(1) Criteria. All water quantity and water quality criteria as per subsections (f)(1) and (f)(2) of this section.

(2) Administrative procedures. At building permit review, stormwater management criteria will be applied, generally to assess the applicant's compliance with these criteria through the implementation of best management practices. An applicant's stormwater management plan must comply with the criteria listed in subsection (f) of this section and follow the guidelines outlined in the document entitled Layman's Brochure distributed by the county.

(3) Lot coverage expansion/retrofitting requirements. Those existing single-family and duplex lot owners wishing to expand impervious area

shall bring the increase in impervious area into compliance with this section. Any substantial improvements shall be brought into compliance with the applicable provisions of the land development regulations in accordance with Section 114-3(f)(1) and 114-3(f)(2).

(e) General criteria.

(1) Water management areas. Such areas shall be legally reserved to and maintained by the operational entity and be dedicated on the plat, deed restriction, or easements. Any change in the use of the property must comply with this regulation and any other requirements of the Comprehensive Plan and this Land Development Code. Stormwater management areas shall be connected to a public road or other location from which operation and maintenance means of access are legally and physically available to the operational entity, in accordance with county land development regulations governing subdivision of land.

(2) Environmental impacts. All surface water management plans shall be reviewed by the staff to evaluate anticipated impacts of the proposed work on the environment of the county. The following environmental features, among others, shall be used by the staff in evaluating impacts:

- a. Wetlands;*
- b. Water bodies (including determination of discharge to impaired waters or OFW);*
- c. Intermittent (seasonally wet) ponds;*
- d. Mixed upland and wetland systems;*
- e. Pinelands;*
- f. Dunes/beach berms;*
- g. Hammock areas;*
- h. Uplands areas; and*
- i. Preferred habitat of rare and endangered plant and animal species.*

(3) Legal operational entity requirements.

a. An acceptable, responsible entity that agrees to operate and maintain the surface water management system shall be identified in the building permit application. The entity must be provided with sufficient ownership so that it has control over all water management facilities authorized. The following are examples of entities that are acceptable:

1. Governmental agencies;
2. Nonprofit corporations, including homeowners associations, property owners associations, condominium owners associations, or master associations; or
3. The property owner as permittee, or his successors, if the property is wholly owned by the permittee and is intended to be so retained.

b. The entity must provide legally binding written documentation that it will accept the operation and maintenance of all surface water management systems prior to approval.

(4) *Water quality considerations.* All new surface water management systems shall be evaluated based on the ability of the system to prevent degradation of receiving waters. All new surface water management systems shall be designed to either:

a. Meet net improvement criteria as defined in Section 114-2(a)(5); or

b. Reduce the post-development annual average stormwater for both total nitrogen load and total phosphorus load by 95%.

(5) *Water quantity considerations.* All new stormwater management systems shall be evaluated on the ability of the system to prevent flooding of on-site structures, adjacent properties, roads, and road rights-of-way based upon antecedent rainfall conditions.

(f) *Technical criteria.*

(1) *Water quantity.*

a. *Discharge.* Off-site discharge is limited to amounts that will not cause adverse off-site impacts.

These amounts are:

1. Historic discharges based on natural site drainage patterns; or

2. Amounts determined in previous South Florida Water Management District or the county permit actions.

b. *Drainage and flood protection criteria.* The surface water management system shall be designed using a 24-hour rainfall duration and 25-year return frequency in computing allowable off-site discharge rate. Flood protection and floodplain encroachment standards shall be those established in the

Monroe County Land Development Regulations and Comprehensive Plan. If post-development conditions are such that a volume greater than the retention and/or detention volume required for stormwater management is already being retained on site, that condition shall be maintained.

(2) Water quality.

a. Degradation of receiving water quality prohibited. Projects shall demonstrate either of the following:

- 1. Meet net improvement criteria: or*
- 2. Reduce the post-development annual average stormwater for both total nitrogen load and total phosphorus load by 95%.*

b. Presumption of Compliance. Projects designed, constructed, operated, and maintained in accordance with the BMPs requirements found in the current edition of the Manual of Stormwater Management Practices are presumed to be in compliance with the requirements of this article.

- 1. Requirements for submittal include a stormwater pollution prevention plan, an operational phase pollution prevention plan, site-specific water quality evaluation, grading plan (including sufficient topographic information), and all other requirements by permitting agencies*

- 2. For the purposes of this section, the term "disturbed area" includes the entire lot, except that the areas covered by the following BMPs shall be subtracted from the calculation of disturbed area:*

- i. Forested upland areas/vegetative buffer strips (both natural and manmade) which will be retained intact and over or through which vehicular access or travel is not possible and will not occur; and*

- ii. Open water surfaces and wetlands (salt marsh, buttonwood, mangroves, or freshwater marsh habitat types).*

It will be the responsibility of the applicant to affirmatively demonstrate that the BMPs used for the project are designed, constructed, and maintained properly.

3. For the purposes of this section, the term "discharging directly to sensitive waters" means the discharge of runoff via a pipe or channel outfall to the near shore waters, including canals, for which there is no intervening stormwater treatment system such as those listed in subsection (g)(2)b.3. of this section. Sensitive receiving waters are defined as: class I waters, class II waters, class III waters, outstanding Florida waters, impaired water bodies as defined by 62-303, F.A.C., and/or canals connecting with these waters.

(3) Construction considerations. After complying with the water quantity and water quality criteria provisions of this section as applicable, if discharge structures are necessary, the following design construction considerations shall apply:

a. Discharge structures.

1. All design discharges from the site shall be made through and controlled by structural discharge facilities. Earth berms shall be used only to disperse or collect sheet flows from or to ditches, swales, or other water channels, served by discharge structures.

2. Discharge structures shall include gratings for safety and maintenance purposes. Regularly-scheduled removal of trash is mandatory.

3. Discharge structures shall include systems that would allow discharge from other than the top or bottom of the water column and shall include a cleanable jump area for the sediment removal. Discharge structures from areas with greater than 50 percent impervious area or systems with inlets in paved areas shall include a baffle, skimmer, or other mechanism suitable for preventing oil and grease from discharging to and/or from retention/detention areas.

4. Direct discharges, such as through culverts, storm drains, or weir structures, will normally be allowed to receive waters which by virtue of their large capacity and configuration, are easily able to absorb concentrated discharges. Such receiving waters might include existing storm sewer systems and manmade ditches, canals, the bay, channels, and the ocean.

5. Indirect discharges, such as overflow and spreader swales, are required where the receiving water or its

adjacent supporting ecosystem might be degraded by a direct discharge. The discharge structure would therefore discharge into the overflow, spreader swale, or other channel, which in turn would release the water to the actual receiving water. Such receiving waters might include marshes, wetland, salt marshes and land naturally receiving overland sheet flow.

b. Dry retention areas (not applicable to natural or mitigation wetland areas).

1. Dry retention areas shall allow for the return of the groundwater level in the area to the control elevation.

2. On-site mosquito control ditches or other appropriate features for such purpose shall be incorporated into the design of dry retention areas.

3. The design of dry retention areas shall incorporate considerations for regular maintenance and vegetation harvesting procedures.

c. Wet retention areas.

1. Dimensional criteria (as measured at or from the control elevation).

i. Depth. A minimum of 20 percent of the area shallower than six feet is required.

ii. Side slopes for purposes of public safety, water quality enhancement and maintenance. All wet retention areas shall have side slopes no steeper than 4:1 (horizontal/vertical) out to a depth of two feet below the control elevation, or an equivalent substitute. Side slopes shall be topsoiled, nurtured or planted from two feet below to one foot above control elevation to promote vegetation growth. Littoral zone vegetation growth survival shall be a condition for operation permit issuance.

2. Support facility design criteria. Perimeter maintenance and operation easements of ten feet (minimum preferable) width at slopes no steeper than 4:1 (horizontal/vertical) should be provided beyond the control elevation water line. Control elevations must be set so as not to cause flooding in roadways and to protect road subgrades.

d. Impervious areas. Runoff shall be discharged from impervious surfaces through retention areas, detention devices, filtering and cleansing devices, and/or subjected to some type of best management practice (BMP) prior to discharge from the project site. For projects that include substantial paved areas, such as shopping centers, large highway intersections with frequently stopped traffic, and high-density developments, provisions shall be made for the removal of oil, grease, and sediment from stormwater prior to discharge into the receiving waters of a watercourse.

e. Stagnant water conditions. Configurations that create stagnant water conditions shall not be allowed.

(g) Stormwater management plans. It is the responsibility of the applicant to include in the stormwater management plan for the development sufficient information for the Planning Director or designee to evaluate the environmental and stormwater discharge characteristics of the affected areas, the potential and predicted impacts of the proposed activity on community waters, and the effectiveness and acceptability of those measures proposed by the applicant for reducing adverse impacts. The stormwater management plan shall contain maps, charts, graphs, tables, photographs, narrative descriptions, calculations, explanations, and citations to supporting references, and any additional information deemed necessary by the Planning Director. The stormwater management plan must be sealed by an engineer registered in the state with experience in stormwater management and drainage design.

(h) Manual of Stormwater Management Practices and Layman's Brochure.

(1) The Planning and Environmental Resources Department staff shall compile a Manual of Stormwater Management Practices for the guidance of persons preparing stormwater management plans and designing or operating stormwater management systems. The Manual of Stormwater Management Practices (March 2020) and Layman's Brochure (March 2020) shall be the primary implementation tool and shall be updated periodically to reflect the most current and effective practices. The Manual of Stormwater Management Practices and Layman's Brochure shall be made available to the public.

(2) The Manual of Stormwater Management Practices shall include guidance and specifications for the preparation of stormwater management plans. Acceptable techniques for obtaining, calculating, and presenting the information required in the stormwater management plans shall be described.

(3) The Manual of Stormwater Management Practices and Layman's

Brochure shall include guidance for acceptable best management practices (BMP's) for stormwater management systems for single-family and duplex residences. It shall address the condition that improvements to the land may result in water improvement, thereby creating surface water over land that would otherwise not be wetland.

(4) The Manual of Stormwater Management Practices and Layman's Brochure shall include guidance in the selection of environmentally sound practices for the management of stormwater and the control of erosion and sedimentation. The development and use of techniques that emphasize the use of natural systems shall be encouraged.

(5) The Manual of Stormwater Management Practices shall also establish minimum specifications for the construction of stormwater management facilities. Construction specification shall be established in accordance with sound engineering practices.

(6) The Planning and Environmental Resources Department shall submit the Manual of Stormwater Management Practices and subsequent revisions of it to the BOCC for review and approval. The Manual of Stormwater Management Practices may also be submitted for review to the Florida Department of Environmental Protection's Nonpoint Source Management Section in Tallahassee, Florida, and the South Florida Water Management District.

(7) Adherence to these regulations shall be based on the guidelines outlined in the Manual of Stormwater Management Practices.

In the County's 2017 Comprehensive Plan, stormwater management systems policies are as follows in Goal 1001:

GOAL 1001

Monroe County shall provide a stormwater management system which maintains precipitation-based drainage to protect real and personal properties, public health and safety, and which promotes and protects groundwater and nearshore water quality [F.S. § 163.3177(6)(c)]

Objective 1001.1

Monroe County shall ensure that at the time a certificate of occupancy or its functional equivalent is issued, adequate stormwater management facilities are available to support the development at the adopted level of service standards. [F.S. § 163.3177(6)(c)]

Policy 1001.1.1

Water Quality Level of Service Standards - Minimum Water Quality:

All projects shall be designed so that the precipitation-based discharges will

meet the design and performance standards established in Rule 62-302.500, F.A.C., and the County's Manual of Stormwater Management Practices and either demonstrate that post development total nitrogen and total phosphorous loads are less than pre-development loads to the receiving water body (net improvement) or demonstrate a ninety-five percent (95%) reduction in stormwater total nitrogen load and total phosphorus load. Treatment and disposal facilities must be designed and operated so that off-site discharges meet Florida State Water Quality/Quantity Standards as set forth in Rule 62-302.500, F.A.C. All projects should be designed in accordance with the Florida Department of Transportation and South Florida Water Management District standards and taking into account projections for sea level rise. [F.S. § 163.3177(6)(c)]

Every three years, after the adoption of the 2030 Comprehensive Plan, Monroe County shall review the standards for detention and retention volumes for surface water to ensure they achieve minimum water quality standards.

Policy 1001.1.2

Monroe County shall maintain land development regulations which provide a Concurrency Management System (See Capital Improvements Policy 1401.4.5). The Concurrency Management System shall ensure that no certificate of occupancy or its functional equivalent will be issued for new development unless adequate stormwater management facilities needed to support the development at the adopted level of service standards are available concurrent with the impacts of development. [F.S. § 163.3177(3)(a)3; F.S. § 163.3180(1)(b), (2)].

The County's Municipal Service Benefit Unit for Sea Level Rise and Flood Mitigation Program

Unique to Monroe County is Article VII - the Municipal Service Benefit Unit (MSBU) for Sea Level Rise and Flood Mitigation Program, the findings of which are contained in Sec. 22-143:

Sec. 22-143. - Findings.

It is hereby ascertained, determined, and declared that:

a) Pursuant to Article VIII, Sec. 1, Florida Constitution, and F.S. §§ 125.01 and 125.66, the county has all powers of local self-government to perform county functions and to render county and municipal services in a manner not inconsistent with law and such power may be exercised by the enactment of county ordinances, including but not limited to the power pursuant to F.S. § 125.01, to establish municipal service benefit units to provide recreation, transportation and other essential facilities.

b) The assessments to be imposed pursuant to this article shall constitute

non-ad valorem assessments within the meaning and intent of the Uniform Assessment Collection Act.

c) The assessments to be imposed pursuant to this article are imposed by the board, not the property appraiser or tax collector. The duties of the property appraiser and tax collector under the Uniform Assessment Collection Act are ministerial.

d) The purposes of this article are to:

(1) provide procedures and standards for the imposition of assessments within the county by resolution under the general home rule powers of a county to impose special assessments; and

(2) authorize a procedure for the funding of public services, facilities, programs, or local improvements providing special benefit to subsequently identified property within the county.

The balance of the local ordinance is largely procedural, but its importance is its creation of a County funding mechanism for capital projects that address broader flood mitigation initiatives.

Land Use / Land Development

Land use and land development policies generally control how communities develop and where. There is potential to improve level-of-service delivery for stormwater and flooding not only in new developments, but also through redevelopment opportunities. The County may wish to consider modifying or adopting new policies in response to increasing flood risk and the outcomes from this Vulnerability Assessment, including:

- Changes to the County’s adopted development stormwater standards, based on an evaluation of whether they are currently being met, whether they will be met in the future based on changing environmental conditions, and whether they can be improved or enhanced to account for reduced downstream outfall capabilities in the face of increasing tidal flooding. Further policy considerations may include exceeding the SFWMD permitting criteria for commercial developments, new residential subdivisions, multi-family developments, and roadways, depending on project location or need to account for reduced outfall capabilities in tidally-influenced areas.
- Updates to the County’s Stormwater Management Master Plan, last updated in 2001. It should be updated based upon work completed in this Vulnerability Assessment, the concurrent Watershed Management Plan update, and the Roads Vulnerability Assessment completed in 2024. An update to the Stormwater Management Master Plan could lead the County to consider

implementing a stormwater assessment for additional funding of stormwater projects. Funding generated by the existing Municipal Service Benefit Unit could be also be used to implement such capital projects.

Completion of an Adaptation Plan that addresses priorities beyond the road elevation and stormwater projects already contained within the Roads Vulnerability Assessment completed in 2024.

Conclusion

This comprehensive vulnerability assessment has illuminated critical insights into Monroe County's susceptibility to climate change and sea level rise. These findings underscore the urgent need for proactive measures to safeguard the county's communities, infrastructure, and environment. By developing and implementing these strategic adaptation plans, Monroe County can enhance the resilience of its critical infrastructure and its people. Focusing on specific areas and involving the community make critical systems more robust and capable of protecting lives and livelihoods during extreme weather events. A These efforts will yield a safer and more resilient future for everyone.

By conducting an in-depth analysis of physical, socio-economic, and environmental vulnerabilities specific to Monroe County, this vulnerability assessment equips decision-makers with a holistic understanding of the county's susceptibility to climate change impacts. This knowledge forms the basis for tailored mitigation and adaptation strategies aimed at enhancing the county's resilience and sustainability.

Monroe County's coastal location exposes it to the relentless forces of sea-level rise, storm surges, and high tide flooding. The potential impacts on critical infrastructure, communities, and the economy are significant and cannot be ignored. By further developing these types of adaptation strategy recommendations and working together with residents and stakeholders, Monroe County can fortify its defenses against the growing threats of climate change.

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APPENDIX A: DATA REQUEST AND GAP ANALYSIS RESULTS

Early on, the project team provided Monroe County with a Data Request (provided under separate cover as Appendix A.1) detailing the types, categories, and specific qualities of information that would be needed to conduct this Vulnerability Assessment thoroughly and in compliance with State of Florida statutory guidelines.

Following collection and submittal of that information by the County, the project team then conducted a Gap Analysis (provided in full under separate cover as Appendix A.2) to identify areas where data were insufficient or missing. This analysis played a crucial role in identifying regions and parameters that required additional data or alternative approaches to fill the gaps.

By pinpointing data deficiencies, the assessment team was able to prioritize efforts to collect missing data or explore alternative methods to estimate the required information. This iterative process allows for continuous refinement of the data collection strategy and ensures the assessment is built on the most reliable and comprehensive data available.

The analysis focused on comparing available data against the information required for effective vulnerability assessment. The identified gaps can be broadly categorized into five challenges, with potential solutions to each.

- **INSUFFICIENT GEOSPATIAL DATA:** Geospatial data provides a geographic dimension to the analysis. The data was insufficient or missing in certain regions, impacting the ability to map and visualize spatial relationships between different entities, such as transportation networks, critical infrastructure, and natural resources. Another example of this is seemingly more relevant to older communities and is exemplified in areas where infrastructure (like stormwater systems) may have been installed but are not mapped within presently available datasets.

Solution to Consider: Create maps of the areas missing asset data to direct

field teams. Utilize permitting systems where possible to extract geospatial data and fill gaps where practicable (for example: stormwater management systems).

- **INCOMPLETE INFRASTRUCTURE AND FACILITIES DATA:** Data within attribute tables were incomplete. This gap affects the assessment of potential vulnerabilities these critical infrastructures may face due to changing environmental conditions. Including more specific components about each asset within geospatial databases allows for those components to be analyzed in similar studies.

Solution to Consider: Perform department specific assessments on most frequently utilized data, encourage data stewardship, and assign specific “owners” for maintaining data quality. Additionally, assigning a data owner enables the public to interact with a particular person, division, branch, or department rather than the general organization.

- **LACK OF UPDATED NATURAL, CULTURAL, AND HISTORIC RESOURCES DATA:** The existing data for some natural, cultural, and historic resources might be outdated or missing, creating gaps in assessing the impact of climate change and sea-level rise on these resources. Generally speaking, this data is traditionally limited to land use inventories, protected species inventories, and protected structures.

Solution to Consider: Solicit community input on identifying/locating socially and/or culturally significant natural areas, cultural assets, and historic resources within the community. Connecting with people and understanding the landscape from a “boots on the ground” perspective is critical.

- **TERMINOLOGY AND NAMING CONVENTION DISCREPANCIES:** A significant challenge that arose during the gap analysis was discrepancies in naming conventions and terminologies across different data sources. For instance, certain datasets might refer to an asset under a different name or categorize it under a different heading. This inconsistency makes it difficult to ascertain whether a critical asset is truly missing from the data, or whether it's simply listed under a different term.

Solution to Consider: Coordinate with data providers to clarify what assets are included in each data category. Develop a standardized nomenclature and taxonomy for the assets and facilities. This approach can help reduce ambiguity and ensure a consistent understanding across all data sources. Additionally, consider creating a cross-reference glossary of terminologies used by different data sources to mitigate the risk of overlooking critical assets due to naming discrepancies. This can be done in collaboration with data providers to ensure the terminologies align with industry standards and

local context. To assist with addressing challenge area 5, including this information within associated metadata would help future analytics teams.

- **INCONCLUSIVE DATA COVERAGE AND METAINFORMATION:** In some cases, it is unclear whether certain databases include certain types of critical assets. For example, bus stops and routes may be included under the general heading of 'Bus Routes' or 'Streets,' but without more specific information, it is difficult to be sure.

Solution to Consider: If the data is not available, consider commissioning targeted surveys or studies to gather the necessary data. The development of metadata, providing detailed information about each dataset, can be a great way to enhance understanding of data coverage. Consider including a percentage of total assets mapped under that specific data type as an element of this metadata to help outside consultants understand if they are working with a dataset that contains 25%, 50%, 75%, or some other percentage of that particular asset.

Considering these gaps, the project team utilized a range of strategies to fill as many data voids as practicable within the assessment timeline. This included tapping into additional data sources not previously considered, such as satellite imagery for geospatial data, government records for infrastructure and facilities data, conservation databases for natural, cultural, and historic resources data, and census data for socioeconomic data. Furthermore, the team may have leveraged methods like statistical estimation or modeling to fill in gaps when direct data collection was not feasible. This comprehensive approach ensures a robust, reliable, and inclusive vulnerability assessment.

As noted above, the Data Request is provided under separate cover as **Appendix A.1**, and the Gap Analysis Results are provided as **Appendix A.2**.

A detailed nautical chart of a coastal region, likely the Chesapeake Bay area, showing islands, water depths, and navigational markers. The chart is overlaid with a grid and various symbols.

APPENDIX B: BASELINE ASSET INVENTORY MAPS

Under separate cover.

APPENDIX C: CRITICAL ASSET INVENTORY WORKBOOK

Critical Assets and Regionally Significant Assets

Subsection 380.093, F.S. Compliance

The assessment process aligns with Subsection 380.093, F.S., utilizing the Florida Department of Environmental Protection’s Critical Asset List. The categories of data collected, organized into four primary categories, are directly correlated with statutory compliance:

- **Transportation Assets** and evacuation routes, including airports, bridges, bus terminals, ports, major roadways, marinas, rail facilities, and railroad bridges.

Layer Name	Asset Type	Geometry	Count	Reg_Sig	Source
Aviation Facilities	Aviation	point	3	Y	Homeland Security
Bridges	Road	point	18		Monroe County
Evacuation Routes	Road	line	13	Y	National Bridge Inventory
Major Roadways	Road	line	199		FDOT
Marinas	Water	point	380		FWC
Boat Ramps	Water	point	25		Monroe County
Port Facilities	Water	point	7	Y	FEMA RAPT
Rest Areas and Welcome Centers	Road	point	10		FDOT
Airport Runways	Aviation	line	5	Y	FEMA RAPT, Homeland Security
Canals	Water	polygon	502		Monroe County
Petroleum Terminal	Road	point	2		Homeland Security

- **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.

Layer Name	Asset Type	Geometry	Count	REG_SIG	Source
Wastewater treatment facilities and lift stations	Wastewater	point	40	Y	FKAA
Stormwater Structures	Stormwater	point	206	Y	Monroe County
Trench Drains	Stormwater	point	84	Y	Monroe County
swManhole	Stormwater	point	33	Y	Monroe County
swInlet	Stormwater	point	65	Y	Monroe County
MTHON POINTS	Stormwater	point	365	Y	Monroe County
Manholes	Stormwater	point	67	Y	Monroe County
KW POINTS	Stormwater	point	366	Y	Monroe County
Injection Wells	Stormwater	point	41	Y	Monroe County
Catch Basins	Stormwater	point	302	y	Monroe County
KW POLYLINES	Stormwater	line	321		Monroe County
MTHON POLYLINES	Stormwater	line	342		Monroe County
swGravity Main	Stormwater	line	413		Monroe County
ssSystem Valve	Sanitary Sewer	point	702		FKAA
ssNetwork Structure	Sanitary Sewer	point	168		FKAA
ssManhole	Sanitary Sewer	point	2098		FKAA
ssLPS Valve	Sanitary Sewer	point	1594		FKAA
ssLPS Pump	Sanitary Sewer	point	1939		FKAA
ssLPS CntlPanel	Sanitary Sewer	point	834		FKAA
ssControl Valve	Sanitary Sewer	point	412		FKAA
FKAA Waste Critical	Sanitary Sewer	point	168		FKAA
wwtpFacilities	Sanitary Sewer	polygon	87		FKAA
wwtpLiquid Storage	Sanitary Sewer	polygon	68		FKAA
wwtpVaults	Sanitary Sewer	polygon	9		FKAA
ssGravity Main	Sanitary Sewer	line	2072		FKAA
ssLPS Main	Sanitary Sewer	line	664		FKAA
ssPressurized Main	Sanitary Sewer	line	1519		FKAA
rTank	Reclaimed Water	point	1		FKAA
rSystem Valve	Reclaimed Water	point	160		FKAA
rNetwork Structure	Reclaimed Water	point	3		FKAA
rControl Valve	Reclaimed Water	point	9		FKAA
FKAA Reuse Critical	Reclaimed Water	point	3		FKAA

Layer Name	Asset Type	Geometry	Count	REG_SIG	Source
rPressurized Main	Reclaimed Water	line	353		FCAA
wTank	Potable Water	point	21	Y	FCAA
wSampling Station	Potable Water	point	331		FCAA
wNetwork Structure	Potable Water	point	20		FCAA
wMaster Tap	Potable Water	point	155	Y	FCAA
wHydrant	Potable Water	point	1656		FCAA
wControl Valve	Potable Water	point	1327		FCAA
wCathodic Rect	Potable Water	point	67		FCAA
wCathodic Protection	Potable Water	point	542		FCAA
FCAA Potable Critical	Potable Water	point	30		FCAA
FCAA Buildings	Potable Water	point	64		FCAA
wtpFacilities	Potable Water	polygon	130		FCAA
wtpTanks	Potable Water	polygon	65		FCAA
wtpVaults	Potable Water	polygon	62		FCAA
wtpWell	Potable Water	polygon	31	Y	FCAA
wPressurized Main	Potable Water	line	14827		FCAA
Substations	Electrical	point	22	Y	FKEC
FKEC Transformers	Electrical	point	6432		FKEC
FKEC Substations	Electrical	point	9		FKEC
FKEC Sec Junction Cabinets	Electrical	point	34		FKEC
FKEC Reclosers	Electrical	point	23		FKEC
FKEC PRI Switchgear	Electrical	point	26		FKEC
FKEC PRI Sectionalizing Cabs	Electrical	point	36		FKEC
FKEC PRI Risers	Electrical	point	285		FKEC
FKEC PRI Pullboxes	Electrical	point	408		FKEC
FKEC Pad Mounted Transformers	Electrical	point	833		FKEC
Electrical Overhead Distribution Lines	Electrical	line	35448		FKEC
Solid and Hazardous Waste Facilities	Solid Waste	point	364		FDEP
Weather Radar Stations	Communication	point	1		Homeland Security
USPS	Communication	point	3		Homeland Security
US Coast Guard	Military	point	1		Homeland Security
UPS Facilities	Communication	point	17		Homeland Security
Solid Waste Landfill Facilities	Solid Waste	point	8		Homeland Security

Layer Name	Asset Type	Geometry	Count	REG_SIG	Source
Solid Waste Disaster Debris Management Sites	Solid Waste	point	258		Homeland Security
Commercial Transmission Towers	Communication	point	8		Homeland Security
Mobile Broadcast Towers	Communication	point	2		Homeland Security
Microwave Service Towers	Communication	point	162		Homeland Security
Formerly Used Defense Sites	Military	point	14		Homeland Security
FM Transmission Towers	Communication	point	19		Homeland Security
FCAA Admin Critical		point	13		FCAA
FedEx Facilities	Communication	point	13		Homeland Security
DHL Facilities	Communication	point	4		Homeland Security
Department of Defense Sites	Military	point	1		Homeland Security
Critical Facilities		point	76		Monroe County
Closed Landfills	Solid Waste	point	3		Homeland Security
Cellular Towers	Communication	point	38		Homeland Security, FDEP
Military Installations	Military	polygon	6		DOT

- 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.

Layer Name	Asset Type	Geometry	Count	Reg_Sign	Source
State Government Facilities	Law	point	11		Homeland Security
Schools	Education	point	24		Homeland Security
Logistical Staging Area	Emergency	point	19		Homeland Security
Local Government Facilities	Law	point	16		Homeland Security

Layer Name	Asset Type	Geometry	Count	Reg_Sign	Source
Veterans Health Administration Medical Facilities	Non-Emergency Medical	point	2		Homeland Security
Urgent Care Facilities	Non-Emergency Medical	point	2		Homeland Security
Supplemental Colleges	Education	point	1		Homeland Security
State Government Facilities	Law	point	2	Y	Homeland Security
Schools MC	Education	point	9		Monroe County
Public Schools	Education	point	22		Homeland Security
Public Housing Developments	Housing	point	3		Homeland Security
Public Health Departments	Non-Emergency Medical	point	1		Homeland Security
Private Schools	Education		5		Homeland Security
Pharmacies	Non-Emergency Medical	point	23		Homeland Security
Nursing Homes	Housing	point	5		Homeland Security
National Shelter System Facilities	Emergency	point	14	Y	Homeland Security
Mobile Home Parks	Housing	point	101		Homeland Security
Low Income Housing Tax Credits	Housing	point	17		Homeland Security
Local Law Enforcement	Law	point	7		Homeland Security
Hospitals	Emergency	point	4	Y	Homeland Security
Fire Stations	Emergency	point	23		Homeland Security
FDOT Facilities	Law	point	1		FDOT
EMS Stations	Emergency	point	13		FEMA RAPT
Emergency Operations Centers	Emergency	point	2	Y	Homeland Security
Emergency Facilities	Emergency	point	31		Homeland Security
Disaster Management Facilities	Emergency	point	59		Homeland Security
DEP Office Locations	Law	point	1		FDEP
Critical Facilities Government	Law	point	30		Homeland Security
Courthouses	Law	point	3		Homeland Security
Colleges and Universities	Education	point	1		Homeland Security

Layer Name	Asset Type	Geometry	Count	Reg_Sign	Source
Child Care Centers	Education	point	32		Homeland Security
Prisons	Law	polygon	5		Homeland Security
College and University Campuses	Education	polygon	1		Homeland Security

- **Natural, Cultural, Historical Resources**, including conservation lands, parks, shorelines, surface waters, wetlands, and historical and cultural assets.

Layer Name	Asset Type	Geometry	Count	REG_SIG	Source
Historic Structures	Historical	point	9		FDHR
All Places of Worship	Cultural	point	69		Homeland Security
Heritage Trail Line	Natural	line	138		
Surface Waters Flowline	Natural	line	5912		FWC
Districts Canals Levees	Natural	line	11		FWC
Shorelines	Natural	line	7523		FWC
Ports Waterways	Natural	line	1		FWC
Historical Bridges	Historical	line	32		FDHR
Wetlands	Natural	polygon	6452		FWC/FDEP
Surface Waters Areas	Natural	polygon	3036		FWC
Ponds	Natural	polygon	50		FWC
Parks Structures	Cultural	polygon	83		Homeland Security
Parks	Cultural	polygon	10		Homeland Security
Resource Groups	Cultural	polygon	49		FDHR
National Registry Listed	Historical	polygon	36		FDHR
Florida State Parks	Natural	polygon	10		FDEP
County Conservation Lands	Natural	polygon	3932		Monroe County
Conservation Lands by Manager	Natural	polygon	47		FDEP
Conservation Lands	Natural	polygon	27156		FDEP
Conservation Easements	Natural	polygon	2		FDEP
Cemeteries	Cultural	polygon	6		FDHR
Archeological Sites	Historical	polygon	56		FDHR

- **Regionally Significant Assets:** As defined in Subsection 380.093, F.S., regionally significant assets are critical facilities that serve a broader geographic area, including neighboring communities. These assets may encompass water resource facilities, regional medical centers, emergency operation centers, regional utilities, major transportation hubs, airports, and seaports. Identifying and safeguarding these assets is crucial for regional resilience and response coordination.

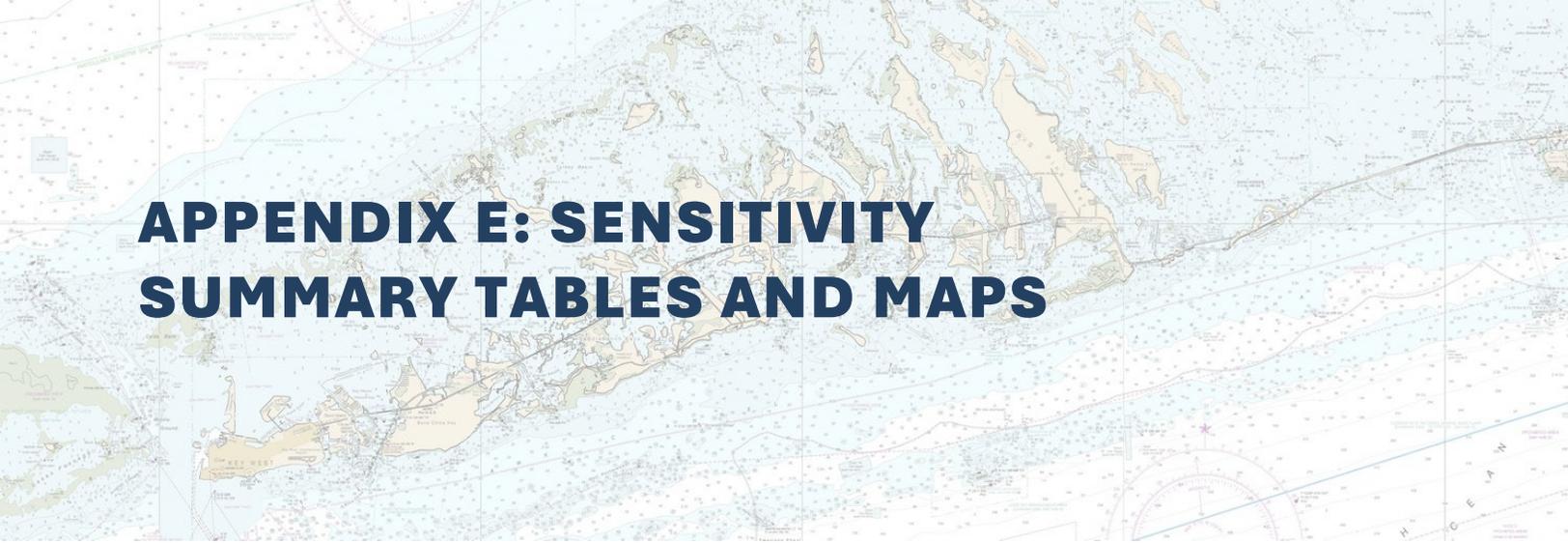
Layer Name	Asset Class	Asset Type	Geometry	Count	Source
Electrical Substations	Critical Infrastructure	Electrical	point	22	FKEC
Hospitals	Critical Community and Emergency	Emergency	point	4	Homeland Security
Emergency Operations Center	Critical Community and Emergency	Emergency	point	2	Homeland Security
Airports	Transportation	Aviation	point	3	Homeland Security
Evacuation Routes	Transportation	Road	line	13	National Bridge Inventory
Bridges	Transportation	Road	point	18	Monroe County
Potable Water Facilities	Critical Infrastructure	Potable	polygon	130	FCAA
Wastewater Facilities	Critical Infrastructure	Wastewater	polygon	87	FCAA
National Shelter System Facilities	Critical Community and Emergency	Emergency	point	14	Homeland Security

This tabulation informs the resulting asset lists generated within the hot spots within this vulnerability assessment. Collaboration with local government entities will facilitate further identification of critical and regionally significant assets, ensuring a comprehensive assessment of potential climate risks and effective planning for the County’s future.

A nautical chart showing a coastal area with islands and water depths. The chart includes various symbols for navigational hazards, depth soundings, and geographical features. The text 'APPENDIX D: EXPOSURE ANALYSIS MAPS' is overlaid in large, bold, dark blue letters.

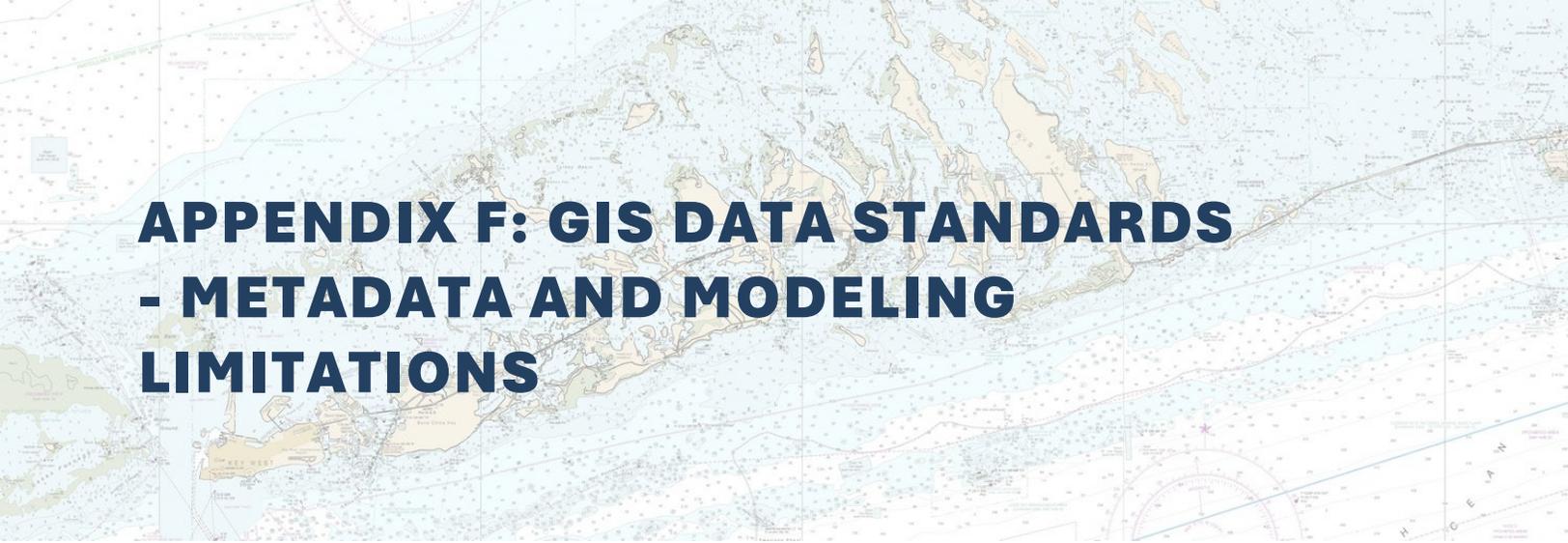
APPENDIX D: EXPOSURE ANALYSIS MAPS

Under separate cover.

A nautical chart showing a coastal area with islands and reefs. The chart includes depth soundings, navigational aids, and a compass rose. The text is overlaid on the top portion of the chart.

APPENDIX E: SENSITIVITY SUMMARY TABLES AND MAPS

Under separate cover.



APPENDIX F: GIS DATA STANDARDS - METADATA AND MODELING LIMITATIONS

Resilient Florida Planning Grants GIS Data Standards

This appendix outlines the Geographic Information System (GIS) data standards, metadata requirements, and modeling limitations pertinent to flood climate projections. Adhering to these standards ensures that all geospatial data used in vulnerability assessments are consistent, accurate, and compatible with the Florida Department of Environmental Protection's (DEP) GIS infrastructure. The document serves as a reference for stakeholders involved in resilience planning, flood risk management, and emergency preparedness.

Pursuant to [Section 380.093 \(3\)\(c\), Florida Statutes](#), grantees who receive funding to complete a vulnerability assessment shall submit to the Florida Department of Environmental Protection (DEP) all electronic mapping data used to illustrate the flooding and sea level rise impacts identified in the assessment. The grantees shall also submit the associated metadata for each geospatial item. These items must be compatible with DEP's Geographic Information System (GIS) infrastructure and tools and mapping coordinate reference systems. To aid in the compliance with this requirement, the following list has been compiled of acceptable digital data formats, metadata standards and required mapping datums.

Digital File Formats:

- Vector Data Formats:
 - [File Geodatabase Feature Class](#) - Feature classes are homogeneous collections of common features, each having the same spatial representation, and containing both the geometric shape of each feature as well as descriptive attributes. Feature classes can only be

stored inside a geodatabase. This is an Esri proprietary format.

- Raster Data Formats:
 - File Geodatabase Raster - Native data model for storing raster datasets inside a geodatabase. This is an Esri proprietary format.

Datums and Coordinate Reference Systems:

- Geospatial data shall be delivered projected into the appropriate Florida State Plane Coordinate System.
- Horizontal Datum: North American Datum of 1983 with 1990 Adjustments (NAD83/90), or later.
- Vertical Datum: North American Vertical Datum of 1988 (NAVD88).

Metadata Standards:

- Metadata shall be compliant with the *Content Standard for Digital Geospatial Metadata* (CSDGM) developed by the Federal Geographic Data Committee (FGDC). Acceptable formats are:
 - File Geodatabase FGDC-CSDGM Metadata - format for creating and editing the metadata of Esri items. The metadata is embedded in the item it describes. This is an Esri proprietary format.
- The Department encourages metadata to include the following information, as applicable:
 - Title - Name for the dataset.
 - Summary - Short summary of what the dataset represents.
 - Description - Basic information about the dataset and its purpose.
 - Process Summary - Steps in creating the dataset or layer.
 - Dates of Data Collection - Collection date of the dataset.
 - Date of Publication - Date of publishing or last update of the dataset.
 - Contact Person - Person responsible of the maintenance of the dataset.
 - Credits - Person or entity responsible for the compiling the dataset.

- Use Limitation - Restrictions or legal prerequisites to using the dataset.

Critical Assets Attributes

- To standardize information for all the critical assets across the state, delivered critical asset datasets should have following attributes, as applicable:
 - Entity Name - Name of entity (i.e., County, city, local government, etc).
 - Asset Name - Asset label or description (i.e., hydrant, stormwater pipe, cell tower, etc).
 - Asset Type - Statutory asset type (i.e., airports, bridges, roadways, marinas, etc).
 - Asset Class - Statutory asset group (i.e., transportation and evacuation route, critical infrastructure, critical community and emergency facilities, etc).
 - Asset Owner/Operator - The owner or maintainer of the asset.
 - Asset Elevation - Elevation of the asset.
 - Asset Size/Capacity Data (i.e., capacity for wastewater facilities, acres, etc.)
 - Asset Unique ID - Unique identifier of the asset.

Pursuant to 380.093(2) Definitions, **Asset Type** refers to the individual asset, and **Asset Class** refers to the broader asset category. See classification table below:

Asset Type	Asset Class
Airports	Transportation and Evacuation Routes
Bridges	Transportation and Evacuation Routes
Bus Terminals	Transportation and Evacuation Routes
Ports	Transportation and Evacuation Routes
Major Roadways	Transportation and Evacuation Routes
Marinas	Transportation and Evacuation Routes
Rail Facilities	Transportation and Evacuation Routes
Railroad Bridges	Transportation and Evacuation Routes
Wastewater Treatment Facilities and Lift Stations	Critical Infrastructure
Stormwater Treatment Facilities and Pump Stations	Critical Infrastructure
Drinking Water Facilities	Critical Infrastructure
Water Utility Conveyance Systems	Critical Infrastructure
Electric Production and Supply Facilities	Critical Infrastructure
Solid and Hazardous Waste Facilities	Critical Infrastructure
Military Installations	Critical Infrastructure
Communications Facilities	Critical Infrastructure
Disaster Debris Management Sites	Critical Infrastructure
Schools	Critical Community and Emergency Facilities
Colleges and Universities	Critical Community and Emergency Facilities
Community Centers	Critical Community and Emergency Facilities
Correctional Facilities	Critical Community and Emergency Facilities
Disaster Recovery Centers	Critical Community and Emergency Facilities
Emergency Medical Service Facilities	Critical Community and Emergency Facilities
Emergency Operation Centers	Critical Community and Emergency Facilities
Fire Stations	Critical Community and Emergency Facilities
Health Care Facilities	Critical Community and Emergency Facilities
Hospitals	Critical Community and Emergency Facilities
Law Enforcement Facilities	Critical Community and Emergency Facilities

Local Government Facilities	Critical Community and Emergency Facilities
Logistical Staging Areas	Critical Community and Emergency Facilities
Affordable Public Housing	Critical Community and Emergency Facilities
Risk Shelter Inventory	Critical Community and Emergency Facilities
State Government Facilities	Critical Community and Emergency Facilities
Conservation Lands	Natural, Cultural, and Historical Resource
Parks	Natural, Cultural, and Historical Resource
Shorelines	Natural, Cultural, and Historical Resource
Surface Waters	Natural, Cultural, and Historical Resource
Wetlands	Natural, Cultural, and Historical Resource
Historical and Cultural Assets	Natural, Cultural, and Historical Resource

Compliance with FDEP Standards

Both geodatabases adhere to the Florida Department of Environmental Protection (FDEP) standards:

- **Digital Formats:**

- **Analysis Rasters Geodatabase:** Uses File Geodatabase Raster format.
- **Critical Asset Inventory Geodatabase:** Uses File Geodatabase Feature Class format.

- **Coordinate Systems:**

- Both geodatabases are projected into the appropriate Florida State Plane Coordinate System.
- **Horizontal Datum:** NAD83/90 or later.
- **Vertical Datum:** NAVD88.

- **Metadata Standards:**

- Metadata complies with the Content Standard for Digital Geospatial Metadata (CSDGM) by the Federal Geographic Data Committee (FGDC).

- Provided within the geodatabases, attached to feature classes/rasters, and as separate XML files.
- **Critical Asset Attributes:**
 - The Critical Asset Inventory includes all required attributes to standardize information across the state, facilitating consistent analysis and reporting.
- By complying with these standards, the datasets ensure compatibility with DEP's GIS infrastructure, supporting effective flood risk management, resilience planning, and emergency preparedness efforts.

Provided Geodatabases and Metadata

Here is an overview of the compliance efforts and where to find the relevant data:

Analysis Rasters Geodatabase

Title: Analysis Rasters (.gdb)

Content: This geodatabase contains flood projection data utilized for exposure analysis in the flood vulnerability assessment. It includes raster layers representing various flood scenarios, such as sea-level rise projections, high tide flooding frequencies, storm surge events, rainfall-induced flooding, and compound flooding assessments.

Location: "Analysis_Rasters.gdb" in the project files.

Metadata: Detailed metadata is included for each raster layer within the geodatabase. Metadata provides information on data sources, processing methods, scenario descriptions, and usage limitations.

Format: File Geodatabase Raster (Esri proprietary format)

Projection: Florida State Plane Coordinate System

Horizontal Datum: North American Datum of 1983 with 1990 Adjustments (NAD83/90) or later

Vertical Datum: North American Vertical Datum of 1988 (NAVD88)

Metadata Format: File Geodatabase FGDC-CSDGM Metadata (embedded within the geodatabase and available as separate XML files).

Additional Details:

- **Raster Layers:** The geodatabase includes raster datasets for multiple planning horizons (Present Day, 2040, 2070, and 2100) and sea-level rise scenarios based on NOAA (2017) Intermediate-Low (NIL) and Intermediate-High (NIH) projections. The naming convention indicates scenario parameters, such as sea-level rise projection, high tide flooding frequency, storm surge events, rainfall events, and combined flood events.
- **Data Sources:** Developed using the most recent publicly available digital elevation models from the U.S. Geological Survey (USGS) National Elevation Dataset. Sea-level rise projections were calculated using the NOAA VDatum tool to transform Mean Higher High Water (MHHW) elevations from NAVD88 for each scenario year.
- **Usage:** Intended for planning-level vulnerability assessments to identify areas at risk under various future climate scenarios. Not suitable for site-specific engineering or detailed design applications.
- **Use Limitation:** Data is provided "as is" and based on best available information. Users should be aware of its limitations and not rely on it for detailed engineering analyses without further validation.

Critical Asset Inventory Geodatabase

Title: Critical Asset Inventory (.gdb)

Content: A comprehensive geodatabase containing:

- **Jurisdiction-wide Critical Asset Inventory:** Detailed information on critical assets across Monroe County, categorized by asset type and class.
- **Exposure Analysis Results:** Assessments of assets exposed to projected flood scenarios.
- **Sensitivity Analysis Findings:** Evaluations of asset vulnerabilities based on sensitivity to flooding.

Location: "Critical_Asset_Inventory.gdb" in the project files.

Metadata: Every feature class in this geodatabase is accompanied by compliant metadata. See original data providers for additional metadata information.

Additional Details:

- **Tags:** Vulnerability Assessment, Transportation Assets, Evacuation Routes, Monroe County, Florida, environment, location, planning cadastre, society, structure, transportation, economy, utilities, communication.

- **Summary:** Provides a comprehensive analysis of Monroe County's critical assets for flood risk vulnerability assessment, aiding in resilience planning and emergency preparedness.
- **Use Limitation:** Data is provided "as is" based on the best available information. Intended for high-level vulnerability assessments and planning purposes, not for detailed engineering analyses.

Accessing Metadata

- **Within Geodatabases:** Open the geodatabases using GIS software (e.g., ArcGIS). Right-click on any layer or feature class to view properties and associated metadata.
- **Separate XML Files:** Metadata is also provided as separate XML files within the respective folders for easy viewing and sharing without specialized software.

Usage Considerations

- **Data Limitations:** Both datasets are intended for high-level planning and vulnerability assessments. They are not suitable for detailed engineering analyses or site-specific design without further validation.
- **Data Currency:** The datasets represent conditions as of March 31, 2024. Users should verify if more recent data is available for their specific needs.
- **Liability Disclaimer:** Data is provided "as is." Users accept all responsibility for interpretations or conclusions drawn from the data and release the creators from any liability.

Modeling Limitations

Understanding the limitations inherent in the modeling approaches used in this project is essential for interpreting the results, assessing the scope, and determining its applicability to other planning areas. Constraints such as the project's timeline, budget, scale, and objectives influenced the choice of modeling methods and the level of detail provided.

The project primarily relied on planning-grade hydrostatic (bathtub) modeling, which is often used for preliminary flood assessments. This approach offers a simplified representation of flood scenarios by identifying areas below a certain elevation that are susceptible to flooding, assuming uniform water levels. While this method provides a broad overview, it lacks the ability to account for the dynamic behavior of water, such as flow velocity, wave interactions, and stormwater drainage capacity.

Consequently, the bathtub model can overestimate or underestimate flood extents, particularly in areas with complex topography or where localized drainage and runoff patterns play a significant role.

Hydrological Models

Hydrological models offer a macroscopic overview of water movement, focusing on broad-scale processes such as runoff, infiltration, and evapotranspiration. These models work within the spatial and temporal scales pertinent to the system being studied, but their assumptions about surface processes can lead to inaccuracies when trying to capture localized variations, abrupt changes in water movement, or highly urbanized environments. For instance, the model may not fully reflect the effects of impermeable surfaces or engineered drainage systems, which are critical in urban flood planning. While hydrological models are useful for understanding regional water behavior, they provide only a generalized picture, making them less effective for precise, site-specific flood assessments.

Hydrodynamic Models

In contrast, hydrodynamic models solve the fundamental equations of fluid motion (such as the Navier-Stokes equations) to simulate detailed water flow behaviors, including turbulence, wave interactions, and sediment dynamics. These models are highly detailed and require significant computational resources due to their focus on fine-scale processes. Although hydrodynamic models would offer a more nuanced understanding of flood behavior, especially in coastal or riverine environments, the constraints of this project's timeline, budget, and scope precluded their use. Their application would have provided deeper insights into the complex interactions of floodwaters, but the tradeoff in time and resource allocation was not feasible for this phase of the project.

Hydraulic Models

Hydraulic models specialize in analyzing water movement within controlled environments like channels, pipes, or engineered structures, providing insights into the hydraulic behavior of stormwater systems and other man-made drainage networks. However, they often rely on steady-state assumptions, which may not capture transient phenomena such as sudden storm surges or flash flooding. Additionally, many hydraulic models do not account for sediment transport, further limiting their ability to predict erosion or sedimentation impacts. As with hydrodynamic models, the detailed data required for accurate hydraulic modeling—such as high-resolution cross-sectional profiles of water bodies—was not fully available or feasible within the current project scope.

Data Gaps and Strategic Planning

One of the most significant challenges in this project was the lack of available hydrological and hydraulic modeling data, particularly for detailed flood-depth analysis under various future scenarios, such as rainfall-induced flooding or compound flood events. This gap underscores the need for future strategic efforts in data collection, interdepartmental collaboration, and model integration. By aligning the available models more closely with the county's resilience and adaptation goals, future assessments can address the current gaps, improve accuracy, and enhance the reliability of flood predictions.

While this project provided a critical starting point using bathtub modeling, it is important to acknowledge the limitations of this approach. Future efforts should aim to incorporate more advanced modeling techniques as resources allow, ensuring a more comprehensive understanding of flood risks across different scenarios and improving the County's overall flood resilience.

A nautical chart showing a coastal area with islands, reefs, and depth soundings. The chart is overlaid with a grid and various navigational symbols. The text is centered over the chart.

APPENDIX G: DRAFT AND FINAL LISTS OF CRITICAL ASSETS

Under separate cover

A nautical chart showing a coastal area with islands, water depths, and navigational markers. The chart is overlaid with a grid and various symbols. The text 'APPENDIX H: OTHER SUPPORTING DOCUMENTATION' is centered over the chart.

APPENDIX H: OTHER SUPPORTING DOCUMENTATION