DEP AGREEMENT NO. R2111

Resilient Coastlines Program

Monroe County Board of County Commissioners

Final Project Report

This report was 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.

June, 2021

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Glossary

1. 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.

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

3. 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.

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

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

6. Global Warming – The rise in global temperatures due mainly to the increasing concentrations of greenhouse gases in the atmosphere.

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

8. 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.

9. 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.

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

11. 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.

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

13. 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.

14. Relative Sea Level Rise – The way the height of the ocean rises or falls relative to the land at a particular location.

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

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

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

18. Sea Level Rise (Absolute Sea Level Rise) – The height of the ocean surface above the center of the earth, without regarding to whether nearby land is rising or falling.

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

20. 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.

21. 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.

22. 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.

23. Vulnerability Assessment – A process for identifying who or what is impacted by climate change. It is the combination of exposure, sensitivity, and adaptive capacity.

List of Abbreviations

- AAA – Adaptation Action Area
- CDC – Centers for Disease Control and Prevention
- Compact – Southeast Florida Regional Climate Change Compact
- CRS – Community Rating System
- DEM – Digital Elevation Model
- DEP – Department of Environmental Protection
- FEMA – Federal Emergency Management Agency
- FWC – Florida Fish & Wildlife Conservation Commission
- GIS – Geographic Information Systems
- GHG – Greenhouse Gas
- IPCC – Intergovernmental Panel on Climate Change
- MHHW – Mean Higher High Water
- MLW – Mean Low Water
- MSL – Mean Sea Level
- NASA – National Aeronautics and Space Administration
- NAVD88 – North American Vertical Datum of 1988
- NFIP – National Flood Insurance Program
- NOAA – National Oceanic and Atmospheric Administration
- SFWMD – South Florida Water Management District
- SFHA – Special Flood Hazard Area
- SLAMM – Sea Level Affecting Marsh Model
- SLIP – Sea Level Impact Projection (SLIP) study
- SLR – Sea Level Rise
- USGS – United States Geological Survey
- WMP – Watershed Management Plan

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Introduction

1. Introduction to Monroe County Vulnerability Assessment

In This Section:

I. Introduction to the Monroe County 2021 Vulnerability Assessment

A. Background

Sea level rise is not a new challenge in Monroe County (the "County" or "the Keys"). As an island chain over 100 miles long with many areas of low elevation, extensive canal networks, and a porous foundation, the Keys is already experiencing the impacts of climate change and sea level rise. Sunny-day flooding, more powerful hurricanes, and stronger rainstorms present many complex challenges for managing infrastructure and maintaining quality of life. Since the County began planning its adaptation and resiliency strategy over ten years ago, it has developed a deep and institutional understanding of these threats. This Vulnerability Assessment presents an updated analysis of the Keys' vulnerabilities, with a particular focus on ecological and social vulnerabilities in order to guide future planning efforts.

The Florida Keys is home to a multitude of environmentally-sensitive areas including a National Marine Sanctuary, Four National Wildlife Refuges, the Dry Tortugas National Park and the third-largest coral reef in the world. Preservation of the unique ecosystems and water quality in the Keys is a high priority within the broader conversation of resilience. Monroe County was designated as an "Area of Critical State Concern" in 1984.[1] All of the landmass that makes up the County is situated within state-designated "Outstanding Florida Waters" and the federally-designated Florida Keys National Marine Sanctuary. The County's future social and economic health are inextricably linked to the environment. Because of the County's unique geography, not every adaptation solution that may be available to a mainland community is going to be viable to protect the Keys' island communities against flooding from high tide events, storm surge, and sea level rise.

Image 1: Monroe County is a leader in sea level rise planning. (Source: Monroe County Tourist Development Council, Andy Newman)

Monroe County is a leader in sea level rise planning. The County has been a member of the Southeast Florida Regional Climate Change Compact (Compact) since its inception in 2009, working across disciplines and jurisdictions to develop what is now one of the

[1] Section 380.0552, Fla. Stat., or the "Florida Keys Area Protection Act" established a land use management system applicable to Monroe County that is intended to protect the natural environment, as well as conserve and protect the "community character of the Florida Keys," among other goals. The County coordinates with and reports annually to the Florida Department of Economic Opportunity toward meeting the requirements and objectives set forth pursuant to the statute.

most robust sea level rise planning programs in the State of Florida. The County has collected extensive data and conducted vulnerability assessments and other analyses, both community-wide and site-specific, as well as begun implementation of adaptation projects. These projects include pilot roads elevation projects in the Twin Lakes and Sands Communities. A Countywide "Roads and Flood Mitigation" analysis has been conducted over the past year to the present day in an effort to comprehensively evaluate the vulnerability and "criticality" of all County-owned roads and is likely to be completed in its initial phase by the end of 2021.

Image 2: As an island chain over 100 miles long with many areas of low elevation, extensive canal networks, and a porous foundation, the Keys is already experiencing the impacts of climate change and sea level rise. (Source: Monroe County)

The Keys has a sustainability action plan that guides its resiliency work: the GreenKeys! Climate and Sustainability Action Plan ("GreenKeys!") is updated with new data, policies, programs, and recommendations at least every five years including data from this updated Vulnerability Assessment. A Watershed Management Plan that is consistent with FEMA's National Flood Insurance Program Community Rating System ("CRS") requirements accounting for sea level rise was also recently completed. The County is continuously updating its data collection and vulnerability work in order to ensure sound planning, and this Grant R2111 represents another step in that direction.

While the County has already undertaken initial vulnerability modeling, other more recent initiatives warrant updating its models to serve as the basis for decision-making generally, and specifically, to help serve as the basis for the development of example language to establish Adaptation Action Areas ("AAAs"). This update to the County's Vulnerability Assessment will add current and new data into the mapping output. It will evaluate that data in the context of the updated 2019 Unified Sea Level Rise Projections ("Projections") adopted by the Compact. This project also incorporates outputs from the County's Countywide Roads and Flood Mitigation Analysis as well as data from the County's aforementioned Watershed Management Plan.

This analysis will be utilized to determine infrastructure and habitat impacts, as well as to identify increasingly vulnerable areas for a 2040, 2070, and 2100 planning horizon. This project also incorporates a social vulnerability analysis using best practices and tools identified by the U.S. Centers for Disease Control's ("CDC") Social Vulnerability Index ("SVI").

Finally, the County will consider approaches that incorporate adaptation for infrastructure and public facilities, habitat, and natural resources, as well both public and private property owner adaptation. Updating the Vulnerability Assessment related to habitat impacts will assist the County in aligning land acquisition, management, and restoration policies to utilize critical landscapes, such as mangroves, as a natural resiliency strategy. This has a dual benefit of supporting natural resource-based resilience as well as conservation and environmental stewardship, which are of the utmost importance in the Keys.

B. Resilient Coastlines Program Grant No. R2111

Planning for sea level rise is one of Monroe County's most significant priorities. Accordingly, the County continues to seek and secure funding support for its planning and implementation activities. In 2020, the County was awarded a grant by the Florida Department of Environmental Protection's ("DEP") Resilient Coastlines Program to update its existing vulnerability framework for sea level rise planning. Grant R2111 builds on the County's numerous data collection efforts and analyses to update its Vulnerability Assessment and develop example policy approaches to establish AAAs. The work completed for this Grant R2111 will inform County decision-making for long-term sea level rise planning efforts.

This project builds on the resiliency work the County has been doing for many years. In 2019, the County was awarded a previous grant from DEP also through the Resilient Coastlines Program. That grant, R1915, supported the County's development of comprehensive plan language to comply with Florida's Peril of Flood requirements (Section 163.3178(2)(f), F.S. for the Conservation and Conservation and Coastal Management Element. Grant R1915 also supported an analysis with recommendations to update to the County's other existing comprehensive plan elements incorporating a substantial amount of resiliency planning work and data. This project made recommendations to fully integrated sea level rise into numerous elements of Monroe County's comprehensive plan.

The scope of work for this current Grant, R2111, includes this updated Vulnerability Assessment, as well as several other significant project deliverables that are summarized as follows:

1. Final Memorandum outlining existing data resources, best practices and case studies for the establishment of AAAs.
2. Updated Vulnerability Assessment
3. Memorandum of recommended policy alternatives for the establishment of AAAs
4. Maps, Goals, Objectives and Policies for preliminary AAAs
5. Public engagement meetings
6. Final Report with final recommendations for example AAAs

1. Gap Analysis: Gathering, Reviewing, and Updating Data

A "gap analysis" serves as a qualitative assessment on the accuracy and usefulness of the data utilized by the County for this project. The goal of the gap analysis is to identify areas where data exists or may be improved for the purposes of determining potential vulnerabilities to sea level rise inundation. Based on the gap analysis, the County should work to procure missing or useful information identified.

a. Coordination with Florida Keys Aqueduct Authority, Keys Energy, and Keys Electric Cooperative Association

It should be noted that Monroe County does not own and operate all of the utilities and infrastructure serving the County. The Florida Keys Aqueduct Authority ("FKAA") is responsible for the maintenance and operation of all water and wastewater infrastructure including all plants and linear equipment, pumps and treatment facilities. Keys Energy Services (KEYS) and the Florida Keys Electric Cooperative Association, Inc. (FKEC) operate the electrical infrastructure within the Keys.

The FKAA is the water service provider for the Florida Keys, supplying potable water to all residents while providing reclaimed water and wastewater services in select areas. The FKAA system includes:

- 1,086 Miles of pipe
- 15 Aquifer wells
- 16.5 Million gallons daily
- 26 Pumping Stations
- 45 Bridge crossings
- 48 Million gallons of storage
- 49,123 Customers
- 6 Wastewater plants

The FKAA delivers approximately 17,000,000 gallons per day of high-quality drinking water to the residents of the Florida Keys. FKAA provides central wastewater services to seven regions of the Keys utilizing advanced technologies to maximize nutrient and pollutant removal from wastewater discharges. In two of these areas, the effluent is further disinfected allowing the FKAA to provide valuable reclaimed water to the residents for irrigation. Wastewater from the existing septic systems, on-site systems and cesspits was found to be introducing nutrients and harmful bacteria into the nearshore waters, significantly harming coral and other marine life. With this in mind, providing central sewer throughout the Keys was mandated by the State of Florida in 1999. The project took approximately 20 years and $1 Billion to complete.

FKEC is a member-owned, not-for-profit electric utility serving the Upper and Middle Keys. They serve approximately 33,000 accounts from the Monroe-Dade County line to the Seven Mile Bridge. As a distribution Cooperative, FKEC maintains a 138,000-volt transmission line, which brings power from the mainland to the Florida Keys. FKEC purchases nearly 100% of its energy needs from Florida Power & Light (FPL). Generators in Marathon and FKEC's two solar arrays also contribute to the power supply.

KEYS is the public power utility for the Lower Florida Keys. Headquartered in Key West, Florida, KEYS provides electricity from Key West to the Seven-Mile Bridge and serves more than 28,000 customers. Initially, KEYS only provided electric service to the City of Key West. In 1953, the utility expanded its service area to the Seven-Mile Bridge. In those early years, electricity was produced via local generation. The City of Key West purchased the electric utility in 1943 and the City Council created the Utility Board to oversee KEYS (then known as City Electric System before the utility's name was changed in 2002). In 1969, the Florida State Legislature passed a new enabling act for the governing of KEYS, which is still in effect today, and calls for the popular election of five Utility Board members serving four-year terms. Through the Utility Board, KEYS' customers have a say in their municipal electric utility.

In the late 1970s, the Utility Board studied alternative power supplies and decided to construct a transmission line (or TIELINE) to interconnect to the mainland power grid. On May 8, 1987, KEYS interconnected the TIELINE with the mainland power grid and KEYS' operations changed dramatically. KEYS currently imports nearly all of its power supply and uses local generation for emergency back-up only. The utility relies on power from the mainland because it is far less expensive than local generation. As a member of the Florida Municipal Power Agency's All Requirements Project, KEYS pools its power resources with other public power utilities in the State.

b. Assessment of Existing County and Other Data Sources

The County was provided with the following major categories of requested information to guide data collection efforts: flood understanding and emergency response, built environment, natural environment, and socioeconomic environment. This final Vulnerability Assessment integrates aspects of each category of data collected unless the inclusion of specific datasets was not practicable within the scope and timeline of the project or the data did not exist. Specific information about the community was requested under each category and documented in data request worksheets. Of that data, those listed in Table 1 (Tabulation of Data) in Section 3.A. were either received from the County or gathered by the Project team and were reviewed for completeness and overall usefulness in the assessment.

As previously mentioned, the County has secured extensive LiDAR elevation data that serves as the foundation for its digital elevation model (DEM). Through ongoing efforts, the County has completed other incremental analyses that can be used to update previous modeling work, such as extensive stormwater information developed for the Watershed Management Plan. The County also refined various other datasets since its prior vulnerability work, which served to fast-track this project. Additionally, the County recently completed a Post-Disaster Recovery Strategy, which helped to identify other recovery-specific issues.

2. Public Engagement

Keys residents and stakeholders had multiple opportunities to provide feedback and ask questions of County staff and the Project team about the Vulnerability Assessment. On April 12 (5:30 pm), 14 (2:00 pm), and 15 (5:30 pm), a series of virtual public meetings was held to allow for the maximum participation by residents as possible.

Image 3: Monroe County Public Workshop Announcement (Source Facebook)

The content and format for all three meetings was exactly the same. The meeting format was a hybrid webinar/virtual "town hall" with all proceedings being conducted via Zoom. In each meeting, County staff introduced the work for Resilience Planning Grant R2111, and the Project team gave an informative presentation. Over 50 people attended the 3 combined sessions.

A sample screenshot of the presentation is provided here. Project tasks and subtasks were outlined and described, and a thorough overview of the project was presented. A brief history of the County's many initiatives to address climate change and sea level rise was also provided. The Project team discussed its methodological approach to the Vulnerability Assessment, how the same relates to previous projects and analyses, and the types of data that were collected for this project. Participants were encouraged to ask questions through the Zoom chat function, and at the end of the presentation, people were able to request that specific maps be presented for discussion and review.

Image 4: Rhonda Haag introduces the presentation on the DEP Resiliency Planning Grant R-2111 Sea Level Rise Vulnerability Assessment in a Public Meeting (Source: Monroe County)

Following the series of webinars, the Vulnerability Assessment was also presented to the Monroe County Board of County Commissioners on April 21, 2021. Over two hundred participants from the public attended this meeting over the course of the day with the presentation culminating at the end of the regular meeting agenda.

3. Vulnerability Assessment

Understanding the ecological and economic nuances of specific geographic areas and different types of vulnerabilities is critical to the County's ability to plan effectively. Without this knowledge, there is no basis to consider policies that improve resilience, whether it be coastal flooding from high-tide events, storm surge, flash floods, stormwater runoff, or other related impacts of sea level rise. The following analysis expands on previous efforts and informs the County's decision-making by providing better, more detailed information to identify threatened areas, future infrastructure limitations, and social – as well as economic – considerations.

This grant requires the development of example AAA language based on a data-driven framework that captures County priorities for funding or targeted for future more detailed planning. AAAs language can be included in the Conservation and Coastal Element of the Comprehensive Plan if the County should choose to incorporate this voluntary concept. The example approach will include maps and the AAAs will be supported by goals, objectives, and policies under a separate grant deliverable document.

a. Overview of Modeling Approach

Utilizing a bathtub modeling approach that has been accepted by both state and federal agencies,[2] the Project team assessed Monroe County for its vulnerability to sea level rise inundation using several proprietary analytical functions built within the ArcGIS Pro platform.[3] The future sea level rise estimates used in this assessment were sourced from the 2019 Unified Sea Level Rise Projection ("Projection") from the Compact. The Projection's relative sea level rise curves are depicted in Figure 1 below.

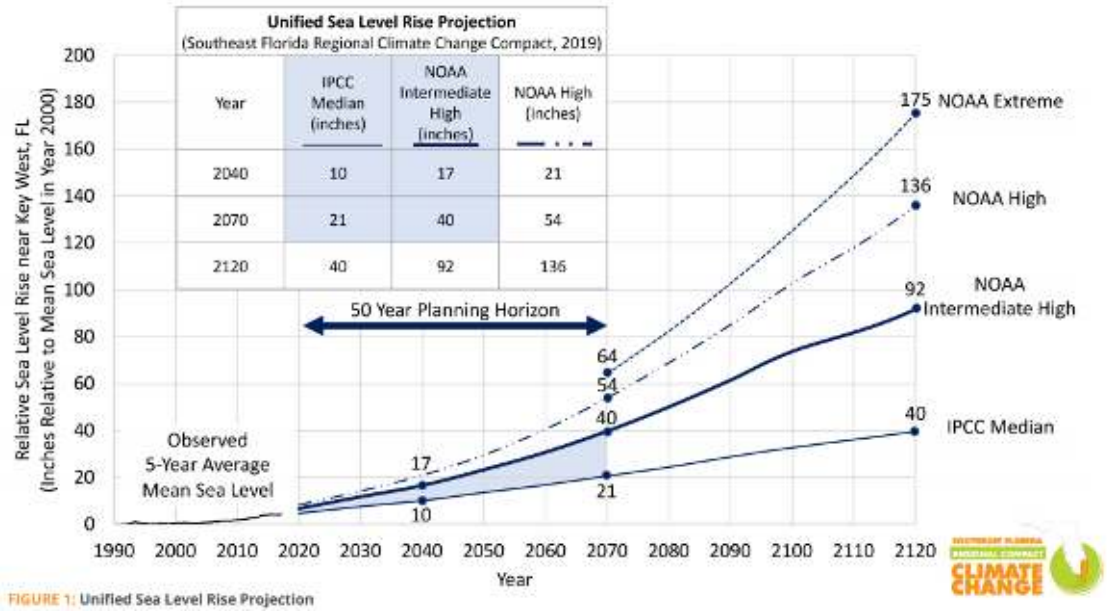


Image 5: The 2019 Unified Sea Level Rise Projection (Source: Southeast Florida Regional Climate Change Compact)

The data gathered (GIS-enabled and non-GIS enabled), which was provided by the County for this project, was utilized to determine the vulnerability of specific infrastructure, land areas, and neighborhoods across the Keys.

The habitat change analysis utilized the most recent version of the Sea Level Affecting Marshes Model (SLAMM), which is an advanced land cover and ecosystem change tool.[4] SLAMM, unlike other flood vulnerability assessment methods, integrates long-term hydrologic functions and ecosystem parameters to give projections about future changes to tidal habitat types, such as saltwater marshes, mangroves, and other coastal wetlands, that are already subjected to regular tidal flooding. The County's previous SLAMM assessment (Warren Pinnacle Consulting, Inc. 2012) was updated using the 2019 Unified Sea Level Rise Projections and the most up-to-date, data and readily accessible LiDAR data, where applicable, in order to identify long-term ecosystem conversion risk potential to upland and intertidal land covers within the County.

[2] Method Description: Detailed Method of Mapping Sea Level Rise Inundation. National Oceanic and Atmospheric Administration Office of Coastal Management (2017).
[3] Environmental Systems Research Institute – ESRI. ArcGIS Pro (2020).
[4] Warren Pinnacle Consulting, Inc. (2016).

b. Social Vulnerability Analysis

The U.S. Centers for Disease Control and Prevention ("CDC") created a tool to assist emergency response planners and public health officials in identifying and mapping communities that will most likely need support before, during, and after a hazardous event.[5] The 2018 Social Vulnerability Index ("SVI") uses U.S. Census data to determine the social vulnerability of each census tract. The SVI ranks each census tract on fifteen social factors, such as poverty, lack of vehicle access, and crowded housing, and groups them into four related themes:
(1) socioeconomic,
(2) minority status and language,
(3) housing composition and disability, and
(4) housing and transportation.

Image 6: Hurricane Irma damage on Islamorada, 2017 (Source: Carlo Allegri for Reuters)

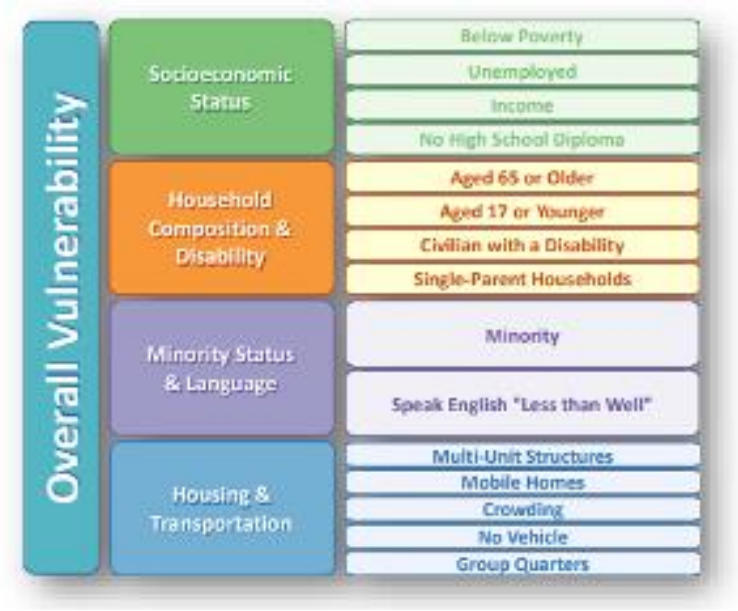


Image 7: SVI Social Vulnerability Index variables for analysis (Source: Centers for Disease Control and Prevention Social Vulnerability Index 2016 Documentation, February 13, 2020, SVI2016Documentation.pdf (cdc.gov).

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

The CDC's SVI database and mapping tools can assist with County emergency preparedness in a number of ways. It can be used to estimate the amount of necessary supplies, such as food, water, medicine, and bedding, as well 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.

[5] Agency for Toxic Substances and Disease Registry's (ATSDR) Geospatial Research, Analysis & Services Program (CDC ATSDR GRASP (2020).

c. *Stormwater Systems*

The County recently completed its Watershed Management Plan under a grant from NOAA. Executed in 2016, the grant *"Advancing Understanding of Risk: Increasing Accuracy of Hazard Damage Assessment Tools by Improving Base Data and Analyzing Opportunities and Barriers for Use in Adaptation Planning"* was completed in August 2019. This grant resulted in field work to collect structure data, summaries of future predicted impacts and recognition and development of strategies to mitigate for impacts to address impacts. The data was also incorporated into GIS format, something the County has never had previously with its last Stormwater Master Plan being completed in 2001. These strategies build upon previous work Project team members had already completed in the County's GreenKeys initiatives, but also work done since that Plan was completed in 2015 with enhanced data collection efforts through field work and analyzing structure data. This grant work included use of the HAZUS[6] model and review of its results and structural data available through the Florida Department of Transportation (FDOT) primarily related to the US-1 transportation facilities (where stormwater structure data exists).

Working with this information, the County reviewed stormwater management systems within this Vulnerability Assessment to update the previous analysis from the Watershed Management Plan. Additionally, work being undertaking in another resilience project – the Roads and Flood Mitigation planning process– was also incorporated into the modeling updates for this project.

d. *Vulnerability Analysis for Adaptation Action Areas*

This Vulnerability Assessment provides the County with a clearer picture of what adaptations are possible and where. Results of the tidal inundation modeling, habitat change modeling, and other efforts associated with this project enabled the County to also identify potential AAAs as previously mentioned. The County developed a data-driven approach that captured its key priorities, and then used this framework in combination with the modeling results to build out future possible AAA boundaries. Upon review of the results of the tidal inundation modeling, habitat change modeling, and the other various efforts undertaken during this Project, the team identified potential AAAs based on a data-driven approach that captured both key objectives and priorities within the County. The bounding polygon identified on the corresponding map series is proposed as an example AAA.

[6] Federal Emergency Management Agency, *Hazus*, https://www.fema.gov/flood-maps/products-tools/hazus (last updated February 16, 2021).

2. Prior Initiatives to Address Sea Level Rise in Monroe County

In This Section:

II. Initiatives to Address Sea Level Rise

The County is a leader in vulnerability planning and has been a member of the Compact since its inception in 2009. In 2016, the County adopted an Energy and Climate Element in the Comprehensive Plan directing the identification of criteria to define AAAs. The County has also collected extensive data, completed other general and site-specific vulnerability analyses, completed the 5-year GreenKeys! Climate and Sustainability Action Plan, acquired county-wide mobile LiDAR elevation data, and drafted proposed Peril of Flood comprehensive plan amendments.

The County's next priority is developing example AAAs and associated Goals, Objectives, and Policies for potential inclusion within the Conservation and Coastal Management Element as described in a specific recommendation in the GreenKeys! Climate and Sustainability Plan (1-31: Develop criteria for Adaptation Action Areas and adoption in Comprehensive Plan). Monroe County will develop example AAAs using existing policy guidance, best practices, case studies, updated data, and the most current approaches as a foundation for this effort. The updated vulnerability model will be utilized to determine infrastructure and habitat impacts as well as areas of increasing vulnerability for 2040, 2070, and 2100 sea level rise assumption horizon.

The County's planning process will also incorporate social vulnerability analyses using best practices identified by the CDC's SVI. Further, the County will consider approaches incorporating infrastructure and public facilities, habitat and land acquisition, management or protections that restore natural shoreline features, and development considerations. Lastly, the County is in the process of updating its Local Mitigation Strategy and has developed a Post Disaster Recovery Strategy to position itself for long-term recovery. These updated strategies will further inform the County's AAA policy framework.

The confluence of all these initiatives provides an immediate critical opportunity to update the GreenKeys Vulnerability Assessment for inundation risk, which can serve as a technical basis to improve resilience to coastal flooding.[7] This comprehensive dataset is key to addressing various policy solutions such as land acquisition or management, infrastructure upgrades, strategic buyouts, or resilient reconstruction and/or transportation improvements.

Image 8: A great white heron in the mangrove stand at Boggy Key (Source: U.S. Geological Survey)

[7] Jason M. Evans, Sea Level Rise Vulnerability Assessment for Monroe County, Florida: *Technical Appendix in Support of the GreenKeys! Sustainability and Climate Action Plan*, (January 26, 2016).

A. GreenKeys

Originally published in June 2016, the GreenKeys! plan is Monroe County's roadmap for addressing climate change, sustainability, and sea level rise. It provides guidance for County decisionmakers, staff, business owners, and residents with 165 recommendations and a 5-year Work Plan to increase sustainability and resilience in the Keys. The GreenKeys! plan was updated in 2019 to reflect the substantial work that has been done since the initial publication of GreenKeys! The 2019 GreenKeys! update also extends the County's sea level rise modeling to 2100, which conforms with the modeling requirements for FEMA's CRS Program (NOAA Intermediate High).[8] The 2100 horizon also aligns with the Compact's Unified Sea Level Rise Projection (from 2015 and 2019). GreenKeys! is a robust plan with articulated objectives to maintain the County's operations and livability into the future. It continues to serve as a framework for County sustainability and resilience budget request and program initiatives.

Image 9: GreenKeys! is the Monroe County Sustainability Action Plan, originally published in 2016 and updated in 2019. (Source: Monroe County)

B. Countywide LIDAR Data Collection

One important recommendation in GreenKeys! was for the County to secure better elevation data. The County procured better elevation data for more accurate planning and efficiencies related to its lands, roads, and buildings for several reasons. The County desires highly accurate elevation information to assess low-lying areas and those that are vulnerable to sea level rise. The availability of accurate elevations enables a number of other tasks including roadway and stormwater systems adaptation.

Accordingly, in 2017, the County initiated a scope of work to collect countywide mobile LiDAR ("light detection and ranging") information. LiDAR technology employs a beam of light that is emitted by a sensor. The amount of time that it takes for that beam of light to hit an object and return to the sensor is calculated. This allows the object's distance from the sensor to be recorded. The LiDAR sensor (or scanner) can send out hundreds of thousands of light pulses each second and can collect very large amounts of information in a short time.

This Project included Mobile LiDAR scanning and data extraction for all of the roadway centerlines within the unincorporated County limits and also the development of spot elevations for first floor elevations of County facilities throughout the Keys. This dataset, which improves on existing, outdated elevation data, is now complete for use in upcoming County analytical efforts for all 311 miles of County roads. The GreenKeys! Technical Appendix C, Sea Level Rise Vulnerability Assessment for Monroe County, provides the existing planning-level analysis of sea level rise impacts to County roads and the Overseas Highway. Impacts to lane miles were analyzed with the FDOT-University of Florida Sketch Planning Tool, which generates output based on elevation data

[8] Federal Emergency Management Agency, National Flood Insurance Program Community Rating System, *Coordinator's Manual,* (Edition 2017), CRS Coordinator's Manual (fema.gov).

and chosen sea level rise scenarios.[9] Significantly, the elevation data used for the analysis was from 2007-2008 collected by the Florida Division of Emergency Management using airborne LiDAR technology. The new LiDAR elevation data drastically improves the overall efficiency and general success of sea level rise planning in the Keys.

C. Pilot Roads Project

The Monroe County Pilot Roads Project was developed in two communities: The Sands (Big Pine Key) and Twin Lakes (Key Largo). The Project team analyzed existing data to determine flooding probabilities, implemented the Unified Sea Level Rise Projections from 2015 to determine future sea level rise and develop design strategies and very preliminary cost estimates. The County received recommendations for future road elevation and drainage improvements. By planning for a 25-year road improvement project useful life, the team was able to determine how much sea level rise is expected and when road inundation would occur. Using the previous the 20-year tidal record, the statistical probability of a flooding event was also established. The County looked at potential road elevations of six, twelve, eighteen, and twenty-eight inches, based on various sea level rise and flooding scenarios.

The Pilot Roads Project and its specific recommendations have served as an initial mechanism to determine costs, regulatory challenges and right of way characteristics that will provide useful information for further planning taking place in the Roads and Flood Mitigation program being undertaken now. The Final Report recommended raising the roads approximately 5" of elevation NAVD88 (4.4 inches as noted in technical material) in Twin Lakes. In the Sands Community, the recommendation was to raise the roads approximately 11" of elevation NAVD88 (10.3 inches as noted in technical material). Both recommendations extend the life of the roads to 2040. Ultimately, the County used this Pilot Project to establish ***interim*** design standards for roads (and corresponding stormwater systems) until the more comprehensive County Roads Analysis and capital planning effort (described below) is complete. Final design is currently underway for the two projects, permits have been secured and one project has received grant funding. The Project has contributed significant amounts of data to the Roads and Flood Mitigation planning process overall and helped make additional adjustments in that process based on lessons learned.

D. NOAA Grant and the Watershed Management Plan

One goal of the County's sea level rise planning efforts is to link modeling and policy tools to leverage the County's investments and efforts: by tailoring identified sea level rise-related risks to CRS, the outcomes will have direct positive impacts to the community. Long-term, strategic planning for sea level rise and climate change-related risk benefits the County and its residents in so many ways. For example, having an updated Watershed Management Plan can translate to individual flood insurance savings. FEMA scores local governments through the CRS, which rewards policy holders with reduced flood insurance rates when their local governments demonstrate strategic planning for flood and damage risk. Monroe County was a Class 5-rated jurisdiction, but was recently scored

[9] The UF GeoPlan Center describes this GIS database in online links and project documentation as the "Sea Level Scenario Sketch Planning Tool" (http://sls.geoplan.ufl.edu/documents-links/).

a Class 3 rating, which would enable NFIP policy holders in Monroe County eligible for a 35% total premium discount.

The County recently developed its Watershed Management Plan, which is a mandatory prerequisite for CRS Class 4 status. Also required for Class 4 is an evaluation of future conditions that includes a median projected sea level rise for the year 2100 - based on NOAA's "intermediate-high" curve - and a 100-year rainfall event. The NOAA intermediate-high curve in 2100 projects 4.13 feet of sea level rise above the 1992 mean sea level. Accordingly, the County's Watershed Management Plan considers impacts from at least 4.13 feet of sea level rise on the performance of stormwater infrastructure during a 100-year rainfall event. Moreover, the County's efforts to improve the utility of its data resulted in the creation of a model that allows different data sets to speak to one another in the same language, allowing for ease of transition and use with various models and applications. The Watershed Management Plan was part of a multi-pronged strategy to improve the County's overall participation in the CRS program.

E. Capital Projects

There has been a substantial focus on infrastructure – roads, in particular. The County is developing a long-term capital plan to address road flooding. The improvement in data accuracy from the LiDAR project described above enables engineers and planners to identify near-term roads subject to flooding and to develop road design plans strategically based on exposure. The County is now in the process of developing a Roads and Flood Mitigation Adaptation Plan based on the results of its Countywide Roads Analysis, described below. The Roads and Flood Mitigation Adaptation Plan will include a roadway vulnerability analysis and recommendations for adaptation measures which include road elevation and stormwater manage and/or flood mitigation features (such as barrier walls). Its purpose is to reduce the frequency and severity of nuisance flooding as well as mitigate flooding during storm events.

Image 10: Monroe County is focused on adapting its roadway infrastructure. (Source: Monroe County)

This Project includes numerous deliverables that will transform the County's approach to ensuring access and mobility throughout the Keys. A vulnerability analysis, policy analysis, cost-benefit analysis, funding strategy, as well as the Implementation Plan will be developed over the course of the Project. The Implementation Plan will include specific recommendations for road adaptations for the next five, ten, fifteen, twenty, and twenty-five years for the vulnerable segments of roadways. It also looks at potential impacts for years 2060 and 2100.

The overall Project work includes adaptation measures based on a proposed acceptable level of service or range of level of service alternatives. Adaptation measures could include roadway

elevation, construction of base and asphalt, drainage, potential pump stations, landscape, or other elements. Another aspect of the Project will identify whether construction easements and private property purchases are needed. The Project team will also address what roadway elevation and stormwater conveyance and treatment methods are needed. The recommended roadway adaptations will include legally-required stormwater capture, transport and treatment systems to meet the water quality standards applicable to Monroe County. Cost-benefit analysis, policy considerations, funding strategies, and other factors will be considered as the County works to fortify its roads.

Residents and stakeholders are part of this process. The County and the Project team gathered information and received feedback from residents in a variety of formats. The County has an interim standard that allows no more than an average maximum seven days of flooding (from sea level rise) on any particular street each year, based on the anticipated length of time the road project will be in service. This standard is likely to be modified based on the results of this Project. Also included will be an analysis and recommendations for green infrastructure to the extent practicable. Vegetation, soils, and other elements can restore some of the natural processes required to manage water and create healthier urban environments.

This Project will merge climate change science and modeling with transportation engineering and planning to develop a long-term roads adaptation plan, based on transparent levels of design criteria, sea level rise projections, and adaptation methodology. It will bring climate change science to the local level, building upon previous efforts, and also bringing together policy, science, engineering, finance, and planning. The end results will help prepare valuable assets - the County's roadway infrastructure - for the current and future impacts of climate change. The outcomes of this Project will include practical guidance for the County as it tackles this issue, and also a detailed Implementation Work Plan for long-term road infrastructure adaptation projects to prepare for sea level rise. The Board of County Commissioners and the broader public will provide oversight in the form of public meetings and updates along the way, as well as through formal presentations of the results.

Finally, the County is protecting critical sites through resiliency improvement projects. Some of these adaptation efforts include a resiliency analysis for Harry Harris Park in Key Largo, which includes modifying the boat ramp located there to eliminate tidal flooding into neighboring residential areas. Another example is an adaptation/resiliency analysis for Bayshore Manor Assisted Living Facility. The method from the Bayshore Manor Assisted Living Facility project can be used going forward to weigh the costs and risks of future facility adaptation. Other facility improvement projects include the elevation of Bernstein Park and the resilient redevelopment and elevation of a fire station on Stock Island.

F. Comprehensive Plan

1. Conservation and Coastal Management Element

The County's most recent Comprehensive Plan was adopted in 2016 at the same time new requirements were being enacted either requiring or providing new avenues to address resiliency within the Coastal Element of Comprehensive Plans. The Peril of Flood legislation (Section

163.3178(2)(f), F.S. was enacted within this same timeframe and requires local governments to address six (6) provisions within a Coastal Element:

(f) A redevelopment component that outlines the principles that must be used to eliminate inappropriate and unsafe development in the coastal areas when opportunities arise. The component must:

1. Include development and redevelopment principles, strategies, and engineering solutions that reduce the flood risk in coastal areas which results from high-tide events, storm surge, flash floods, stormwater runoff, and the related impacts of sea-level rise.

2. Encourage the use of best practices development and redevelopment principles, strategies, and engineering solutions that will result in the removal of coastal real property from flood zone designations established by the Federal Emergency Management Agency.

3. Identify site development techniques and best practices that may reduce losses due to flooding and claims made under flood insurance policies issued in this state.

4. Be consistent with, or more stringent than, the flood-resistant construction requirements in the Florida Building Code and applicable flood plain management regulations set forth in 44 C.F.R. part 60.

5. Require that any construction activities seaward of the coastal construction control lines established pursuant to s. 161.053 be consistent with chapter 161.

6. Encourage local governments to participate in the National Flood Insurance Program Community Rating System administered by the Federal Emergency Management Agency to achieve flood insurance premium discounts for their residents.

Suggested language to meet these requirements was drafted within the scope of the previous Resilience Planning Grant (R1915) for integration into the upcoming Evaluation and Appraisal Report (EAR) process. It should be noted this new Comprehensive Plan language is required and it is not discretionary.

2. Energy and Climate Element

The Energy and Climate Element (2016) is a first of its kind optional element for Comprehensive Plans throughout the State. It combines energy goals, objectives and policies with broader climate, resiliency and sustainability initiatives for both the community at large and for public assets. It also recommends continued data collection, partnerships and analysis to remain current with projected impacts from climate change. Inter-agency collaboration and work of the Compact has also been instrumental in the structure of this Element.

Policy 1502.1.4 in the Energy and Climate Element of the Monroe County Comprehensive Plan states, “Within five years after the adoption of the 2030 Comprehensive plan, Monroe County shall identify proposed Adaptation Action Areas or similar concept to be defined by the county … In AAAs,

strategies will be developed to address vulnerabilities from these effects as well as the rate of impact and available adaptation options. In conjunction with later updates to the 2030 Comprehensive Plan, Monroe County shall update existing, or map new, potential impacts of sea level rise for consideration in long-term planning decisions." This policy was enacted before the Peril of Flood legislation required resiliency concepts be integrated into Coastal Elements of Comprehensive Plans.

The County's GreenKeys! Climate and Sustainability Plan includes Recommendation 1-31, "Develop criteria for Adaptation Action Areas and adoption in Comprehensive Plan." The County's Climate Change Advisory Committee has also provided preliminary criteria suggestions for the development of AAAs that have been utilized to the extent they are still relevant.

Image 11: King Tide flooding at Key Largo Kampground and Marina (Source: Nancy Snyder for McClatchy)

The scope of work for this Grant R2111 implements these policies: updated and new maps in the map book that accompanies this Vulnerability Assessment show potential impacts of sea level rise for consideration in long-term planning decisions.

G. Additional Resiliency Projects and Grants

A key priority for the County is collection and improvement of data. As such, the County partnered with NOAA to produce a HAZUS-MH model for County-wide risks from various types of natural disasters. This Project was supported by a 3-year grant (2016-2019) with a very specific targeted effort to localize the HAZUS-MH tool to Monroe County conditions. The program is titled "*Advancing Understanding of Risk: Increasing Accuracy of Hazard Damage Assessment Tools by Improving Base Data and Analyzing Opportunities and Barriers for Use in Adaptation Planning*." Other grant deliverables included a stormwater structure analysis that has been incorporated into the County's CRS work, as well as legal and policy research related to infrastructure adaptation for local governments. This ultimate work product culminated in the Watershed Management Plan previously referenced.

Examples of datasets include digitization of building footprints and archival elevation certificates: the County has a Geographic Information Systems (GIS) department that digitized all of the Elevation Certificates for both private residences and public facilities in the unincorporated areas of the County. This site- and structure-specific information improves the accuracy of damage cost assessments made by FEMA's HAZUS tool. The HAZUS tool was used to develop damage assessments for 100-Year storm surge flooding scenarios on over 37,000 properties with detailed parcel-level characteristics. Characteristics included 2014 assessed valuations across the County and associated municipalities, as well as over 4,000 structures in the unincorporated County with newly digitized site-level Elevation Certificate data. These flooding scenarios included current 100-year flood heights under an assumption of existing sea level, the "Low" and "High" sea level rise

projections for 2060, as adopted by the Compact, and the NOAA Intermediate-High sea level rise scenario for 2100 as required by FEMA.

Another example of data collection funded through this grant is an assessment of some of the County's stormwater outfalls with previously-unknown invert elevations. Monroe County's Public Works and Engineering Services began a comprehensive and updated field inventory of County-owned stormwater drainage infrastructure in June 2017. This inventory focused on stormwater structures that feed into underground drainage systems or discharge stormwater into surface waters. The grant Project team gathered the elevation data at these outfalls to create a GIS database with full metadata. This high-quality, extremely precise data for those priority outfalls were incorporated into the Stormwater Management GIS created by the grant Project team. Bare ground elevation estimates for twenty-one additional pipe outfalls and all other inventoried infrastructure within the Stormwater Management GIS were extracted from a model developed by the South Florida Water Management District. The Project team worked with FDOT to collect GPS location and field attribute data for an additional set of 99 stormwater structures along US-1 in Key Largo and Tavernier. All of the location and attribute data developed from this field inventory were incorporated into the Monroe County Stormwater Management GIS dataset created by the Project team. Finally, FEMA HAZUS results were reviewed, and data were made available through the Florida Department of Transportation (FDOT) for US-1 transportation facilities for stormwater.

This NOAA grant has created a strong, data-driven foundation to more effectively implement a robust policy framework. With more accurate information and more precisely-tailored models and tools, the County can more effectively plan for future risk and adaptation and better inform and engage the public as to those plans.

The final recommendations of the Watershed Management Plan included the following:

1. Secure the Data: Elevation Data (Timeframe for Completion: 2019)
2. Develop Accurate Vulnerability Information for Roads and Stormwater: Countywide Roads Analysis (Timeframe for Completion: 2019-2021)
3. Set Policy Based on Future Vulnerability: Future Stormwater Design Standards (Timeframe for Completion: 2023)
4. Long Range Planning: Integration with the Comprehensive Plan (Timeframe for Completion: 2021)

Monroe County is also in a partnership with the ACOE to investigate storm and sea level rise vulnerability for the Florida Keys (the "Study"). A Memorandum of Understanding was approved at the October 2018 Board of County Commissioners meeting to undertake a Coastal Storm Risk Management Study. That month, the ACOE began its three-year study to assess risk to the County's only evacuation route. The Overseas Highway through the Keys is a long, low road, creating unique issues to address in an evacuation context. The study will address how present and future risk to coastal storm hazard and sea level rise will affect coastal areas. Specific attention will be given to the integrity of the Overseas Highway.

The overall goal of the Study is to analyze all information through one lens: specifically, to create a geospatial tool that will be multifunctional in terms of its evaluation. The tool will generate

estimates of existing and future coastal vulnerability through a connected and synchronized view of all integrated products.

Image 12: An aerial view of the Overseas Highway, or U.S. 1, through the Florida Keys (Source: Florida Keys News Bureau)

Other goals of the study included (1) providing a common operating picture of coastal risk to be utilized by policymakers at the local, state, and federal levels to comprehensively analyze US1 vulnerability; (2) identifying high-risk locations and characterize current and future hazards by developing depth damage functions along US1; (3) recommending risk-reduction measures to address identified problems; and (4) reviewing and incorporate adaptation or storm resilience project recommendations as appropriate for future planning and funding.

Following the devastation of Hurricane Irma in September 2017, Harry Harris Park in Tavernier was closed for repairs. While other local parks were prioritized for post-storm repairs, Harry Harris was used as debris and vessel storage for months. The boat ramp, playground, and beaches re-opened in February 2018, and the County opened the park's two baseball fields with reconstructed fences, dugouts, and bleachers in 2019. The County installed a new irrigation system for the two baseball fields and new electric wiring in the concession stand. Additionally, workers removed 600 tons of clay that was contaminated with ocean water and seaweed and replaced it with new clay. A third phase of the park's rehabilitation includes completing the lighting for the ball fields and reviving the basketball courts, repaving walkways around the pond, and most importantly, implementing resilient designs for Wilkinson Point and the boat ramp.

A "Rapid Assessment" of sea level rise at Harry Harris Park was conducted by researchers at Stetson University's Institute for Water and Environmental Resilience on December 20, 2018. A grant-funded adaptation plan was developed which includes strategies that focus on the protection of predetermined critical park assets, such as the boat ramp, shoreline, and ballfields and other minor enhancements to mitigate flooding and create new amenities. One such example of protecting critical assets is an increase in the top-of-grade of the boat ramp and upgrading a hardened structure along the ramp to prevent the infiltration of floodwaters to the park.

Finally, the County secured a grant through the DEP's Office of Coastal Management to develop a method to quantify potential losses from coastal flooding exacerbated by sea level rise. This Project resulted in a data-driven process for evaluating the vulnerability of County-owned facilities generally, and specifically, to assess the County-owned and operated Bayshore Manor Assisted Living Facility in Key West. The Facility Vulnerability Approach created by through this grant outlines the following six steps to assess the flood risk and cost of alternatives for County infrastructure:

1. Determine costs of flood damage to the facility for different water levels

2. Identify return period values for current FEMA and future years for SLR
3. Determine future estimates of facility loss
4. Identify potential restrictions on adaptive strategies
5. Identify protection strategies and costs: resilient materials & rebuilding higher
6. Determine present value of loss and NPV of protection strategies

In developing the Facility Vulnerability Approach for Bayshore Manor, the County built a tool that enables analysis of critical County facilities to the year 2100. The 2100-year project horizon can be applied to existing or proposed facilities going forward, allowing for a consideration of damages and losses as a design requirement.

Vulnerability Assessment

3. Monroe County Vulnerability Assessment

In This Section:

III. Vulnerability Assessment for Monroe County

This Vulnerability Assessment provides modeling and data to support policy development and for example language to establish AAAs. The prior, existing assessments used earlier (2008) elevation data from a statewide database. As previously noted, the County has since collected locally-specific mobile LiDAR data, which greatly enhances this updated Vulnerability Assessment, making it more accurate for County decision-making.

The tools that were utilized to produce this assessment include GIS, SLAMM, and the CDC's SVI. These tools can measure the impacts of sea level rise and identify the infrastructure, habitat, and land uses that may be affected. This updated analysis also addresses stormwater management systems, something not previously addressed in the prior Vulnerability Assessment.

This section introduces the fourteen focus areas of the vulnerability map series and describes the data used to generate each focus area analysis. An overview of the methodology is also provided, as well as a summary of results. The map series applies on the NOAA Intermediate High sea level rise curve for and most reflect the 2040, 2070, and 2100 planning horizons at the mean higher high-water condition. A few highlights from the 2040 modeling are incorporated. The greater modeling effort considers the IPCC Median and the NOAA Intermediate High projections for the Year 2040, 2070, and 2100 planning horizons.

The fourteen focus areas analyzed for this Project include the following:

1. Projected Sea Level Rise / Generalized Inundation	**8. Potable Water**
2. Transportation	**9. Sanitary Sewer**
3. General Infrastructure	**10. Power Grid**
4. Essential Infrastructure	**11. Sea Level Rise + FEMA Flood Zones**
5. Emergency Management	**12. Habitat Change**
6. Threatened and Endangered Species Focus Areas	**13. Shoreline Assessment**
7. Stormwater	**14. Social Vulnerability**

The information below and the accompanying map series may capture all three planning horizons or focus on a single year. Unless stated otherwise, the information below is typically limited to the NOAA Intermediate High projection. Any projected water depths below and contained within the GIS data are planning-level estimates only. The water depth projections discussed in this section of the report only consider the mean higher high-water elevation associated with regular tidal inundation and do not factor for the full scope of influence from other environmental factors such as wind or effects exacerbated by storms or precipitation. Accuracy of the water depth is not guaranteed; additional limitations to this modeling effort are discussed in Section I.B.3.a. of this report. Water depths corresponding with a specific feature listed below are related to the LiDAR-derived ground elevation at the location identified within the databases (XY, Lat/Long). The positional accuracy of the GIS databases was not assessed during this analysis.

For this Vulnerability Assessment, the Project team created a comprehensive set of maps that highlight key infrastructure, systems, locations, and habitat impacts from sea level rise within the County. Within each category enumerated below, several conditions are shown on individual maps. Within each section of the Vulnerability Assessment Overview, map conditions are described for ease of interpretation and use of this report. The sample images contained within this section of the report were chosen for their geographic locations, socio-economic diversity and differences in potential vulnerabilities.

A. Tabulation of Available Data

Table 1 below provides a list of all data that was compiled for this project. Geospatial data were analyzed to the best extent practicable within the timeline of the Project. Not all data gathered are incorporated in the assessment due to constraints in formatting, availability within the timeframe for this Project, as well as scope limitations.

Table 1: Tabulation of Data		
Documents, Spreadsheets, and PDF Files		
Data Layer		Source
1	Keys Map (Florida Keys Marine Adaptation Planning)	Florida Fish & Wildlife Conservation Commission (FWC)
2	South Florida Water Management District (SFWMD) Resolution No. 2020-0706	SFWMD
3	U.S. Department of the Interior U.S. Geological Survey Joint Funding Agreement for Development of future Depth-Duration-Frequency Curves (DDF Curves)	U.S. Geological Survey
4	CDBG-DR & CDBG-MIT Grant Applications Deadlines	Monroe County
5	Florida Keys Case Study on Incorporating Climate Change Considerations into Conservation Planning and Actions for State Listed and SGCN in the Florida Keys	FWC, USFWS, Nature Conservancy
6	Florida Keys Terrestrial Adaptation Project (Keys TAP)	FWC, USFWS, Nature Conservancy
7	Keys Adaptation State Species Handout	FWC, USFWS, Nature Conservancy
8	King Tide and Normal Wind Setup Analysis for Monroe County	Wood, Monroe County
9	Monroe County Post-Disaster Recovery Strategy Hurricane Irma (January 2020)	Monroe County, Islamorada, Layton, Marathon, Key Colony Beach, Key West, Florida Keys Aqueduct Authority, Florida Keys Electric Cooperative
10	Taxing Districts	Monroe County
11	MCPA Field Descriptions	Monroe County
12	PC Code	Monroe County
13	Critical Facilities Elevations and GPS	Monroe County
14	Hurricane Irma Damage Inventory List	Monroe County
15	Hurricane Irma Financial Update BOCC Meeting (Nov. 20, 2019)	Monroe County
16	Hurricane Irma Preliminary Damage Assessment (through Mar. 8, 2018)	Monroe County
17	Summary of Hurricane Irma Disaster Recovery Funding for Monroe County and Cities	Monroe County

18	Draft – Sea Level Rise Projections for Monroe County, Florida	Wood and Monroe County
19	Key West International Airport Future Layout Plan	Key West International Airport
20	Key Largo Wastewater Treatment Engineering Plans	Key Largo Wastewater Treatment District
21	Key West Resort Utilities Plant Survey Plans	Key West Resort Utilities
22	Key West Resort Utilities Site Plan	Key West Resort Utilities
23	Key West Resort Utility Easements	Key West Resort Utilities
24	Sea Level Rise Vulnerability Assessment for Monroe County, Technical Appendix in Support of the GreenKeys! Sustainability and Climate Action Plan.	Monroe County, Clearview Geographic LLC, Erin Deady. P.A.
25	Technical Memorandum – Monroe County Mobile LiDAR Accuracy Assessment	Wood
26	GreenKeys! Sustainability and Climate Action Plan	Monroe County
27	Monroe County Community-Wide 2010 Greenhouse Gas Emissions Inventory Report	Cameron Cole, Monroe County
28	Flood Insurance Study for Monroe County and Incorporated Areas	FEMA
29	CDC SVI Metadata	CDC
Geospatial-Enabled Data		
1	Mobile LiDAR for County Roads	Wood
2	Address Points	Monroe County
3	Atons	Monroe County
4	Benthics	Monroe County
5	Boat Ramps	Monroe County
6	County Commission Districts	Monroe County
7	Building Footprints	Monroe County
8	Canals	Monroe County
9	Census 2010	Monroe County
10	Conservation Lands	Monroe County
11	Contours (1 foot)	Monroe County
12	Contours (2 feet)	Monroe County

13	County Boundary	Monroe County
14	County Parcels	Monroe County
15	County Shoreline	Monroe County
16	Critical Facilities	Monroe County
17	Elevation Certificates	Monroe County
18	FAU Shoreline Analysis	Monroe County
19	FEMA Flood Zones	Monroe County
20	Firebox Boundaries	Monroe County
21	First Due Zones	Monroe County
22	FK Overseas Heritage Trail	Monroe County
23	Future Land Use	Monroe County
24	HUD Low to Moderate Income	Monroe County
25	Hurricane Irma Preliminary Substation Damage Letter	Monroe County
26	Hurricane Irma Safety Inspections – Damage Assessment	Monroe County
27	Hurricane Irma Demo Permit Parcel	Monroe County
28	Land Cover Habitat	Monroe County
29	LUD Zoning	Monroe County
30	Marine Facilities	Monroe County
31	Mile Markers	Monroe County
32	Municipal Boundaries	Monroe County
33	Ocean Reef	Monroe County
34	Public Lands	Monroe County
35	Regulatory Markers	Monroe County
36	Sea Level Rise	Monroe County
37	Storm Surge Zones	Monroe County
38	Street Centerline	Monroe County
39	Streets Survey	Monroe County
40	Subdivisions	Monroe County
41	Tier Overlay	Monroe County
42	TNC DR	Monroe County

43	USFWS Species Focus Areas	Monroe County
44	Voting Precincts	Monroe County
45	Zip Codes	Monroe County
46	Florida Keys Electric Cooperative (FKEC) Pad Mount Transformers	FKEC
47	FKEC Switchgear	FKEC
48	Florida Keys Aqueduct Authority (FKAA) Potable and Sanitary Sewer Infrastructure	FKAA
49	Keys Energy Infrastructure	Keys Energy
50	FDEM 2007 5 feet LiDAR	SFWMD
51	NWI Wetlands	FWS
52	Stormwater Data	Monroe County
53	FDEP SAS D2WT	FDEP
54	Florida Drainage Basins (1997)	FDEP
55	HDR Sea Level Rise Scenarios	HDR
56	HDR CMMP Canal Salinity	HDR
57	DFIRM	FEMA
58	Key West Airport Facility	Monroe County
59	SFWMD FLUCCS (2014-2016)	SFWMD
60	FDOT Monroe Drainage Structures	FDOT District 6
61	Key West Resort Utilities	Key West Resort Utilities
62	Historic Structures	Monroe County
63	Tavernier Historic District	Monroe County
64	CDC Social Vulnerabilities	CDC
65	Homeland Infrastructure Foundation-Level Data (HIFLD): All Places of Worship	HIFLD
66	HIFLD: AM Transmission Towers	HIFLD
67	HIFLD: Cellular Towers	HIFLD
68	HIFLD: Child Care Centers	HIFLD
69	HIFLD: Coastal Barrier Resources Systems CBRS Boundaries	HIFLD

70	HIFLD: Colleges and Universities	HIFLD
71	HIFLD: College University Campuses	HIFLD
72	HIFLD: Courthouses	HIFLD
73	HIFLD: DHL Facilities	HIFLD
74	HIFLD: DOD Sites Boundaries	HIFLD
75	HIFLD: DOD Sites Points	HIFLD
76	HIFLD: EMS Stations	HIFLD
77	HIFLD: FDIC Insured Banks	HIFLD
78	HIFLD: FedEx Facilities	HIFLD
79	HIFLD: Ferry Terminals	HIFLD
80	HIFLD: Fire Stations	HIFLD
81	HIFLD: FM Transmission Towers	HIFLD
82	HIFLD: Formerly-Used Defense Sites FUDS Public Properties	HIFLD
83	HIFLD: GNIS Historical Features	HIFLD
84	HIFLD: Hospitals	HIFLD
85	HIFLD: Intermodal Passenger Connectivity Database	HIFLD
86	HIFLD: Land Mobile Private Transmission Towers	HIFLD
87	HIFLD: Land Mobile Commercial Transmission Towers	HIFLD
88	HIFLD: Local Law Enforcement	HIFLD
89	HIFLD: Microwave Service Towers	HIFLD
90	HIFLD: Mobile Home Parks	HIFLD
91	HIFLD: National Bridge Inventory (Bridges)	HIFLD
92	HIFLD: National Flood Hazard Layer	HIFLD
93	HIFLD: National Shelter System Facilities	HIFLD
94	HIFLD: NCUA Insured Credit Unions	HIFLD
95	HIFLD: Nursing Homes	HIFLD
96	HIFLD: Petroleum Ports	HIFLD
97	HIFLD: POL Pumping Station	HIFLD
98	HIFLD: Port Facilities	HIFLD
99	HIFLD: Power Plants	HIFLD

100	HIFLD: Private Schools	HIFLD
101	HIFLD: Public Health Departments	HIFLD
102	HIFLD: Public Schools	HIFLD
103	HIFLD: Runways	HIFLD
104	HIFLD: Solid Waste Landfill Activities	HIFLD
105	HIFLD: Substations	HIFLD
106	HIFLD: Supplemental Colleges	HIFLD
107	HIFLD: Transmission Lines	HIFLD
108	HIFLD: UPS Facilities	HIFLD
109	HIFLD: Urgent Care Facilities	HIFLD
110	Veteran's Health Administration Medical Facilities	HIFLD
111	HIFLD: Weather Radar Stations	HIFLD

B. Methodological Overview

1. 2019 Unified Sea Level Rise Projections

As stated previously, the County adopted the Compact Projection early on in its resilience planning. Though originally published in 2011, the Projection was updated in 2015 and again in December of 2019 to ensure the best available data is applied when local governments plan for sea level rise. The revised 2019 Projection provides an update to the amount and rate of anticipated sea level rise in Southeast Florida through the year 2120, although this Vulnerability Assessment uses 2100 for its planning horizon. Following a two-year process that incorporated user feedback and new scientific information, a group of both Compact staff and agency experts developed the new estimates adopted by the Compact and its signatory local governments. The Projection represents community and geographical consensus, as well as incorporates the most up-to-date, peer-reviewed literature and climate modeling data. The 2019 Projection shows higher and faster sea level rise than previous Compact estimates used in the County's earlier work.

The 2019 Projection is based upon estimates of sea level rise developed by the IPCC Fifth Assessment Report,[10] as well as current Projections from NOAA.[11] The Projection accounts for regional effects, such as gravitational effects of ice melt, changes in ocean dynamics, vertical land movement, and thermal expansion from warming of the Florida Current that produce regional differences in Southeast Florida's rate of sea level rise compared to global projections.

Each of the projection curves assume different models based on growing greenhouse gas emissions concentration, where emissions continue to increase at varying rates until the end of the century based on past, current and future emission rates. Estimates of sea level rise are produced from a baseline year of 2000, and extend to the year 2120. As previously shown in Image 5, sea level rise is projected to be as follows for the NOAA Intermediate High scenario:

17 inches by 2040,
40 inches by 2070, and
74 inches by 2100 above mean sea level

This is established by using a baseline year of 2000 from the Key West tidal gauge. Projections of sea level rise, especially beyond the year 2070, have a significant range of variation as a result of uncertainty in future greenhouse gas emissions, reduction efforts, and resulting geophysical effects.

The 2019 Projection utilizes three curves for application, in descending projection order, the NOAA High Curve, the NOAA Intermediate High Curve, and the curve corresponding to the median of the IPCC AR5 RCP 8.5 scenario.[12] A fourth informational curve, the NOAA Extreme Curve, is included to illustrate the possible upper limit of sea level rise in response to potential ice sheet collapse in the

[10] IPCC (2014).
[11] NOAA, Sweet et al. (2017).
[12] The IPCC AR5 RCP8.5 scenario refers to the Fifth Assessment Report published by the Intergovernmental Panel on Climate Change, which uses four Representative Concentration Pathways scenarios to predict future emissions and their impacts on global climate.

latter part of the century. The NOAA Extreme Curve indicates that without imminent and substantial reductions in greenhouse gas emissions, much greater sea level rise is possible more than 100 years from now.[13]

2. Sea Level Rise Projections Utilized by the State of Florida

Over the last year, the State of Florida has made significant progress on the sea level rise planning front. Some of the drivers of this progress include a need to develop consistent statewide data for a Statewide Flooding and Sea Level Rise Resilience Plan, implementation of Section 161.551, F.S. regarding requirements for projects that receive state funding thus triggering Sea Level Impact Projection (SLIP) studies and the State's desire to standardize vulnerability assessment output from local governments across the state. In summary, while FEMA requires the NOAA Intermediate High sea level rise projection to be used for the CRS program, that the County participates in to receive flood insurance discounts, and the Compact's upper end range of projections is also the NOAA Intermediate High sea level rise projection, new state rules and legislation also requires the use of that same projection to receive state funding. Thus, it is within the County's best interest to utilize that same NOAA Intermediate High condition for planning of projects, as a condition within this Vulnerability Assessment, to remain or even improve participation within the CRS program and finally, as a best practice and partner in the Compact. If the County anticipates or desires receiving any state funding for resiliency planning or project implementation, such as road elevation, stormwater, building elevation or overall adaptation, then the County should continue to use the NOAA Intermediate High sea level rise projection.

A. *The Resilient Florida program and HB 7019*.

The State of Florida solidified its commitment to planning for resiliency and funding projects to address flooding and sea level rise by passing a transformational bill HB 7019/SB 1954. The 18-page bill creates the first major program in Florida to address the future risks of sea level rise and flooding by authorizing up to $100 million annually for a new grant program focused on local governments, subject to legislative appropriation. While this is a key aspect of the legislation, it is not the only important element.

- **Resilient Florida Grant Program.** The Florida Department of Environmental Protection (DEP) is now authorized to fund grants for planning, data collection and projects to address future flood risks including sea level rise. The grant program can fund vulnerability assessments to determine a community's risks to these threats, but those vulnerability assessments must meet certain parameters outlined in the legislation.

- **Comprehensive Statewide Flood Vulnerability and Sea Level Rise Dataset and Assessment.** The legislation also required DEP to develop a statewide plan (not just at the local government level) to address flood vulnerability and sea level rise. It also required DEP to develop a statewide dataset to create this assessment and update it periodically. The Assessment must focus on critical assets and other regionally significant assets at the State level.

- **Statewide Flooding and Sea Level Rise Resilience Plan.** Annually, DEP must now create and update a Statewide Flooding and Sea Level Rise Resiliency Plan which is comprised of ranked projects that mitigate or eliminate risks from flooding and sea level rise. The bill contains requirements for project

[13] Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group (Compact). February 2020. A document prepared for the Southeast Florida Regional Climate Change Compact Climate Leadership Committee. 36p.

submittals and evaluation including a 50% cost share unless the project is within a financially disadvantaged small community, then the cost share requirement may be reduced. Projects must be submitted by a county, municipality, regional resilience entity, water management district or flood control district or have been identified in the statewide assessment previously outlined. Certain project expenses are prohibited, such as those that focus on just recreation, aesthetics, or projects not directly tied to a resiliency benefit. The section includes a scoring system for ranking projects.

- **Funding.** The bill authorizes up to $100 million annually subject to a legislative appropriation. This is important, because while the legislation creates the program, it does not include a dedicated funding source that does not require additional action by the Legislature. This issue is not without divergent perspectives.

- **Regional Resilience Entities.** The bill also authorizes funding for regional resilience entities such as the Southeast Florida Regional Climate Compact or the Coastal Resources Partnership in Palm Beach County for technical assistance, coordination or projects.

- **Florida Flood Hub for Applied Research.** The bill establishes the University of South Florida College of Marine Science (or its successor entity) as the lead academic and research institution to address flooding and sea level rise challenges of the state. The charge of the hub is to coordinate data, modeling, research, establish community programs and cooperate with other governmental entities.

- **Inland and Coastal Flood Control.** The bill requires the State's Office of Economic and Demographic Research to assess the need for future expenditures and costs related to sea level rise, flooding and storm surge. Importantly, the assessment must also identify any "gaps" between estimated revenues and expenditures for these purposes.

So, while this legislation still requires legislative action for appropriations, the Resilient Florida Program is transformational within the state and serves as a national model for other states to emulate.

B. *Rule 62S-7, F.A.C implementing Section 161.551, F.S., Sea Level Impact Projection (SLIP) Studies for State Financial Coastal Construction.*

In the 2020 Legislative session, SB 178 was passed authorizing a new Section of Chapter 161, Beach and Shore Preservation, Section 161.551, F.S. The new section addresses the public financing of construction projects within the coastal building zone. The new statutory section directed Florida Administrative Code rulemaking to develop a standard by which a "state-financed constructor" must conduct a SLIP study. The Department's intent in this rule is to inform and raise awareness with the state-financed constructor of the potential impacts of sea level rise and increased storm risk on coastal infrastructure. Implementation of the findings of the SLIP studies is at the discretion of the state-financed constructor. The statutory framework and new rule for SLIP studies generally becomes effective July 1, 2022 and accomplishes the following:

- Section 161.551, F.S. requires that a project that uses funds appropriate by the state cannot commence until a SLIP study is conducted that meets the Rule requirements; the study must be submitted to DEP and published on the DEP website for at least 30 days. Projects include "Major structure" including houses, mobile homes, apartment buildings, condominiums, motels, hotels, restaurants, towers, other types of residential, commercial, or public buildings, and other construction having the potential for substantial impact on coastal zones. It also includes "Nonhabitable major structure" means swimming pools, parking garages, pipelines, piers, canals, lakes, ditches, drainage structures, other water retention structures, water and sewage treatment plants, electrical power plants and all related structures or facilities, transmission lines, distribution

lines, transformer pads, vaults and substations, roads, bridges, streets, and highways, and underground storage tanks. All of the above are subject to the SLIP study requirement.

- A state-financed constructor can either use a tool developed by DEP or conduct the SLIP study by their own method that meets the standards and criteria in the rule.

- The project cannot commence until the SLIP study is completed and has been published on DEP's website for 30 days.

- Standards for the SLIP study include (flooding, inundation and wave action):
    - Sea level rise projections for 50 years or expected life of structure whichever is less. With multiple features, one SLIP study can be conducted for the component with the highest risk category for all project features.
    - The NOAA Intermediate High sea level rise scenario must be used.
    - NOAA tide gauges are prescribed for use (two closest to project site)
    - Use of NAVD 88 datum
    - Land subsidence contribution
    - FEMA storm surge for the 1% annual chance (100 year) flood event + NOAA Intermediate High sea level rise scenarios compared to critical project elevations (finished floor elevations or lowest adjacent grade)
    - Depth-damage curves from 2015 North Atlantic Coast Comprehensive Study, titled "Resilient Adaptation to Increasing Risk: Physical Depth Damage Function Summary Report," must be used to estimate the cost of future flood damage, for vertical construction only
    - Show the risk to public safety and environmental impacts expected over 50 years or the expected life of the structure, whichever is less, thru use of Risk Categories in the Florida Building Code and windspeed

- Alternatives must be provided for project's design and siting and the SLIP study must state how the alternatives would address public safety and environmental impacts including but not limited to, leakage of pollutants, electrocution and explosion hazards, and hazards resulting from floating or flying structural debris as well as the risks and costs associated with construction, maintenance and repair of the structure.

- If the state-financed constructor chooses to undertake the SLIP study not using the DEP tool, then the report contents shall include, but not be limited to, a description of the approach used in conducting the study, numbered references to the information used in the study, a narrative with graphic illustrations to demonstrate the application of the study approach to the information used, and a discussion of the assessments and alternatives.

- Failure to comply may result in DEP enforcement action including injunctive relief to cease construction and recovery of any portion of the funding supplied by the state.

3. Vulnerability Assessment Overview

For this Vulnerability Assessment, the Project team created a comprehensive set of maps that highlight key infrastructure, systems, locations, and habitat within the County. Within each category enumerated below, several conditions are shown on individual maps. The sample images contained within this section of the report were chosen for their geographic locations, socio-economic diversity, and differences in potential vulnerabilities.

Each page of the map books included as an Appendix to this Vulnerability Assessment features an informative header with specific details about the map, the sea level rise projection overlaid upon the DEM, the planning horizon, and an index key to help orient the user around the County-wide series. Page 1 of each map book serves as a page index framing the geographic extent and scale of each subsequent page.

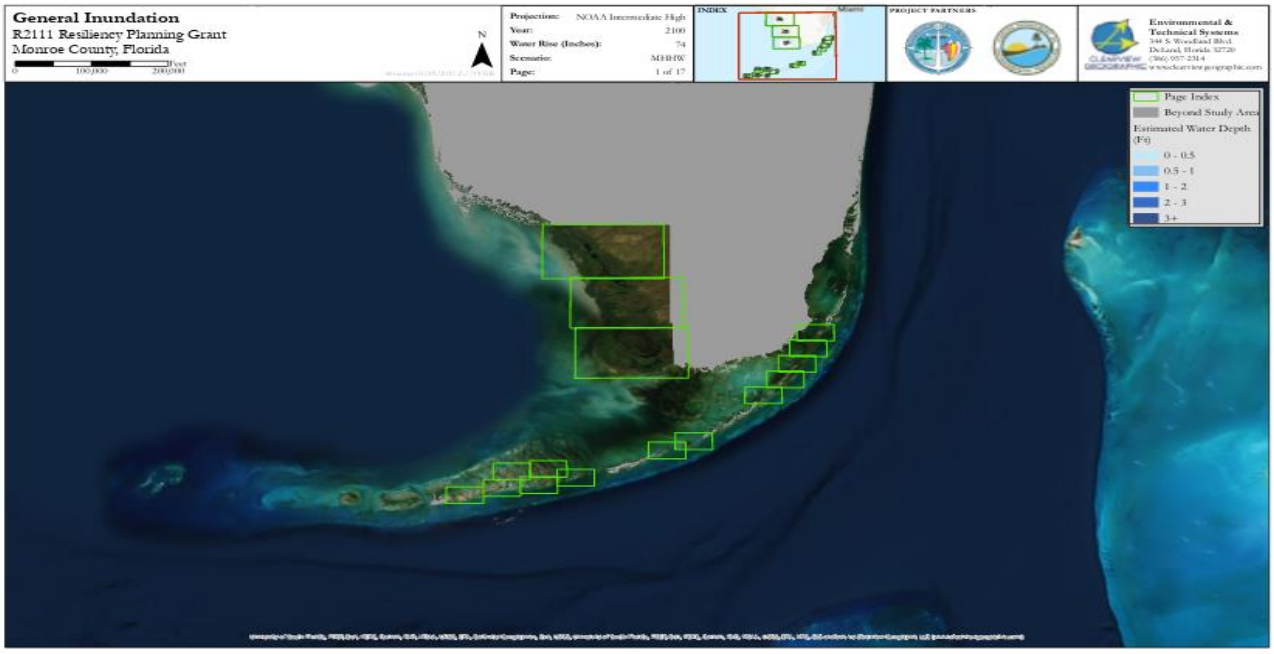


Image 13: A map index on Page 1 of each map book serves as an index framing the geographic extent and scale of each

Additionally, the final map series features overlay text boxes that help further orient the user, addressing some important modeling limitations and explaining additional information about the data on each map. A grey overlay titled “Beyond Study Area” defines the outward boundary of the assessment study area of unincorporated Monroe County. Pages with minimal-to-no-data may have area, assets, and/or infrastructure that are not digitized in Monroe County’s available GIS databases.

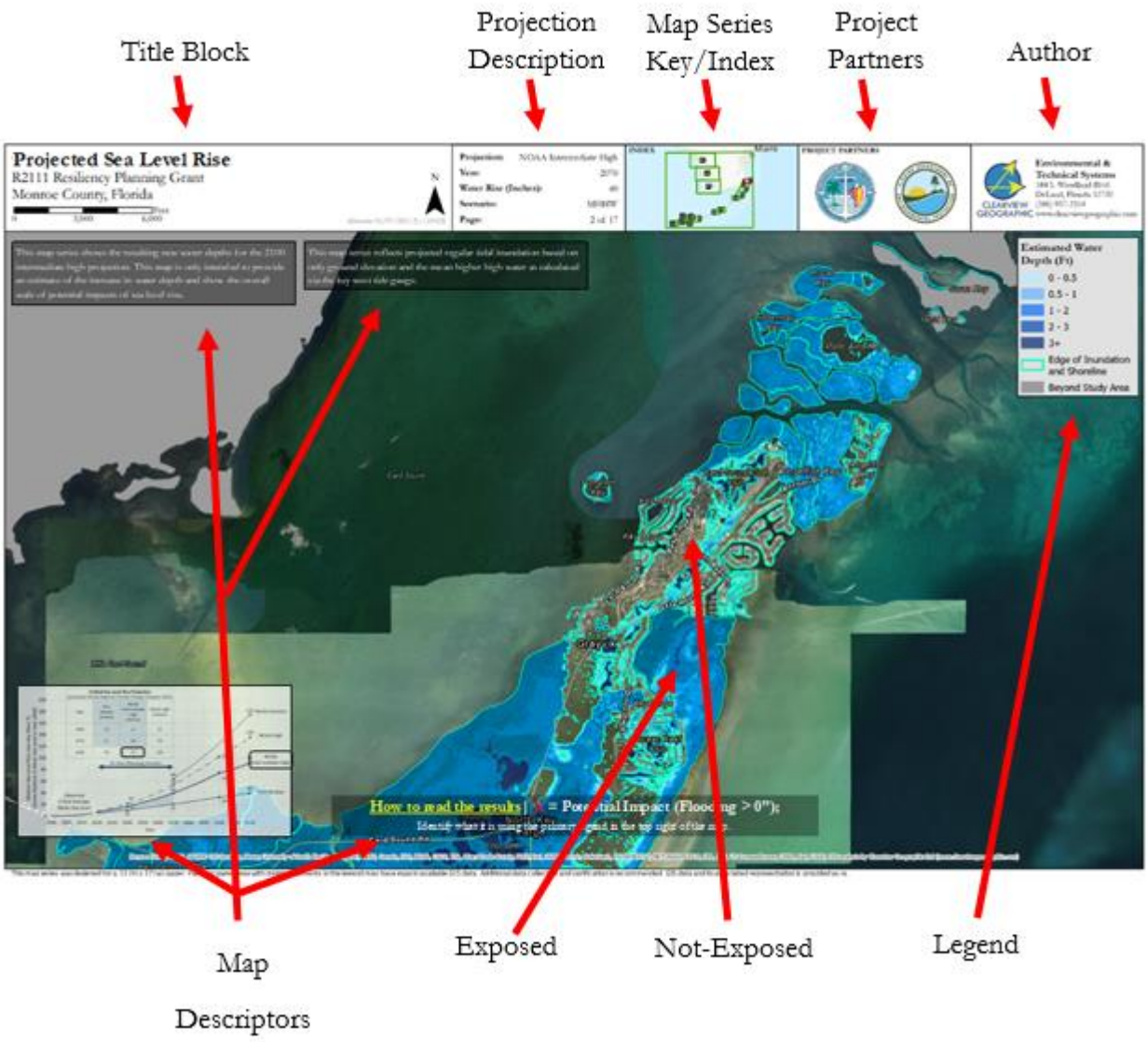
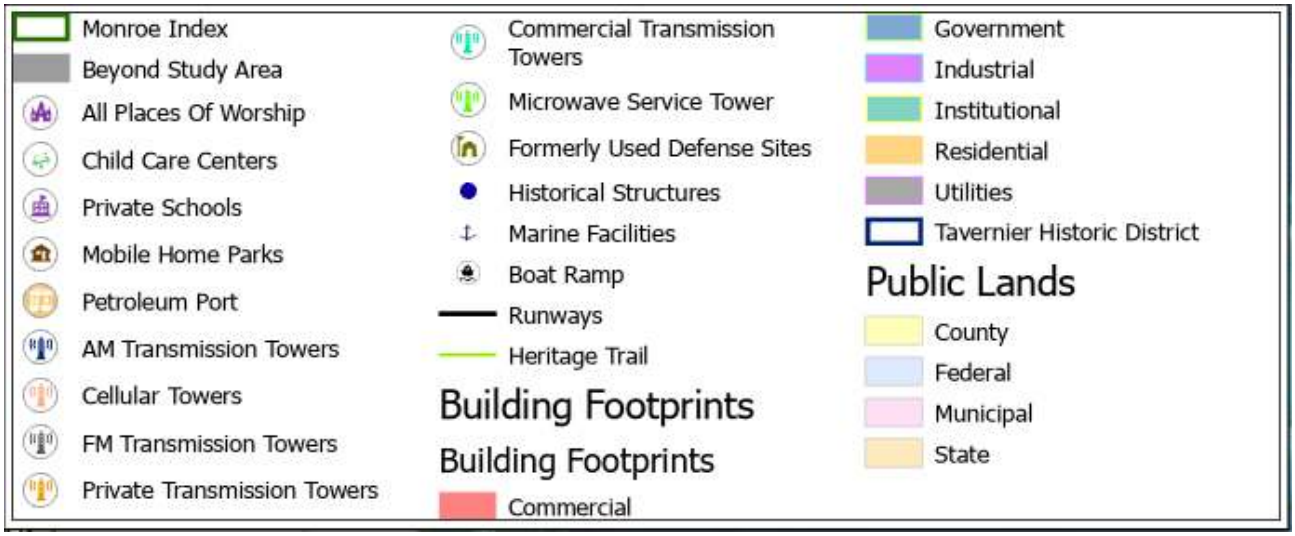


Image 14: Each map series features descriptor boxes, a legend, and an index showing the greater geographical context for that particular map in order to ensure maximum clarity

Potential vulnerability to sea level rise based on the NOAA Intermediate High sea level rise scenario is typically communicated through colored overlays. An explanation of the overlays is also included in the map descriptors highlighted above. To assist with prioritization efforts, this follows a standard: 2040 exposure/red overlay, 2070 exposure/orange overlay, and 2100 exposure/yellow overlay. This overlay should be cross checked with the available map legend, or GIS databases if more applicable, to determine what infrastructure is impacted. A sample map legend is featured below.



a. Projected Sea Level Rise / Generalized Inundation

The sea level rise projections, planning horizons, and associated NAVD88 values utilized in this analysis were sourced from the Compact's 2019 Unified Sea Level Rise Projections. The Compact's Projections start at a "zero" sea level rise baseline in the year 2000, and are referenced in mean sea level at the Key West Tide Gauge.

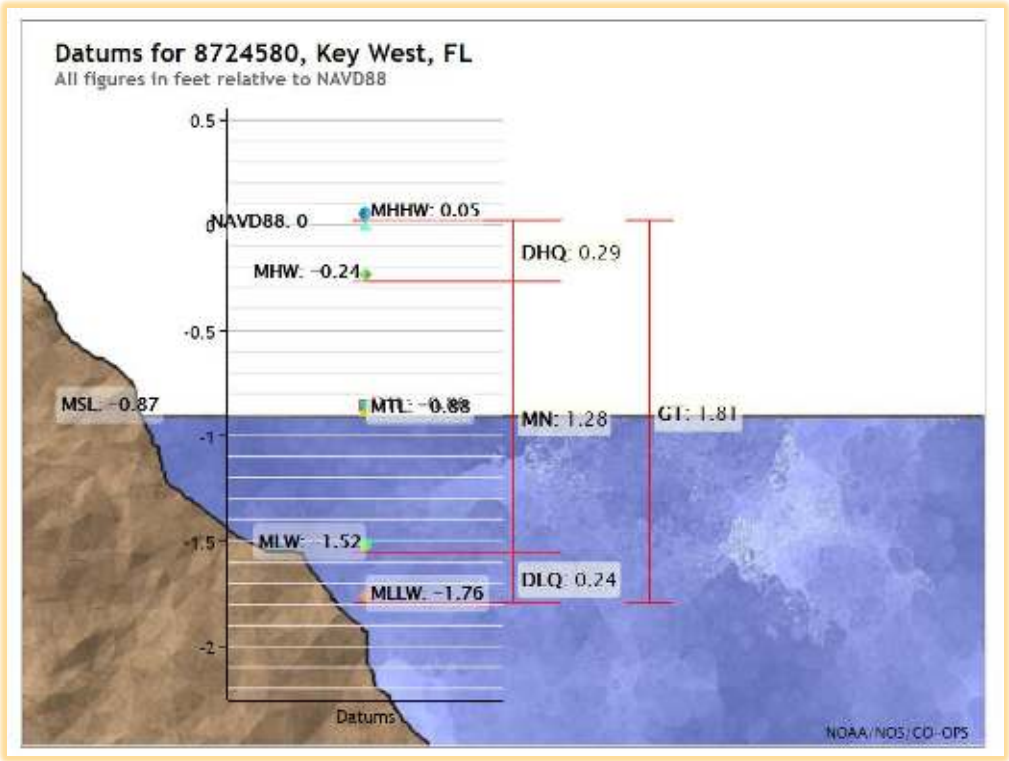


Image 15: Key West Tide Gauge, 83-01 epoch

The foundation of the general inundation model was constructed using a combination of the County's recent mobile LiDAR data, a 2007 DEM from the Florida Department of Emergency Management, as well data from the United States Geological Survey. The highest-quality data was preserved to the best extent practicable, while the lowest quality data served to fill gaps in the model. An example of the DEM for this Project is shown below in Image 15.

Image 16: Digital elevation model for Resilience Planning Grant R211

By leveraging the Compact's Projections, the Project's DEM, the Key West tide gauge (ID: 8724580), and NOAA's vertical datum conversion software ("VDATUM"), the County identified critical elevations for a range of tides using the IPCC Median and NOAA Intermediate High projections (Tables 2 & 3) for the 2040, 2070, and 2100 planning horizons. Depth grids representing approximate water depth in feet at a given location and at a given snapshot planning horizon were produced as follows:

Table 2: Critical Elevations for NOAA Intermediate High (NAVD88)

Year	MLLW	LSML	MHHW
2040	-1.16	0.6	0.65
2070	0.77	2.53	2.58
2100	3.59	5.35	5.4

Table 3: Critical Elevations for IPCC Medium (NAVD88)

Year	MLLW	LSML	MHHW
2040	-1.72	0.04	0.09
2070	-0.85	0.91	0.96
2100	0.16	1.92	1.97

In general, infrastructure lower than the identified critical elevations *may* be vulnerable to inundation corresponding to the planning horizon. While infrastructure situated or installed higher than the critical elevations exceed the reach of the bathtub sea level rise model, it is important to note that these elevations do not consider future rainfall-induced flood events, complete fluidity of the waters' surface, nearby drainage capacity, or floodwater control and flood-proofing structures.

Most of the overlays, extractions, quantities, and underlying assumptions in this Vulnerability Assessment are based on the output from this general inundation modeling methodology.

The map series and raster depth grid projections depict the results of the modified bathtub model. The provided water depth estimates are intended to help communicate the potential scale of impacts due to sea level rise: they are represented in a blue gradient where light blues are shallow waters and darker blues are deeper waters. A cyan line highlights the limits of potential inundation, as shown in the table below.

Table 4: Water Depth Example

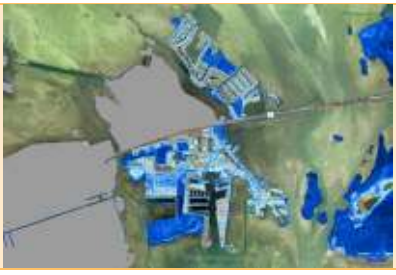
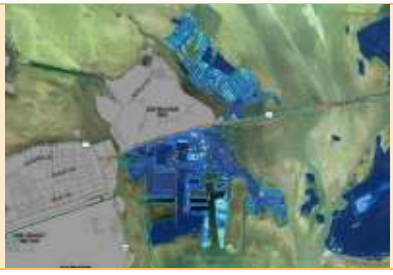
2040 (17 inches SLR)	2070 (40 inches SLR)	2100 (74 inches SLR)
Port Largo		
		
Duck Key		
		
Stock Island		
		

Table 5 below provides an estimate of land area in square miles vulnerable to sea level rise under the NOAA Intermediate High and the IPCC Median projections, specific to the project planning horizons.

Table 5: Vulnerable Land Area (Square Miles)		
Year	NOAA Intermediate High	IPCC Medium
2040	371	202
2070	1091	554
2100	1404	985

b. Transportation

The transportation analysis includes the best available location data supplied by the County's GIS data regarding mile markers, boat ramps, airport runways and the Heritage Trail system. These locations were overlaid with the sea level rise projection produced using the methodology described above. A summary of the results is provided in Table 6 below. It should be noted that to maintain consistency between this project and the Roads and Flood Mitigation planning process, street vulnerability was not included in this analysis.

The results of the transportation analysis are represented by an overlay where the colors red, orange, and yellow indicate potential vulnerability to sea level rise by planning horizon. Infrastructure that falls within the footprint of the bathtub modeling is flagged as potentially exposed. In the map series, mile markers are provided as supplemental information. Please reference the "General Infrastructure" map set to find a visual analysis of the attributes listed below.

Tables 6 and 7 below summarize the results of the transportation asset analyses for transportation infrastructure excluding street or road segments.

Table 6: Vulnerable Transportation Infrastructure				
Transportation Infrastructure	Infrastructure Impacted by Year at MHHW in Inches of SLR			
	2040 (17")	2070 (40")	2100 (74")	Total Features in Dataset
Petroleum Ports	0	1 (100%)	1 (100%)	1
Boat Ramps	7 (38.89%)	12 (66.67%)	14 (77.78%)	18

Table 7: Vulnerable Transportation Networks (Linear Miles) at MHHW				
	2040 (17")	2070 (40")	2100 (74")	Total Length of Features in Dataset
Runways	0	0.035 (0.7%)	5.006 (100%)	5.006
Heritage Trail	0.431 (0.37%)	8.186 (7.1%)	29.552 (26.5%)	115.218

c. General Infrastructure

The general infrastructure analysis includes building footprints classified by land use code, mobile home parks, historic structures and structures, marine facilities, former U.S. Department of Defense sites, and various transmission towers. These locations were overlaid with the sea level rise projection produced using the methodology described above. An overview of the visual display of the output and summary of the results is provided in Table 8 below.

The results of the general infrastructure assessment are classified by planning horizon and represented by the standard colored overlay. Building footprints categorized by type are included as supplemental information.

Table 8: General Infrastructure Analysis Example

Stock Island	Duck Key	Port Largo
		

Table 9 below provides a summary of the types of general infrastructure located within the County, based on County-supplied data[14] that may be vulnerable to the NOAA Intermediate High sea level rise projection.

Table 9: Vulnerable General Infrastructure

General Infrastructure	Infrastructure Impacted by Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
AM Transmission Towers	1 (50%)	1 (50%)	1 (50%)	2
Boat Ramps	7 (38.89%)	12 (66.67%)	14 (77.78%)	18
Cellular Towers	10 (58.82%)	12 (70.59%)	14 (82.35%)	17
Commercial Transmission Towers	15 (48.39%)	18 (58.06%)	23 (74.19%)	31

[14] See Table 1 (Tabulation of Available Data).

FM Transmission Towers	4 (19.05%)	13 (61.90%)	15 (71.43%)	21
Formerly Used Defense Sites	0	7 (43.75%)	10 (62.5%)	16
Historical Structures	7 (2.68%)	76 (29.12%)	179 (68.58%)	261
Marine Facilities	32 (12.45%)	108 (42.02%)	178 (69.26%)	257
Microwave Service Tower	4 (8.89%)	20 (44.44%)	32 (71.11%)	45
Private Transmission Towers	19 (14.07%)	55 (40.74%)	90 (66.67%)	135
Child Care	0	1 (10.00%)	5 (50.00%)	10
Mobile Home Parks	0	33 (48.53%)	53 (77.94%	68
Places of Worship	0	12 (37.50%)	24 (75.00%)	32
Private Schools	0	0	0	1

The following three tables summarize County-supplied datasets including a general parcel inventory, building inventory and lands in public ownership (County, Federal, Municipal and State). Table 10 summarizes sea level rise impacts to individual parcels (all parcels whether or not a building is located on the parcel). The two subsequent tables further characterize those data outputs further identifying those with actual buildings or lands in public ownership. Finally, the lands in public ownership dataset is included because of the County's aggressive and successful participation in FEMA's CRS program and the fact that program evaluates protection of open space within that framework. Some publicly owned land within the County's dataset may help the County to continue to receive credit in that CRS activity.

Table 10: Vulnerable Parcel Inventory

Parcel	Infrastructure Impacted by Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
Parcels	25051 (38.32%)	40177 (61.46%)	45865 (70.17%)	65,366
Tavernier Historic District Parcels	55 (18.52%)	93 (31.31%)	190 (63.97%)	297

Table 11: Vulnerable Building Inventory				
Building Type	Infrastructure Impacted by Year at MHHW			Total Features n Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
Accessory	5 (2.73%)	95 (51.91%)	154 (84.15%)	183
Commercial	52 (5.45%)	299 (31.31%)	587 (61.47%)	955
Government	9 (2.00%)	174 (38.67%)	336 (74.67%)	450
Industrial	7 (4.38%)	53 (33.13%)	121 (75.63%)	160
Institutional	4 (.70%)	56 (37.84%)	100 (67.57%)	148
Residential	1113 (5.30%)	10653 (50.75%)	17869 (85.12%)	20,992
Utility	3 (3.30%)	22 (24.18%)	72 (79.12%)	91

Table 12: Lands in Public Ownership				
Public Land	Total Area (Sq Mi) Impacted by Year at MHHW			
	2040 (17'')	2070 (40'')	2100 (74'')	Total Features in Dataset
County	1.65 (35.48%)	3.00 (64.52%)	3.84 (82.58%)	4.65
Federal	317.78 (30.09%)	631.33 (59.79%)	634.82 (60.12%)	1055.98
Municipal	0.39 (17.33%)	0.73 (32.44%)	1.30 (57.78%)	2.25
State	15.20 (50.45%)	21.57 (71.59%)	24.34 (80.78%)	30.13

d. Essential Public Infrastructure

The essential public infrastructure analysis includes schools and universities, mail courier services, banks and financial institutions, health departments, care facilities, solid waste facilities, and other critical facilities supplied by the County in this dataset. Parks are included in the "Critical Infrastructure" dataset where they are described as "Staging Areas".[15] It should be noted that while this output and map series in the Appendix are noted as "Public Infrastructure" the team added other components from data sources beyond those supplied by the County to include also privately held infrastructure or services that serve the public at large, and as such were included in this analysis. These locations were overlaid with the sea level rise projection produced using the methodology described above (NOAA Intermediate High). An overview of the visual display of the output and summary of the results is provided in Table 13 below.

[15] The County should consider a separate data layer identifying County Parks.

The results of the essential public infrastructure analysis are classified by planning horizon and represented by the standard colored overlay.

Table 13: Essential Public Infrastructure Analysis Example		
Stock Island	**Duck Key**	**Port Largo**
		

The table below provides a summary of the types of critical infrastructure that may be vulnerable to the NOAA Intermediate High sea level rise projection.

Table 14: Vulnerable Essential Public Infrastructure				
Essential Public Infrastructure	Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
Airfields	0	1 (50%)	2 (100%)	2
College/University Campuses	0	0	0	1
Public Schools	0	0	2 (40%)	5
Express Mail Facilities	0	7 (20.59%)	16 (47.06%)	34
FDIC Insured Banks	0	3 (16.67%)	7 (38.89%)	18
NCUA Insured Credit Unions	0	0	1 (100%)	1
Veteran's Health Administration Medical Facility	1 (100%)	1 (100%)	1 (100%)	1
Electronic Broadcasting System	0	0	2 (100%)	2
Communication Company Facilities	0	0	3 (75%)	4
Government Center	0	0	0	1

Debris Sites	0	6 (37.5%)	11 (68.75%)	16
Disaster Recovery	0	0	0	3
Emergency Operation Centers	0	0	0	1
EMS Stations	0	0	5 (45.45%)	11
Fire Stations	0	2 (18.18%)	5 (45.45%)	11
Hospitals	0	0	0	1
Police Facilities	0	0	0	1
Military Facilities	0	0	2 (100%)	2
Point of Dispensing	0	0	1 (100%)	1
Refuge of Last Resort	0	0	1 (50%)	2
Emergency Shelter	0	1 (33.33%)	2 (66.67%)	3
Staging	0	1 (25%)	2 (50%)	4
Landfills	0	0	0	2
Weather Radar Stations	0	0	0	1

In the next series of tables, it should be noted that based upon County-supplied data, including GIS point locations, the precise point of demarcation may be anywhere on the parcel including the building, parking lot or entrance. Without a further, more detailed investigation of the site, it is impossible to know exactly where the point of demarcation occurs on the site. What is important though is the fact that the MHHW value is the water level based on the modeling effort and the XY location of the data point. This should not be considered an exact water depth. The summary tables are an indication of where further site investigations should occur and where further flood mitigation measures could be implemented. For example: the Veterans' Health Administration Building (first row in the Table 15 below) includes a MHHW elevation of 1.48 feet. This value is the estimated water depth at the XY point location of the VA facility, but the XY point location could be in the center of the building, out in the parking lot somewhere, somewhere on the parcel/nearby. This information should not be interpreted to mean that if the building is simply elevated by 1.48 feet it will withstand impacts from the 2040 NOAA Intermediate High sea level rise condition. More site-specific investigation would be warranted. The bottom line is that this is an evaluation to "flag" priority site investigations to prioritize infrastructure retrofits or relocations.

Table 15 – Essential Public Infrastructure - Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + MHHW 2040 (17 inches of sea level rise)				
Category	Name	Address	City	MHHW Water Levels in Feet
Veterans' Health Admin Medical Facilities	Key West	1300 Douglas Circle	Key West	1.48

Table 16 - Essential Public Infrastructure - Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + MHHW 2070 (40 inches of sea level rise)				
Category	Name	Address	City	MHHW Water Levels in Feet
Airfield	Sugarloaf Airfield		Sugarloaf Key	1.49
Express Mail Facilities	DHL: The Prudential Ocean Reef	24 Dockside Lane	Key Largo	0.13
Express Mail Facilities	Fedex: Drop Box	31 Ocean Reef Dr	Key Largo	0.13
Express Mail Facilities	Fedex: Drop Box (Self-service)	5450 Macdonald Ave	Stock Island	0.15
Express Mail Facilities	Fedex: Drop Box (Self-service)	5450 Macdonald Ave	Stock Island	1.07
Express Mail Facilities	UPS: Drop Box	31 Ocean Reef Dr	Key Largo	0.13
Express Mail Facilities	UPS: Drop Box	155 Key Deer Blvd	Big Pine Key	0.40
Express Mail Facilities	UPS: Drop Box	30646 Overseas Hwy	Big Pine Key	0.59
FDIC Insured Bank	Bank of America (Ocean Reef Branch)	31 Ocean Reef Dr	Key Largo	0.22
FDIC Insured Bank	Centennial Bank (Big Pine Key Branch)	101 Wilder Rd	Big Pine Key	0.16

FDIC Insured Bank	First State Bank of the Florida Keys (Stock Island Branch)	5450 Macdonald Ave	Stock Island	1.13
Veterans' Health Admin Medical Facilities	Key West	1300 Douglas Circle	Key West	3.41
Debris Site	Carysfort Debris Site	State Road 905	Key Largo	0.82
Debris Site	Blimp Rd Debris Site	Blimp Rd	Cudjoe Key	0.74
Debris Site	Big Pine Flea Market	30250 Overseas Hwy	Big Pine Key	0.07
Debris Site	E Shore Drive Site	East Shore Dr	Summerland Key	1.27
Debris Site	South Pointe Debris Site	17001 Overseas Hwy	Sugarloaf Key	1.06
Debris Site	Toppino Debris Site	141 Overseas Hwy	Rockland Key	0.83
Fire Stations	Monroe County Fire Rescue Stock Island Station 8	5655 MacDonald Ave	Stock Island	0.06
Fire Stations	Conch Key Fire Station 17	8 S Conch Ave	Conch Key	0.26
Emergency Shelter	Burton Memorial united Methodist Church	93001 Overseas Highway	Tavernier	1.15
Staging	Bernstein Park	3rd St	Stock Island	1.18

Table 17 - Essential Public Infrastructure - Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + MHHW 2100 (74 inches of sea level rise)				
Category	Name	Address	City	MHHW Water Levels in Feet
Airfield	Sugarloaf Shores Airfield	5 Bat Tower Road	Summerland Key	4.31
Airfield	Ocean Reef Club Airport	764 Barracuda Lane	Ocean Reef	0.64
Public Schools	Ocean Studies Charter School	92295 Old Hwy	Tavernier	0.51
Public Schools	Big Pine Academy	30220 Overseas Hwy	Big Pine Key	1.50
Express Mail Facilities	Fedex: Drop Box	31 Ocean Reef Dr	Key Largo	2.95
Express Mail Facilities	Fedex: Pak Mail & Ocean Reef (Authorized Shipping Center)	24 Dockside Lane	Key Largo	2.41
Express Mail Facilities	Fedex: Keys Shipping & Business (Authorized Shipping Center)	235 Key Deer Blvd	Big Pine Key	2.69
Express Mail Facilities	Fedex: Winn Dixie Plaza (Self-service)	151 Key Deer Blvd	Big Pine Key	2.97
Express Mail Facilities	Fedex: Barnett Bank (Self-service)	US Hwy 1 & Westshore Dr	Summerland Key	2.28

Express Mail Facilities	Fedex: Drop Box (Self-service)	5450 Macdonald Ave	Stock Island	3.89
Express Mail Facilities	UPS: Drop Box	31 Ocean Reef Dr	Key Largo	2.95
Express Mail Facilities	UPS: Authorized Shipping Center	24 Dock Side Ln	Key Largo	2.41
Express Mail Facilities	UPS: Drop Box	798 Duck Key Dr	Duck Key	2.00
Express Mail Facilities	UPS: Drop Box	1 Ships Way	Big Pine Key	1.63
Express Mail Facilities	UPS: Drop Box	155 Key Deer Blvd	Big Pine Key	3.22
Express Mail Facilities	UPS: Drop Box	30646 Overseas Hwy	Big Pine Key	3.41
Express Mail Facilities	UPS: Authorized Shipping Center	235 Key Deer Blvd	Big Pine Key	2.69
Express Mail Facilities	UPS: Drop Box	25000 Overseas Hwy	Summerland Key	2.76
FDIC Insured Bank	Bank of America (Ocean Reef Branch)	31 Ocean Reef Dr	Key Largo	3.04
FDIC Insured Bank	Iberiabank (Ocean Reef Branch)	35 Ocean Reef Dr, Suite 100	Key Largo	1.78
FDIC Insured Bank	Centennial Bank (Big Pine Key Branch)	101 Wilder Rd	Big Pine Key	2.98
FDIC Insured Bank	First Tennessee Bank (Big Pine Key Branch)	30400 Overseas Hwy	Big Pine Key	0.60

FDIC Insured Bank	First State Bank of the Florida Keys (Big Pine Key Branch)	30515 Overseas Hwy	Big Pine Key	1.30
FDIC Insured Bank	First State Bank of the Florida Keys (Summerland Key Branch)	24794 Overseas Hwy	Summerland Key	0.89
FDIC Insured Bank	First State Bank of the Florida Keys (Stock Island Branch)	5450 Macdonald Ave	Stock Island	3.95
NCUA Insured Credit Union	Keys Credit Union	29977 Overseas Hwy	Big Pine Key	0.79
Veterans' Health Admin Medical Facilities	Key West	1300 Douglas Circle	Key West	6.23
Communication Company Facilities	Bell South Key Largo	94930 Overseas Hwy	Key Largo	0.53
Communication Company Facilities	Bell South Big Pine Key	30769 Avenue A	Big Pine Key	0.13
Communication Company Facilities	Bell South Sugarloaf	MM 20 Overseas Hwy	Sugarloaf Key	0.86
Debris Site	Carysfort Debris Site	State Road 905	Key Largo	3.64

Debris Site	Blimp Rd Debris Site	Blimp Rd	Cudjoe Key	3.56
Debris Site	Ships Way Debris Site	MM 0 Overseas Hwy	Big Pine Key	2.12
Debris Site	Big Pine Flea Market	30250 Overseas Hwy	Big Pine Key	2.89
Debris Site	Big Pine School	30220 Overseas Hwy	Big Pine Key	1.90
Debris Site	Sugarloaf School Site	255 Crane Boulevard	Sugarloaf Key	2.67
Debris Site	Sugarloaf Shores Airfield	5 Bat Tower Road	Summerland Key	2.13
Debris Site	E Shore Drive Site	East Shore Dr	Summerland Key	4.09
Debris Site	South Pointe Debris Site	17001 Overseas Hwy	Sugarloaf Key	3.88
Debris Site	Toppino Debris Site	141 Overseas Hwy	Rockland Key	3.65
Debris Site	Dickerson Debris Site	125 Toppino Industrial Drive	Rockland Key	0.09
Electrical Broadcasting System	WFKZ FM 103.1	93351 Overseas Hwy	Tavernier	2.71
Electrical Broadcasting System	WWUS US1 Radio 104.7	30336 Overseas Hwy	Big Pine Key	1.52
EMS	Conch Key EMS Station	8 S Conch Ave	Conch Key	2.75

EMS	Keys Emergency Medical Services Incorporated	30358 Overseas Highway	Big Pine Key	1.00
EMS	Naval Air Facility Key West Fire & EMS Station 1	Saratoga Ave	Key West	1.41
EMS	Naval Air Facility Key West Fire & EMS Station 2	Saratoga Ave	Key West	1.41
EMS	Naval Air Facility Key West Fire & EMS Station 3	Saratoga Ave	Key West	1.41
Fire Stations	Monroe County Fire Rescue Stock Island Station 8	5655 MacDonald Ave	Stock Island	2.73
Fire Stations	Naval Air Facility Key West Fire & Emergency Service Station 1	Saratoga Ave & Midway Ave	Key West	0.27
Fire Stations	Sugarloaf Key Volunteer Fire Department Station 10	17175 Overseas Highway	Sugarloaf	0.73
Fire Stations	Big Pine Volunteer Fire Department	390 Key Deer Boulevard	Big Pine Key	2.24

Fire Stations	Conch Key Volunteer Fire Department Station 17	10 South Conch Ave	Conch Key	2.79
Military Facility	US Airforce Tethrostat Site	1800 Blimp Rd	Cudjoe Key	1.27
Military Facility	Naval Air Station Key West	MM 8 Overseas Highway	Boca Chica	1.92
Point of Dispensing	Key Largo Community Park	500 St Croix Pl	Key Largo	0.51
Refuge of Last Resort	Key Largo Bay Beach	103800 Overseas Hwy	Key Largo	0.50
Emergency Shelter	Sugarloaf School	255 Crane Blvd	Summerland Key	2.52
Emergency Shelter	Burton Memorial united Methodist Church	93001 Overseas Highway	Tavernier	3.97
Staging	Tavernier Towne Parking Lot	91200 Overseas Hwy	Tavernier	0.24
Staging	Bernstein Park	3rd St	Stock Island	4.00

e. Emergency Management

The emergency management analysis included the locations of emergency medical centers, fire police stations, hospitals, nursing facilities, weather radar stations, and national shelter facilities identified either by the Homeland Infrastructure Database or supplied by the County. These locations were overlaid with the sea level rise projection produced using the methodology described above (NOAA Intermediate High). An overview of the visual display of the output and summary of the results is provided in Table 18 below. An underlay of a 2010 storm surge zone study produced by the Florida Department of Emergency Management is included to highlight the potential for higher storm surge zones as local sea levels rise.

The results of the emergency management infrastructure analysis are classified by planning horizon and represented by the standard colored overlay. Storm surge zones sourced from the 2010 Florida Department of Emergency Management study are included as supplemental information.

Table 18: Emergency Management Analysis Example

Stock Island	Duck Key	Port Largo
		

The table below provides a summary of the types of emergency management infrastructure that may be vulnerable to the NOAA Intermediate high sea level rise projection.

Table 19: Vulnerable Emergency Management Infrastructure

Emergency Management Infrastructure	Infrastructure Impacted by Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
EMS Stations	0	0	5 (45.45%)	11
Fire Stations	0	2 (18.18%)	5 (45.45%)	11
Hospitals	0	0	0	1
Police Stations	0	0	0	1
Military Facilities	0	0	2 (100%)	2
Emergency Shelters	0	1 (33.33%)	2 (66.67%)	3
Weather Radar Stations	0	0	0	1

In the next series if tables, it should be noted that based upon County-supplied data, including GIS point locations, the precise point o demarcation may be anywhere on the parcel, including the building, parking lot, or entrance. Without a further, more detailed investigation of the site, it is impossible to know exactly where the point of demarcation occurs on the site. What is important, though, is the fact that the MHHW value is the water level, based on the modeling effort and the X/Y location of the data point. This should not be considered an exact water depth. The summary tables are an indication of where further site investigation should occur, and where further flood mitigation measures could be implemented. For example, the Burton Memorial United Methodist Church (first row in Table X below) includes a MHHW elevation of 1.15 feet. This value is the estimated water depth at the X/Y point location of the VA facility, but the X/Y point location could be in the center of the building, out in the parking lot, or somewhere else on the parcel or nearby. This information should not be interpreted to mean that if the building is simply elevated by 1.15 feet, it will withstand impacts from the 2040 NOAA Intermediate High sea level rise condition. More site-specific investigation would be warranted. The elevations below indicate a priority site for further study and to prioritize retrofits or perform a cost-benefit analysis for relocation.

Table 20: Emergency Management Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + MHHW (2070)				
Name	Category	Address	City	MHHW Water Levels in Feet
Burton Memorial united Methodist Church	Emergency Shelter	93001 Overseas Highway	Tavernier	1.15
Monroe County Fire Rescue Stock Island Station 8	Fire Stations	5655 MacDonald Ave	Stock Island	0.06
Conch Key Fire Station 17	Fire Stations	8 S Conch Ave	Conch Key	0.26

Table 21: Emergency Management Infrastructure Impacted by NOAA Intermediate High Sea Level Rise + MHHW (2100)				
Name	Category	Address	City	MHHW Water Levels in Feet
Conch Key EMS Station	EMS	8 S Conch Ave	Conch Key	2.75
Keys Emergency Medical Services Incorporated	EMS	30358 Overseas Highway	Big Pine Key	1.00
Naval Air Facility Key West Fire & EMS Station 1	EMS	Saratoga Ave	Key West	1.41
Naval Air Facility Key West Fire & EMS Station 2	EMS	Saratoga Ave	Key West	1.41
Naval Air Facility Key West Fire & EMS Station 3	EMS	Saratoga Ave	Key West	1.41
Sugarloaf School	Emergency Shelter	255 Crane Blvd	Summerland Key	2.52
Burton Memorial united Methodist Church	Emergency Shelter	93001 Overseas Highway	Tavernier	3.97
US Airforce Tethrostat Site	Military Facility	1800 Blimp Rd	Cudjoe Key	1.27
Naval Air Station Key West	Military Facility	MM 8 Overseas Highway	Boca Chica	1.92
Monroe County Fire Rescue Stock Island Station 8	Fire Stations	5655 MacDonald Ave	Stock Island	2.73

Naval Air Facility Key West Fire & Emergency Service Station 1	Fire Stations	Saratoga Ave & Midway Ave	Key West	0.27
Sugarloaf Key Volunteer Fire Department Station 10	Fire Stations	17175 Overseas Highway	Sugarloaf	0.73
Big Pine Volunteer Fire Department	Fire Stations	390 Key Deer Boulevard	Big Pine Key	2.24
Conch Key Volunteer Fire Department Station 17	Fire Stations	10 South Conch Ave	Conch Key	2.79

f. Threatened and Endangered Species Focus Areas

General biological conditions of threatened and endangered species as listed in the Florida Administrative Code[16] were reviewed, including habitat and home range. Additionally, the County identified species focus areas for the Eastern Indigo Snake, Cape Sable Thoroughwort, Tree Cactus, Woodrat, Marsh Rabbit, Caretta Caretta, Cotton Mouse, Silver Rice Rat, Tree Snail, Key Deer and the Schaus Swallow Tail. These species focus areas were assessed for potential vulnerabilities to sea level rise based on their unique conditions.

There are numerous threats to the continued existence of threatened and endangered species in the Keys. These include, but are not limited to, loss of habitat due to regular tidal flooding, habitat change, and habitat migration as species "move uphill" to find food, shelter, and other necessities. The impacts of human population growth present threats as well. Potential changes in coastal soil chemistry (salinity, nutrient availability, etc.) to the availability of fresh groundwater are cause for concern as these are the foundational building blocks of sensitive ecosystems.

There are many potential impacts of sea level rise that could affect almost all species that depend on coastal habitat. Man-made structures constructed with or storing hazardous materials can harm sensitive ecosystems, particularly because substances and contaminants can accumulate in a living organism over time. Regular tidal flooding may impact nesting reptiles, amphibians, and insect species by suffocating eggs, which prevents carbon dioxide and oxygen exchange. This could cause a generational deficit, which would represent a negative impact on population trends. Aquatic plant concentrations may decrease due to changes in water quality and outward fish migration due to lack of suitable habitat and foraging area.

The threatened and endangered species map series includes aerial calculations of the vulnerable species focus areas within the County, and are provided with corresponding map documents that show where potential vulnerabilities may occur. Sea level rise planning horizons are displayed as a hatched pattern with 2040 having the closest pattern and 2100 having the farthest.

Table 22: Threatened and Endangered Species Focus Areas Analysis Example

Stock Island	Duck Key	Port Largo
		

[16] Rule 68A-27.003, F.A.C.

Table X quantifies the land area vulnerable to the NOAA Intermediate High sea level rise projection's tidal inundation model that fall within the County's species focus areas.

Table 23: Species Focus Areas				
Species	Total Area (Sq Mi) Impacted by NOAA Intermediate High Sea Level Rise + MHHW by Year			
	2040 (17'')	2070 (40'')	2100 (74'')	Total (Sq. Mi)
American Crocodile	24.486 (52.46%)	30.035 (64.35%)	34.698 (74.33%)	46.678
Bartram Hairstreak Butterfly	0.051 (2.04%)	1.508 (60.27%)	2.494 (99.68%)	2.502
Cape Sable Thoroughwort	0.961 (13.30%)	3.180 (44.00%)	7.130 (98.66%)	7.227
Cotton Mouse	0.199 (3.04%)	1.310 (20.01%)	3.390 (51.77%)	6.548
Eastern Indigo Snake	58.467 (57.22%)	84.262 (82.47%)	91.440 (89.49%)	102.179
Florida Leafwing Butterfly	0.045 (2.08%)	1.333 (61.74%)	2.157 (99.91%)	2.159
Florida Semaphore Cactus	0.875 (12.80%)	3.059 (44.75%)	4.678 (68.43%)	6.836
Key Deer	27.015 (55.54%)	42.881 (88.17%)	46.805 (96.23%)	48.637
Marsh Rabbit	19.302 (63.45%)	28.120 (92.43%)	29.605 (97.31%)	30.422
Piping Plover	0.525 (12.96%)	0.647 (15.98%)	0.719 (17.75%)	4.05
Schaus Swallowtail	0.228 (2.92%)	1.626 (20.81%)	4.191 (53.63%)	7.815
Silver Rice Rat	26.881 (56.83%)	43.038 (90.99%)	45.458 (96.10%)	47.302
Tree Cactus	0.878 (6.14%)	6.883 (48.14%)	10.910 (76.30%)	14.299
Tree Snail	0.878 (6.14%)	6.883 (48.14%)	10.910 (76.30%)	14.299
West Indian Manatee	0.931 (58.74%)	1.026 (64.73%)	1.074 (67.76%)	1.585
Woodrat	0.199 (3.04%)	1.310 (20.00%)	3.390 (51.76%)	6.549

Table 24: Species Focus Areas (Linear Miles of Coastal Beach Habitat)[17]			
Species Focus Areas	2040 (17'')	2070 (40'')	2100 (74'')
Caretta Caretta/Logger Head Sea Turtle	0.724 (2.25%)	21.037 (65.43%)	22.156 (68.91%)

g. Stormwater

The stormwater analysis includes the best available inventory of stormwater infrastructure throughout the County. Catch basins, injection wells, manholes, outfalls, and trench drains located within the County's stormwater GIS database are incorporated into the model and this dataset was actually created by the Project team in a previous grant. While this is the most comprehensive stormwater dataset available for this project, it should be noted that it may not include ever single stormwater structure within unincorporated County. These locations were overlaid with the sea level rise projection produced using the methodology described above (NOAA Intermediate High). An overview of the visual display of the output and summary of the results is provided in Table 25 below.

The results of the stormwater analysis are classified by planning horizon and represented by the standard colored overlay. Pages with minimal-to-no data may have stormwater infrastructure that is not digitized in Monroe County's stormwater databases.

Table 25: Stormwater Analysis Example		
Stock Island	**Duck Key**	**Port Largo**
		

Table 26 provides a summary of the types of stormwater infrastructure assets that may be vulnerable to the NOAA Intermediate High sea level rise projection. Additionally, some key infrastructure assets that are potentially vulnerable to the NOAA Intermediate High Sea Level Rise

[17] U.S. Fish & Wildlife Service, North Florida Ecological Services Office, *Loggerhead Sea Turtle Critical Habitat for the Northwest Atlantic Ocean,* https://www.fws.gov/northflorida/SeaTurtles/2014_Loggerhead_CH/Terrestrial_critical_habitat_loggerhead.html (last updated February 7, 2018).

condition are detailed in the following table. The results of the potable water analysis are classified by planning horizon and represented by the standard colored overlay.

Table 26: Vulnerable Stormwater Infrastructure				
Stormwater Infrastructure	Infrastructure Impacted by Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
Catch Basins	13 (6.1%)	168 (78.5%)	210 (98.1%)	214
Injection Wells	0	9 (56.3%)	16 (100%)	16
Manholes	2 (3.84%)	44 (84.62%)	50 (96.2%)	52
Outfalls	1 (5.9%)	6 (35.3%)	8 (47.1%)	17
Trench Drains	14 (16.67%)	54 (64.3%)	74 (88.1%)	84

h. Potable Water

The potable water analysis includes water treatment facilities, vaults, tanks, wells, pressurized mains, service lines, hydrants, wells, sampling stations, values, and other points of interest specific to the County's water supply. These locations were overlaid with the sea level rise projection produced using the methodology described above. An overview of the visual display of the output and summary of the results is provided below. Key infrastructure assets that are potentially vulnerable to the NOAA Intermediate High Sea Level Rise condition are detailed in the following table.

The results of the potable water analysis are classified by planning horizon and represented by the standard colored overlay.

Table 27: Potable Water Analysis Example		
Stock Island	**Duck Key**	**Port Largo**
		

Table 28 below provides a summary of the types of potable water infrastructure assets that may be vulnerable to the NOAA Intermediate High sea level rise projections.

Table 28: Vulnerable Potable Water Infrastructure				
Potable Water Infrastructure	Infrastructure Impacted by Year at MHHW			Total Features in Dataset
	2040 (17'')	2070 (40'')	2100 (74'')	
Cathodic Protection	2 (0.57%)	19 (5.44%)	123 (35.24%)	349
Cathodic Rect.	0	6 (19.35%)	17 (54.84%)	31
Control Valves	29 (2.91%)	468 (46.99%)	830 (83.33%)	996
Fitting	14 (1.56%)	212 (23.61%)	705 (78.5%)	898
Hydrants	10 (1.23%)	236 (28.92%)	622 (76.23%)	816
Master Tap	0	7 (7.69%)	47 (51.65%)	91
Network Structures	0	2 (18.18%)	7 (63.64%)	11
Sampling Stations	2 (1.1%)	55 (30.39%)	125 (69.1%)	181
System Valves	74 (1.78%)	1252 (30.09%)	3140 (75.46%)	4161
Tanks	0	1 (11.11%)	7 (77.8%)	9
Water Treatment Facilities	0	15 (23.08%)	65 (100%)	65
Water Treatment Tanks	0	8 (22.22%)	36 (100%)	36
Water Treatment Vaults	0	9 (28.13%)	32 (100%)	32
Water Treatment Wells	0	7 (30.43%)	18 (78.26%)	23

Table 29: Vulnerable Potable Water Infrastructure (Linear Miles) at MHHW				
	2040 (17'')	2070 (40'')	2100 (74'')	Total Length of Features in Dataset
Service Lines	1.651 (1.62%)	34.095 (33.43%)	83.391 (81.77%)	101.978
Pressurized Mains	13.068 (2.32%)	178.144 (31.62%)	379.56 (67.36%)	563.477
Retired Mains	1.829 (1.47%)	33.935 (27.21%)	83.874 (67.26%)	124.701

i. Sanitary Sewer

The sanitary sewer analysis captures wastewater treatment facilities, liquid storage units, vaults, gravity fed and pressurized mains, pumps, laterals, manholes, cleanout locations, as well as various valves and control panels. These locations were overlaid with the sea level rise projection produced using the methodology described above. An overview of the visual display of the output and summary of the results is provided in Table 30 below. The results of the sanitary sewer analysis are classified by planning horizon and represented by the standard colored overlay.

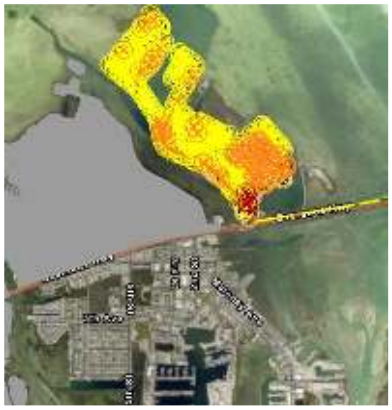
Table 30: Sanitary Sewer Analysis Example		
Stock Island	Duck Key	Port Largo
		

Table 31 below provides a summary of the types of wastewater infrastructure assets that may be vulnerable to the NOAA Intermediate High sea level rise projections. Additionally, linear miles of potentially vulnerable pipe networks are detailed in the following table.

Table 31: Vulnerable Sanitary Sewer Infrastructure				
Sanitary Sewer Infrastructure	Infrastructure Impacted by Year at MHHW			
	2040 (17'')	2070 (40'')	2100 (74'')	Total Features in Dataset
Clean Outs	9 (0.12%)	3246 (42.1%)	7597 (98.55%)	7709
Control Valves	5 (1.21%)	227 (54.8%)	394 (95.2%)	414
Fitting	8 (0.93%)	293 (35%)	766 (89.5%)	856
LPS Control Panels	10 (1.2%)	411 (49.3%)	829 (99.4%)	834
LPS Pumps	43 (2.2%)	1144 (58.9%)	1881 (96.9%)	1942
LPS Valves	14 (0.9%)	822 (51.7%)	1560 (98.1%)	1590
Manholes	12 (0.6%)	835 (51.8%)	1976 (98.8%)	2000
Network Structures	2 (0.47%)	220 (51.3%)	426 (99.3%)	429
System Valves	0	286 (41.1%)	667 (95.83%)	696
Wastewater Facilities	0	22 (25.3%)	74 (85.1%)	87
Wastewater Liquid Storage	0	16 (23.9%)	53 (79.1%)	67
Wastewater Vaults	0	1 (11.1%)	9 (100%)	9

Table 32: Vulnerable Sanitary Sewer Infrastructure (Linear Miles)				
	Infrastructure Impacted by Year at MHHW			
	2040 (17'')	2070 (40'')	2100 (74'')	Total Length of Features in Dataset
Gravity Main	0.344 (0.34%)	40.170 (39.5%)	100.908 (99.2%)	101.767
Lateral	0.238 (0.46%)	22.317 (43.4%)	50.502 (98.12%)	51.477
LPS Main	1.171 (2.2%)	31.844 (59.3%)	50.400 (93.8%)	53.745
Pressurized Main	1.32 (1.5%)	34.078 (37.6%)	79.829 (87.01%)	90.597

j. Power Grid

The power grid analysis includes power generation and transmission infrastructure such as power plants, substations, and overhead transmission lines. These locations were overlaid with the sea level rise projection produced using the methodology described above. An overview of the visual display of the output and summary of the results is provided in Table 33 below. The results of the power grid analysis are classified by planning horizon and represented by the standard colored overlay.

Table 33: Power Grid Analysis Example		
Stock Island	Duck Key	Port Largo
		

Table 34 below provides a summary of the types of electrical infrastructure assets that may be vulnerable to the NOAA Intermediate High sea level rise projections.

Table 34: Power Grid Vulnerability				
Infrastructure Impacted by Year at MHHW				
Asset Type	2040	2070	2100	Total Features in Dataset
Misc. Facilities	0	0	6 (66.67%)	9
Padmount Transformers	6 (1.13%)	53 (9.94%)	364 (68.3%)	533
Power Plants	2 (66.67%)	2 (66.67%)	2 (66.67%)	3
Substations	0	4 (31.7%)	6 (46.2%)	13
Substations Generators	0	0	2 (40%)	5
Switchgears	0	24 (45.3%)	48 (90.6%)	53
Switchgear Facilities	0	2 (33.3%)	3 (50%)	6
Transmission Relay Facilities	0	0	1 (50%)	2

Table 35: Power Grid Vulnerability (Linear Miles)				
	2040 (17'')	2070 (40'')	2100 (74'')	Total Length of Features in Dataset
Transmission Lines	11.263 (8.4%)	28.605 (21.4%)	53.767 (40.1%)	133.962

k. Sea Level Rise + FEMA Comparison

The most recent effective FEMA flood zones within the National Flood Hazard Layer[18] were compared with the sea level rise projections produced using the methodology described above. An overview of visual display of the output and summary of the results is included in the following sections. To evaluate the impacts of an extreme flood event worsened by the effects of sea level rise, FEMA's HAZUS-MH tool was utilized to simulate the Year 2100 condition with a 100-year storm surge event under NOAA's high projection. This process produced a water depth grid similar to the regular tidal flooding modeling above.

This output has been included to highlight areas that may be under insured and potentially more vulnerable to sea level rise impacts. The assumption being people don't get flood insurance unless they are within the 100-yr and sometimes 500-yr floodplain. This chart and mapping effort reveals that sea level rise tidal inundation is a potential risk within both the 100-yr, 500-yr and even outside the floodplain.

[18] 12087C_STUDY1, February 18, 2015.

Table 36: Sea Level Rise + FEMA Analysis Example		
Stock Island	Duck Key	Port Largo
		

Table 37: FEMA NFHL Comparison to NOAA Intermediate High Sea Level Rise Projection (Land area in Acres)				
Flood Zone/Annual Risk	Acres Impacted by SLR Tidal Inundation			Total Acres in Current Floodplain
	2040 (17'')	2070 (40'')	2100 (74'')	
100-yr (1% annual chance)	215,840.47 (34.29%)	428,942.72 (68.15%)	436,401.86 (69.33 %)	629,373
500-yr (0.2% annual chance)	2.59 (0.33%)	9.29 (1.2%)	106.79 (13.78%)	769
Acres Entirely Outside Floodplain			10.43	N/A

Table conclusions:

- Based on the current 100-yr floodplain and the 2040 SLR projection -> 215,840 acres of land that is within the 100-yr floodplain may experience regular tidal flooding
- Based on the current 500-yr floodplain and the 2070 projection -> 9 acres of land within the 500-yr floodplain may experience tidal inundation.
- Based on the current 100-yr and 500-yr floodplain -> 10 acres of land are NOT within current the floodplain BUT may experience regular tidal inundation

l. Habitat Change

Sea Level Affecting Marshes Model (SLAMM), which is an advanced land cover and ecosystem change tool (Warren Pinnacle Consulting, Inc., 2016). SLAMM, unlike other flood vulnerability assessment methods, integrates long-term hydrologic functions and ecosystem parameters to give projections about future changes to tidal habitat types, such as saltwater marshes, mangroves, and other coastal wetlands, that are already subjected to regular tidal flooding.

The sea level rise-induced habitat change projections were conducted in SLAMM using a variety of data inputs: Florida Fish & Wildlife Conservation Commission's 2019 Cooperative Land Cover Database, a digital elevation model-derived slope raster, and other parameters were either obtained during the data collection effort or taken from the County's previous Vulnerability Assessment. Default values within the program and the 2019 land cover database quantified a total amount of carbon sequestration change. An attempt was made to project changes in submerged aquatic vegetation; however, the program would not respond to the raster dataset representing the distance to the mouth of the nearest estuary. Table 38 below displays Big Pine Key as an example reference for planning horizons.

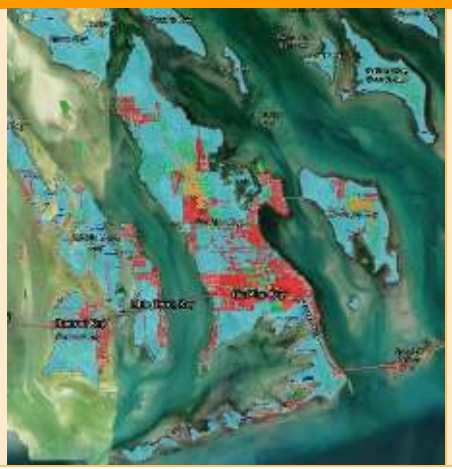
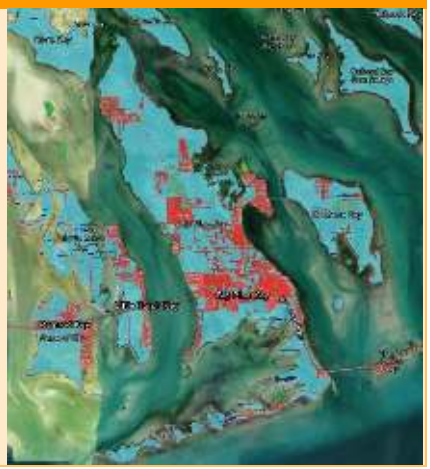
Several exploratory runs of SLAMM were performed for mainland Monroe County as part of this Project. However, technical review of these results indicated low confidence in the SLAMM output for mainland Monroe County. The model was challenged by the intricate hydrologic connectivity between the greater Everglades drainage networks and wetland systems across a low tidal energy coastline with very low relief. Additional factors, such as the highly-complex interfaces between freshwater and saltwater exchange among surface and groundwater, as well as the impacts of ongoing projects associated with the Comprehensive Everglades Restoration Plan, also could not be reasonably incorporated into the SLAMM runs for this project. A modeling effort that would appropriately capture the potential impacts of sea level rise within the context of this sensitive ecosystem would require much more substantial calibration and higher resolution environmental datasets than could be supported through the resources associated with this current Vulnerability Assessment.

The following tables, Tables 39-41, provides a model output for the entire overview within Monroe County. For planning purposes, the tabular output is segmented into the following delineation: the Upper-Keys, Middle-Keys, and Lower-Keys. These divisions were selected arbitrarily for analysis purposes and ease of review to break up the table output.

The results of the habitat change modeling are summarized by habitat type and provided in tables corresponding with specific geographic extents within Monroe County. The extents were chosen to show the full context of the County while also narrowing down to the glades, upper, middle, and lower Keys to assist with regional habitat management planning efforts. Specific changes from one habitat type to another can be observed via the complete map series starting with the base year of 2019 and continuing onward through the three project planning horizons of 2040, 2070 and 2100.

Table 38: Habitat Change Analysis Example

Big Pine Key

2040	2070	2100
		

The tabular outputs below provide total acreages and percent change by habitat type within the study area for the NOAA Intermediate High sea level rise projections. Though the same data were used, the attached corresponding map series is not specifically divided to match the summary tables provided below. Table 39 shows the sum of all habitat Countywide.

Table 39: Sum of All Habitat Countywide

SLAMM Output - County wide acres of land area; "present" is cross walk from FWC CLC Nov - 2019 to SLAMM NWI categories.

					Change from			Change from	
Habitat Type	**Present**	**2040**	**Change**	**2070**	**Present**	**2040**	**2100**	**Present**	**2070**
Developed Dry Land	18117.0	15650.2	-14%	9457.7	-48%	-40%	4660.3	-74%	-70%
Undeveloped Dry Land	13885.0	8441.5	-39%	4607.6	-67%	-45%	2243.0	-84%	-73%
Swamp	35076.6	160.0	-100%	61.8	-100%	-61%	36.5	-100%	-77%
Cypress Swamp	31795.3	15.1	-100%	0.1	-100%	-99%	0.0	-100%	-100%
Inland-Fresh Marsh	147827.4	788.3	-99%	68.3	-100%	-91%	25.0	-100%	-97%
Trans. Salt Marsh	0.0	452.1		67.8		-85%	1190.9		163%
Mangrove	342369.1	240306.2	-30%	24375.0	-93%	-90%	15148.5	-96%	-94%
Tidal Flat	3591.7	570.9	-84%	194.3	-95%	-66%	1025.7	-71%	80%
Ocean Beach	122.3	111.4	-9%	57.0	-53%	-49%	25.2	-79%	-77%
Rocky Intertidal	7978.6	3555.5	-55%	790.0	-90%	-78%	203.7	-97%	-94%
Inland Open Water	573.6	195.7	-66%	86.7	-85%	-56%	56.4	-90%	-71%
Estuarine Open Water	17664.2	314304.0	1679%	538375.5	2948%	71%	548125.6	3003%	74%
Open Ocean	1596.4	1809.3	13%	2013.5	26%	11%	2097.3	31%	16%
Irreg.-Flooded Marsh	0.0	0.4		0.0		-100%	0.4		-8%
Tidal Swamp	15.1	4.5	-70%	2.4	-84%	-47%	1.0	-93%	-77%
Flooded Developed Dry Land	0.0	2466.8		8659.2		251%	13456.7		446%
Flooded Forest	0.0	31780.2		31795.2		0%	31795.3		0%
Aggregated Non Tidal	32002.0	26558.5	-17%	22724.5	-29%	-14%	20359.9	-36%	-23%
Freshwater Non-Tidal	214699.3	963.5	-100%	130.2	-100%	-86%	61.5	-100%	-94%
Open Water	19834.1	316309.0	1495%	540475.7	2625%	71%	550279.4	2674%	74%
Low Tidal	11692.6	4237.8	-64%	1041.3	-91%	-75%	1254.6	-89%	-70%
Saltmarsh	0.0	0.0		0.0			520.6		
Transitional	342369.1	272539.0	-20%	56238.0	-84%	-79%	48135.2	-86%	-82%
Freshwater Tidal	15.1	4.5	-70%	2.4	-84%	-47%	1.0	-93%	-77%
GHG (10^3 Kg/Metric Tons)		573559.9		562072.1		-2%	574672.1		0%

As stated above, the maps and tables following are to assist with identifying the divisions between the Upper-Keys, Middle-Keys, and Lower-Keys using this order. The map below represents the upper portion of the Keys. Habitat change model outputs for the Upper Keys are provided in Table 40.

Image 17: Habitat Change in the Upper Keys shown from Mile Marker 110 to Mile Marker 70

Table 40: Upper Keys Habitat Change

SLAMM Output - Subset of the upper portion of the study area within the Keys. Acres of land area; "present" is cross walk from FWC CLC Nov - 2019 to SLAMM NWI categories.

					Change from			Change from	
Habitat Type	**Present**	**2040**	**Change**	**2070**	**Present**	**2040**	**2100**	**Present**	**2070**
Developed Dry Land	6139.432	5874.7	-4%	4632.0	-25%	-21%	2839.6	-54%	-39%
Undeveloped Dry Land	4463.0197	4014.1	-10%	3202.1	-28%	-20%	1921.2	-57%	-40%
Swamp	57.822659	31.9	-45%	24.5	-58%	-23%	10.4	-82%	-58%
Cypress Swamp	0	0.0		0.0			0.0		
Inland-Fresh Marsh	0	0.0		0.0			0.0		
Tidal-Fresh Marsh	0	0.0		0.0			0.0		
Trans. Salt Marsh	0	16.6		15.4		-7%	361.6		2241%
Mangrove	20196.12	6991.7	-65%	3597.2	-82%	-49%	1814.2	-91%	-50%
Tidal Flat	1123.9835	199.6	-82%	115.7	-90%	-42%	817.7	-27%	607%
Ocean Beach	6.4494504	7.6	18%	9.7	51%	27%	8.0	24%	-18%
Rocky Intertidal	491.04781	237.4	-52%	88.7	-82%	-63%	27.6	-94%	-69%
Inland Open Water	149.89412	102.5	-32%	35.8	-76%	-65%	24.1	-84%	-33%
Estuarine Open Water	745.9123	15633.7	1996%	20136.4	2600%	29%	21971.0	2846%	9%
Open Ocean	689.64641	696.9	1%	708.6	3%	2%	729.5	6%	3%
Irreg.-Flooded Marsh	0	0.2		0.0		-100%	0.4		
Tidal Swamp	12.676506	4.3	-66%	2.4	-81%	-45%	1.0	-92%	-57%
Flooded Developed Dry Land	0	264.8		1507.4		469%	3299.8		119%
Flooded Forest	0	0.0		0.0			0.0		
Aggregated Non Tidal	10602.452	10153.5	-4%	9341.6	-12%	-8%	8060.6	-24%	-14%
Freshwater Non-Tidal	57.822659	31.9	-45%	24.5	-58%	-23%	10.4	-82%	-58%
Open Water	1585.4528	16433.1	936%	20880.8	1217%	27%	22724.6	1333%	9%
Low Tidal	1621.4808	444.6	-73%	214.1	-87%	-52%	853.4	-47%	299%
Saltmarsh	0	0.0		0.0			249.9		
Transitional	20196.12	7008.5	-65%	3612.7	-82%	-48%	2176.2	-89%	-40%
Freshwater Tidal	12.676506	4.3	-66%	2.4	-81%	-45%	1.0	-92%	-57%
GHG (10^3 Kg/Metric Tons)		6165.2		15202.6		147%	25939.3		71%

The map below represents the middle portion of the Keys. Habitat change model outputs for the Middle Keys are provided in Table 41.

Image 18: Habitat Change in the Middle Keys shown from Mile Marker 70 to Mile Marker 45

Table 41: Middle Keys Habitat Change

SLAMM Output - Subset of the middle portion of the study area within the Keys. Acres of land area; "present" is cross walk from FWC CLC Nov - 2019 to SLAMM NWI categories.

					Change from			Change from	
Habitat Type	**Present**	**2040**	**Change**	**2070**	**Present**	**2040**	**2100**	**Present**	**2070**
Developed Dry Land	2725.2	2546.5	-7%	1373.5	-50%	-46%	539.5	-80%	-61%
Undeveloped Dry Land	1119.1	683.3	-39%	317.0	-72%	-54%	123.1	-89%	-61%
Swamp	11.8	3.7	-68%	1.8	-85%	-52%	0.5	-96%	-74%
Cypress Swamp	0.2	0.1	-63%	0.0	-80%	-46%	0.0	-100%	-100%
Inland-Fresh Marsh	6.7	2.6	-61%	1.1	-84%	-59%	0.3	-95%	-72%
Tidal-Fresh Marsh	0.0	0.0		0.0			0.0		
Trans. Salt Marsh	0.0	17.9		9.7		-46%	100.5		937%
Mangrove	1880.1	1024.3	-46%	577.5	-69%	-44%	173.0	-91%	-70%
Tidal Flat	52.5	24.6	-53%	9.0	-83%	-63%	48.9	-7%	445%
Ocean Beach	12.5	12.4	-1%	7.6	-39%	-38%	3.5	-72%	-54%
Rocky Intertidal	83.8	53.5	-36%	20.8	-75%	-61%	5.5	-93%	-73%
Inland Open Water	43.6	15.9	-64%	7.8	-82%	-51%	4.9	-89%	-37%
Estuarine Open Water	144.6	1503.0	940%	2379.5	1546%	58%	2789.1	1829%	17%
Open Ocean	64.3	77.7	21%	87.1	35%	12%	93.3	45%	7%
Irreg.-Flooded Marsh	0.0	0.0		0.0			0.0		
Tidal Swamp	0.0	0.0		0.0			0.0		
Flooded Developed Dry Land	0.0	178.7		1351.7		656%	2185.7		62%
Flooded Forest	0.0	0.1		0.2		27%	0.2		25%
Aggregated Non Tidal	3844.3	3408.6	-11%	3042.2	-21%	-11%	2848.3	-26%	-6%
Freshwater Non-Tidal	18.7	6.4	-66%	2.9	-85%	-55%	0.8	-96%	-74%
Open Water	252.4	1596.6	533%	2474.4	880%	55%	2887.3	1044%	17%
Low Tidal	148.8	90.4	-39%	37.5	-75%	-59%	57.9	-61%	55%
Saltmarsh	0.0	0.0		0.0			76.3		
Transitional	1880.1	1042.3	-45%	587.4	-69%	-44%	273.7	-85%	-53%
Freshwater Tidal	0.0	0.0		0.0			0.0		
GHG (10^3 Kg/Metric Tons)		1365.6		2861.0		110%	4072.6		42%

The map below represents the lower portion of the Keys. Habitat change model outputs for the Lower Keys are provided in Table 42.

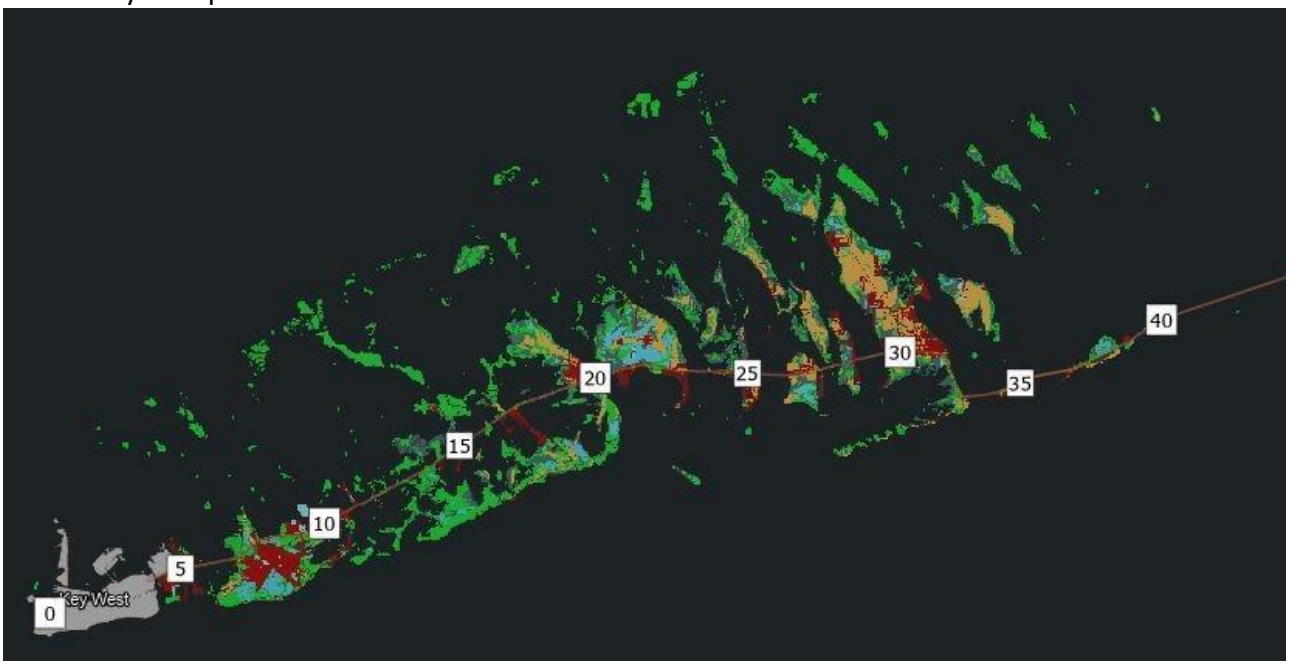


Image 19: Habitat Change in the Lower Keys shown from Mile Marker 40 to Mile Marker 0

Table 42: Lower Keys Habitat Change

SLAMM Output - Subset of the lower portion of the study area within the Keys. Acres of land area; "present" is cross walk from FWC CLC Nov - 2019 to SLAMM NWI categories.

					Change from			Change from	
Habitat Type	**Present**	**2040**	**Change**	**2070**	**Present**	**2040**	**2100**	**Present**	**2070**
Developed Dry Land	8976.7	7283.9	-19%	3487.5	-61%	-52%	1302.6	-85%	-63%
Undeveloped Dry Land	6000.9	3599.0	-40%	1011.8	-83%	-72%	156.6	-97%	-85%
Swamp	0.0	0.0		0.0			0.0		
Cypress Swamp	0.0	0.0		0.0			0.0		
Inland-Fresh Marsh	192.1	44.7	-77%	10.6	-94%	-76%	2.0	-99%	-81%
Tidal-Fresh Marsh	0.0	0.0		0.0			0.0		
Trans. Salt Marsh	0.0	25.9		38.3		48%	682.1		1682%
Mangrove	16209.9	8036.7	-50%	5009.9	-69%	-38%	1899.3	-88%	-62%
Tidal Flat	40.7	16.1	-60%	10.5	-74%	-35%	80.4	98%	667%
Ocean Beach	18.5	23.5	27%	20.0	8%	-15%	9.6	-48%	-52%
Rocky Intertidal	7430.0	3283.3	-56%	688.9	-91%	-79%	171.8	-98%	-75%
Inland Open Water	366.1	76.2	-79%	42.7	-88%	-44%	27.5	-92%	-36%
Estuarine Open Water	2607.4	17592.2	575%	25730.8	887%	46%	29310.3	1024%	14%
Open Ocean	556.9	724.9	30%	858.8	54%	18%	900.0	62%	5%
Irreg.-Flooded Marsh	0.0	0.0		0.0			0.0		
Tidal Swamp	0.0	0.0		0.0			0.0		
Flooded Developed Dry Land	0.0	1692.8		5489.3		224%	7674.2		40%
Flooded Forest	0.0	0.0		0.0			0.0		
Aggregated Non Tidal	14977.6	12575.7	-16%	9988.6	-33%	-21%	9133.4	-39%	-9%
Freshwater Non-Tidal	192.1	44.7	-77%	10.6	-94%	-76%	2.0	-99%	-81%
Open Water	3530.3	18393.2	421%	26632.4	654%	45%	30237.8	757%	14%
Low Tidal	7489.1	3322.9	-56%	719.3	-90%	-78%	261.8	-97%	-64%
Saltmarsh	0.0	0.0		0.0			182.8		
Transitional	16209.9	8062.5	-50%	5048.2	-69%	-37%	2581.4	-84%	-49%
Freshwater Tidal	0.0	0.0		0.0			0.0		
GHG (10^3 Kg/Metric Tons)		5174.2		11624.6		125%	15100.1		30%

The habitat change tabular summaries and corresponding map series can be related to the Threated & Endangered Species Review (Appendix A) as well as other ecological information to assist with conceptualizing potential species migration, habitat change, foraging and nesting area changes, among other facets of biological life history. The dynamic environment within Monroe County is such that the exact geographic location, vegetative profile, and habitat are not delineated within the map series. The modeling output is intended to be utilized in landscape-scale planning only and not for specifically identifying an area where a future habitat condition may occur. The modeling can, however, be cross-checked with identified critical habitat, nesting locations, suitable foraging areas, etc. as a foundational component to identifying where these changes may occur throughout the sea level rise planning horizons. Additional study into field conditions should be expected during this investigation.

m. Shoreline Assessment

The shoreline assessment is a collaborative analysis on various components of Monroe County's shoreline. Sea grass habitats, a categorized ranking of exposure based on the FAU shoreline study, and an analysis of the distance from the nearest shoreline to critical facilities within the County were

used for this model. The maps for this section also feature a recent habitat inventory, critical facilities, and the 2040 estimated water depth grid.

The results of the shoreline assessment are depicted in various data overlays on the maps. The distance from the nearest shoreline to the nearest critical facility is also included. The various shoreline types were divided into four different categories: Seawall, Riprap, Beach and Natural. Definitions for each are provided below.

- Seawall: hardened shoreline utilizing man-made panels (typically concrete or sheet pile) commonly applied along waterways to stabilize the shoreline and provide docking options.
- Riprap: hardened shoreline utilizing rock or similar material typically placed along shoreline requiring stabilization but where docking is not required or possible.
- Beach: sandy shorelines (natural or man-made), differentiated by the quality of the beach (i.e. sand type, beach width).
- Natural: shoreline primarily consisting of different types of vegetation, such as marsh, shrub, and wetlands, as well as mud flats and/or exposed rock.

The man-made hardened shorelines (i.e., Seawall and Riprap) were further divided into exposure levels during storm conditions: exposed or sheltered. A sheltered shoreline is typically within an internal waterway, such as a canal or inlet, or other protected location, while an exposed shoreline would be directly fronting open water (e.g., ocean). While both sheltered and exposed shorelines will be exposed to sea level rise, the impacts along exposed shorelines will be amplified as storm waves increase in intensity with sea level rise and potentially further increase base flood elevations, in addition to the contribution from sea level rise.

Table 43: Shoreline Assessment Example

Stock Island	Duck Key	Port Largo
		

A summary of the County's shoreline characteristics is provided in Table 44 below. From an adaptation perspective, only 26% of the shoreline is man-made and this is typically the costliest type of shoreline to build, rebuild and maintain. The dataset did not provide information as to which parts of the shoreline are publicly-owned.

Table 44: Shoreline Assessment		
Type	Miles	%
Exposed Seawall	39.7	3%
Exposed Rip Rap	45.5	3%
Sheltered Seawall	298.2	19%
Sheltered Rip Rap	21.8	1%
Beach	34.0	2%
Other/Natural	1147.5	72%
Total	1586.8	100%

Table 45 below provides the total number of critical facilities within a given distance from a shoreline type and its corresponding nearest shoreline type. Though a total of 188 critical facilities were included in the model for this Vulnerability Assessment, the total shown in Table X below reflects 166 critical facilities. Parks, recreational areas, and sports fields were not included in the shoreline assessment which explains the discrepancy.

To understand potential vulnerability primarily due to storm conditions, each facility was tabulated relative to the distance from the nearest shoreline and type of shoreline as discussed above. All of the facilities will be impacted by sea level rise at some point, but the closer a facility is to the shoreline the more exposed it will be to additional impacts such as storm waves. For example, a building located 3 blocks from the shoreline behind other buildings will be significantly more protected than a building located front row to the ocean. In addition, facilities fronted by only beach or natural shorelines and close to the shoreline may also have a high level of exposure due to the potentially limited protection by these. It should be noted for the natural shoreline category, information on the width of potential vegetation was not provided and areas fronted by wide areas of vegetation such as mangrove are typically very protected from storm wave impacts.

Table 45: Critical Facilities and Shoreline Proximity						
Shoreline Type		# of Facilities and Distance (ft) from Shoreline Type				Total
		0-100	100-250	250-500	500-2700	
Nearest Shoreline Type	**Exposed Seawall/Rip-Rap**	**2**	**2**	**3**	**10**	**17**
	Sheltered Seawall/Rip-Rap	**7**	**6**	**21**	**29**	**63**
	Beach	**2**	**0**	**3**	**2**	**7**
	Natural/Other	**9**	**15**	**27**	**28**	**79**
Total		**20**	**23**	**54**	**69**	**166**

To highlight potential priorities that could be extracted from this analysis, the tables below identify critical facilities impacted in the Project modeling.

Table 46: Critical Facilities Within 0-500 feet of Shoreline				
Critical Facility Name	**Address**	**Location**	**Facility Type**	**Distance from Shoreline (ft)**
Conch Key Fire Station #17	8 S Conch Avenue	Conch Key	EMS	63
Conch Key Fire Station #17	8 S Conch Avenue	Conch Key	Fire	73
FHP Substation	3491 S Roosevelt Boulevard	Key West	Law	180
Fort Zachary Taylor Landing Zone	100 Angela Street	Key West	Airfield	208
M. C. Public Works Key West	3583 S Roosevelt Boulevard	Key West	County/Government	326
S&H Inc Debris Site	82100 Overseas Highway	Islamorada	DMS	327
Vantage Property Development LLC	21460 Overseas Highway	Cudjoe Key		425

Table 47: Critical Facilities Within 0-250 feet of Shoreline				
Critical Facility Name	**Address**	**Location**	**Facility Type**	**Distance from Shoreline (ft)**
U.S.C.G. Marathon	1800 Overseas Highway	Marathon	Military	43
Layton Volunteer Fire Dept #18	68260 Overseas Highway	Layton	Fire	51
Key Colony Beach Auditorium	600 West Ocean Dr	Key Colony Beach		59
Big Coppitt Fire Station #9	28 Emerald Drive	Big Coppitt Key	Fire	76
Big Coppitt Fire Station #9	28 Emerald Drive	Big Coppitt Key	EMS	84
U.S.C.G. Plantation Key	183 Palermo Drive	Islamorada	Military	96
F.K.A.A. RO Plant & Storage Facility	7200 Front Street	Stock Island	Water	97
Marathon Government Center Annex	490 63Rd Street Ocean	Marathon	County/Government	132
Sheriff's Substation Cudjoe Key	20950 Overseas Highway	Cudjoe Key	Law	212
Keys Energy Services Generating Plant	Stock Island Generating Facility	Stock Island	Energy	217
Summerland Airfield	260 West Shore Drive	Summerland Key	DMS	222

U.S.C.G. Base Key West	Trumbo Point Complex	Key West	Military	234
Key Largo Bay Beach	103800 Overseas Highway	Key Largo	Refuge of Last Resort	235

Table 48: Critical Facilities Within 0-100 feet of Shoreline

Critical Facility Name	Address	Location	Facility Type	Distance from Shoreline (ft)
Blimp Rd Debris Site	Blimp Road	Cudjoe Key	DMS	52
Carysfort Debris Site	State Road 905	Key Largo	DMS	53

n. Social Vulnerability

The social vulnerability map series identifies a 4-tiered weighted index (Socioeconomic, Household Composition & Disability, Minority Status & Language, House Type & Transportation) of the overall social vulnerabilities within census block groups. Building footprints and critical infrastructure that provide public service are included as supplemental information. The SVI indices were overlaid on the nearest-term planning horizon (2040) sea level rise projection produced via the methods described above. An overview of the visual display of the output and summary of the results is included in the following sections. The vulnerability ratings chosen are considered moderate to high levels of vulnerability of ≥50% vulnerable populations. The higher the percentage, the higher the social vulnerability.

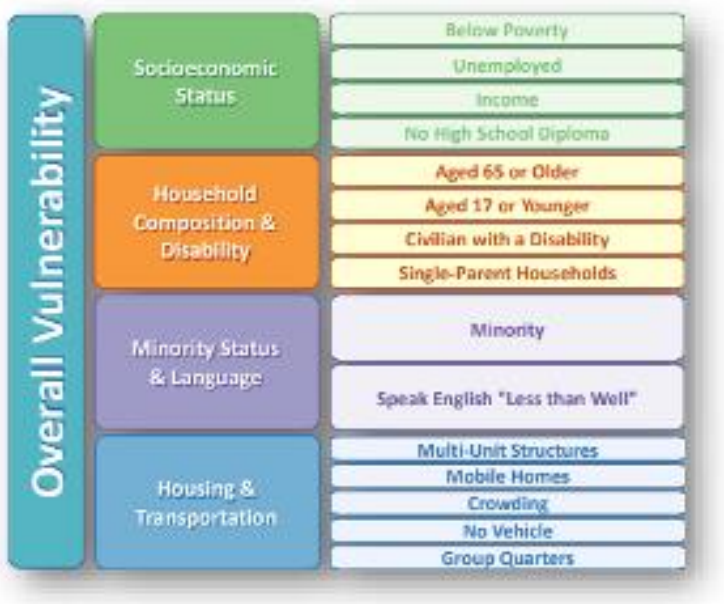
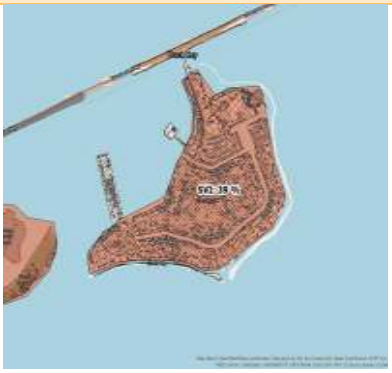


Image 20: SVI Social Vulnerability Index variables for analysis (Source: Centers for Disease Control and Prevention Social Vulnerability Index 2016 Documentation, February 13, 2020, SVI2016Documentation.pdf (cdc.gov).

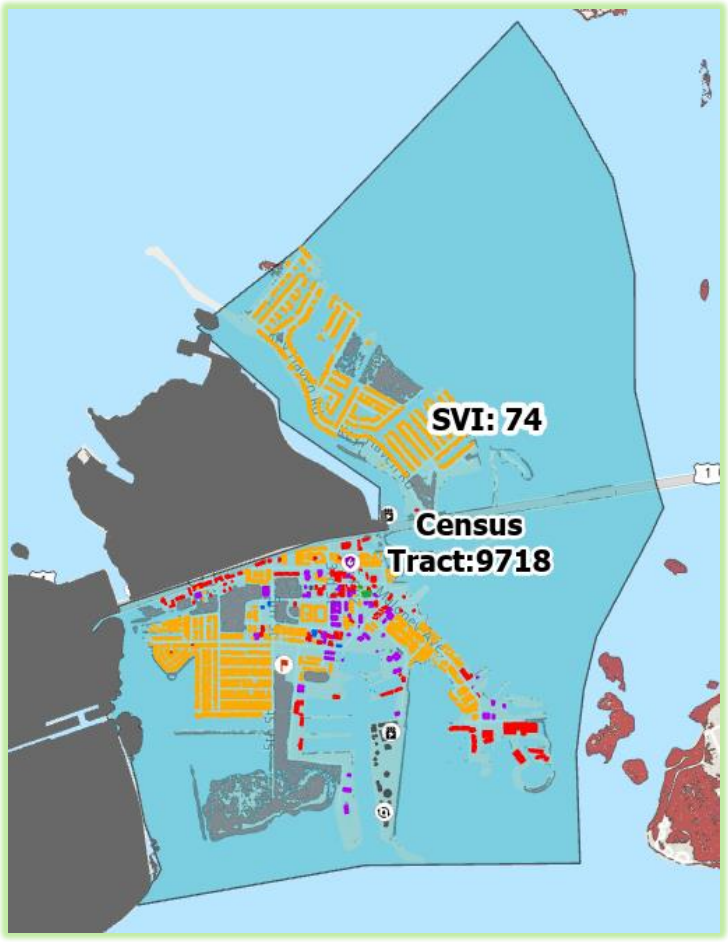
Table 49: Social Vulnerability Analysis Example

Stock Island	Duck Key	Port Largo
		

The following maps depict areas that should be of particular interest. The areas were chosen based on their weighted average of the SVI Criteria Themes. The table below contains the top 5 socially vulnerable areas according to the CDC's 2018 Social Vulnerability Index and is followed by a more in-depth summary of the census tracts individual SVI theme rankings.

Table 50: Top 5 Socially Vulnerable Census Tracts						
Census Tract	Location	Overall Social Vulnerability	SLR Impacts (Sq Mi) by 2040	SLR Impacts (Sq Mi) by 2070	SLR Impacts (Sq Mi) by 2100	Overall Area (Sq Mi)
9718	Stock Island	74.46%	0.28 (20.14%)	0.78 (56.12%)	1.21 (87.05%)	1.39
9704	S of Anglers Park, N of Port Largo	61.11%	1.87 (44.10%)	2.64 (62.26%)	2.97 (70.05%)	4.24
9703	Key Largo	56.97%	1.52 (35.60%)	2.31 (54.10%)	2.58 (60.42%)	4.27
9714.01	South Big Pine Key	50.43%	2.42 (41.44%)	4.63 (79.28%)	5.55 (95.03%)	5.84
9707	Tavernier	41.49%	1.29 (51.19%)	1.64 (65.08%)	2.13 (84.52%)	2.52

Census Tract 9718 | Stock Island



For Census Tract 9718, a 1.5 sq mi area is identified at a rating of 74.46% total social vulnerability impact is an average score of the four related theme groups listed above. The total population of the census tract is approximately 5634. Below is a table with their ratings in each theme and the specific social factors with the highest vulnerability impact rating. If the average from the "theme group" is higher than 50% the attributes within that theme group are further outlined in the subsequent tables below.

Table 51: Stock Island SVI Summary	
SVI Criteria Theme	SVI Ranking
Socioeconomic	49.89
Household Composition & Disability	64.66
Minority Status & Language	82.41
House Type & Transportation	82.64

1. Household Composition & Disability (64.66%)

Table 52: Household Composition & Disability (Percentage of people w/in census block)	
Age 65 or Older	13.4
Age 17 or Younger	20.2
Older than Age 5 w/ Disability	13.1
Single-Parent Households	14.4

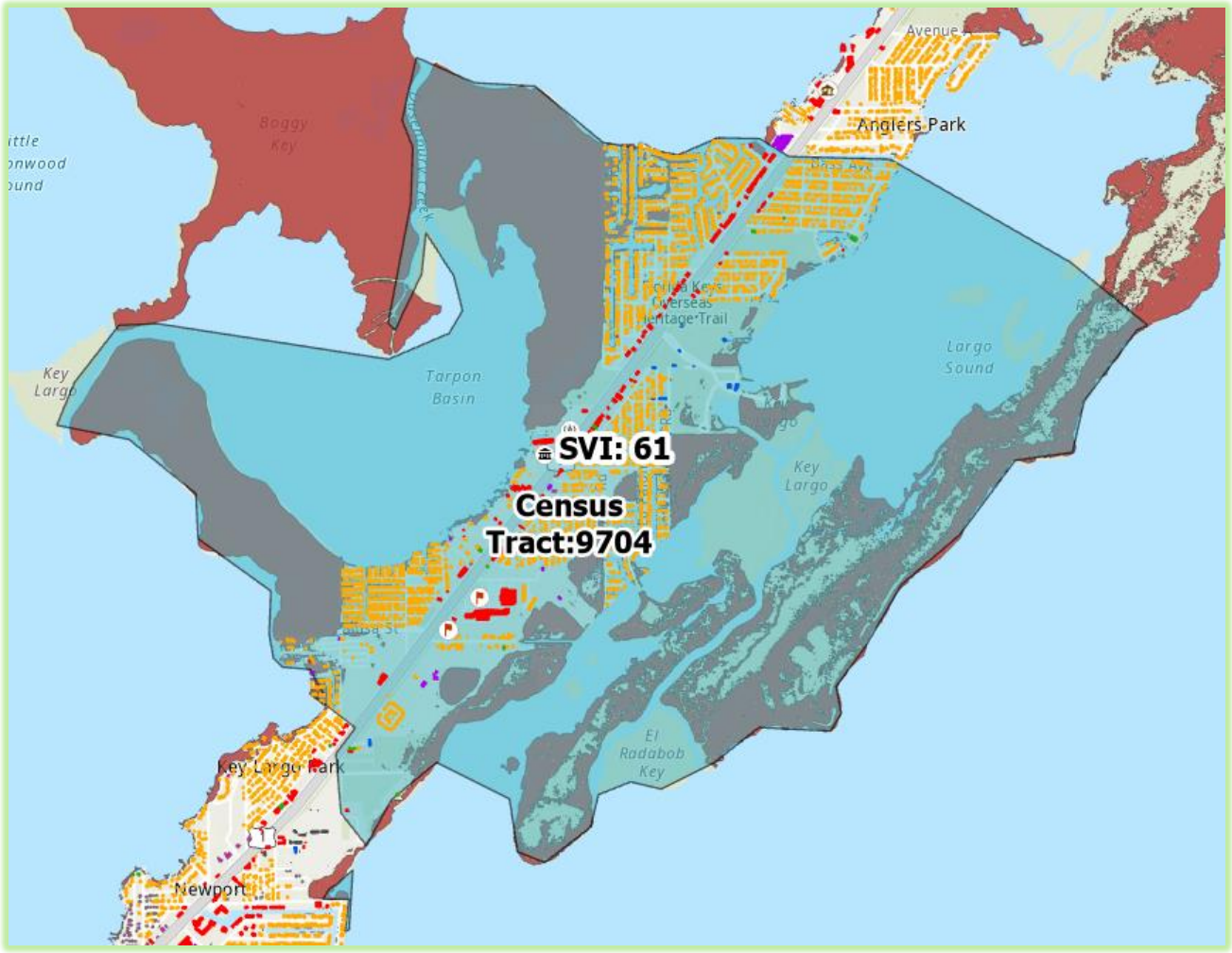
2. Minority Status and Language (82.41%)

Table 53: Minority Status & Language (Percentage of people w/in census block)	
Minority	60.9
Speaks English "Less than Well"	14.6

3. Housing and Transportation (82.64%)

Table 54: Housing Type & Transportation (Percentage of people w/in census block)	
Multi-Unit Structures	8.5
Mobile Homes	29.8
Crowding	11.4
No Vehicle	11.2
Group Quarters	0

Census Tract 9704 | S of Anglers Park, N of Port Largo



For Census Tract 9704, a 4.3 sq mi area is identified at a rating of 61.11% total social vulnerability impact which is an average score of the four related theme groups. The total population of the census tract is approximately 3779. Below is a table with their ratings in each theme and the specific social factors with the highest vulnerability impact ratings.

Table 55: Port Largo SVI Summary

Theme	SVI Ranking
Socioeconomic	55.78
Household Composition & Disability	27.84
Minority Status & Language	66.42
House Type & Transportation	68.44

1. Socioeconomic Status (55.78%)

Table 56: Socioeconomic Status (Percentage of people w/in census block)	
Percentage of persons below poverty	19.7
Unemployment Rate	4.1
Per Capita Income Estimate	31280
Percentage of persons with no High School Diploma	16.9

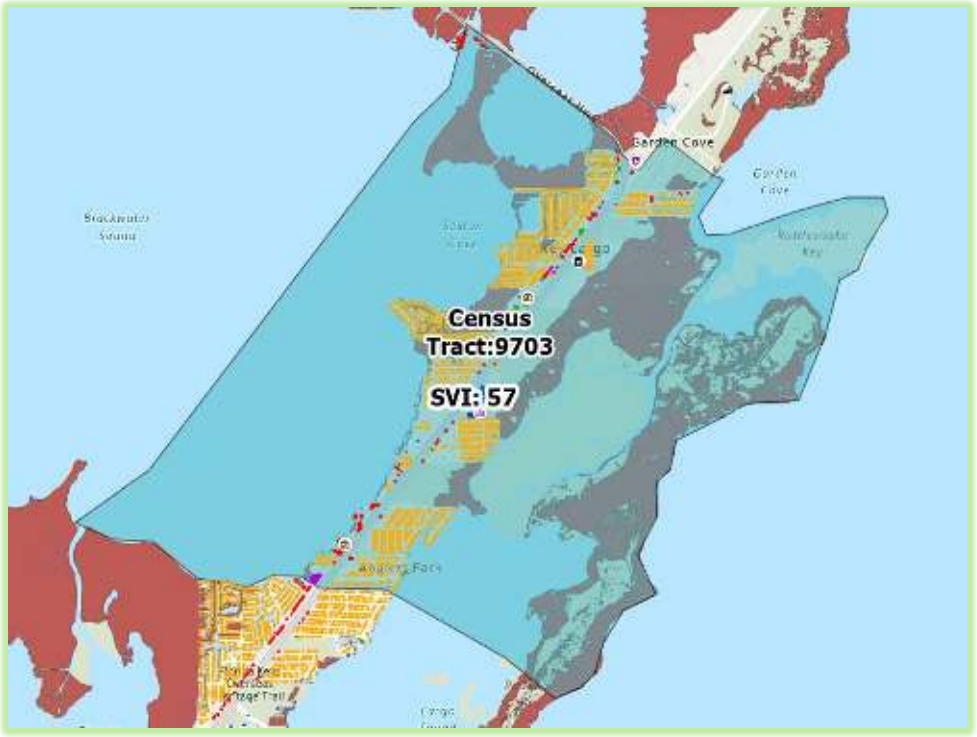
2. Minority Status and Language (66.42%)

Table 57: Minority Status & Language (Percentage of people w/in census block)	
Minority	34.9
Speaks English "Less than Well"	8.6

3. Housing and Transportation (68.44%)

Table 58: Housing Type & Transportation (Percentage of people w/in census block)	
Multi-Unit Structures	2.5
Mobile Homes	40.9
Crowding	4.8
No Vehicle	2
Group Quarters	0.1

Census Tract 9703 | Key Largo



For Census Tract 9703, a 4.4 sq mi area is identified at a rating of 56.97% total social vulnerability impact which is an average score of the four related theme groups. The total population of the census tract is approximately 2282. Below is a table with their ratings in each theme and the specific social factors with the highest vulnerability impact ratings.

Table 59: Key Largo SVI Summary	
Theme	**SVI Ranking**
Socioeconomic	23.76
Household Composition & Disability	91.33
Minority Status & Language	41.41
House Type & Transportation	76.66

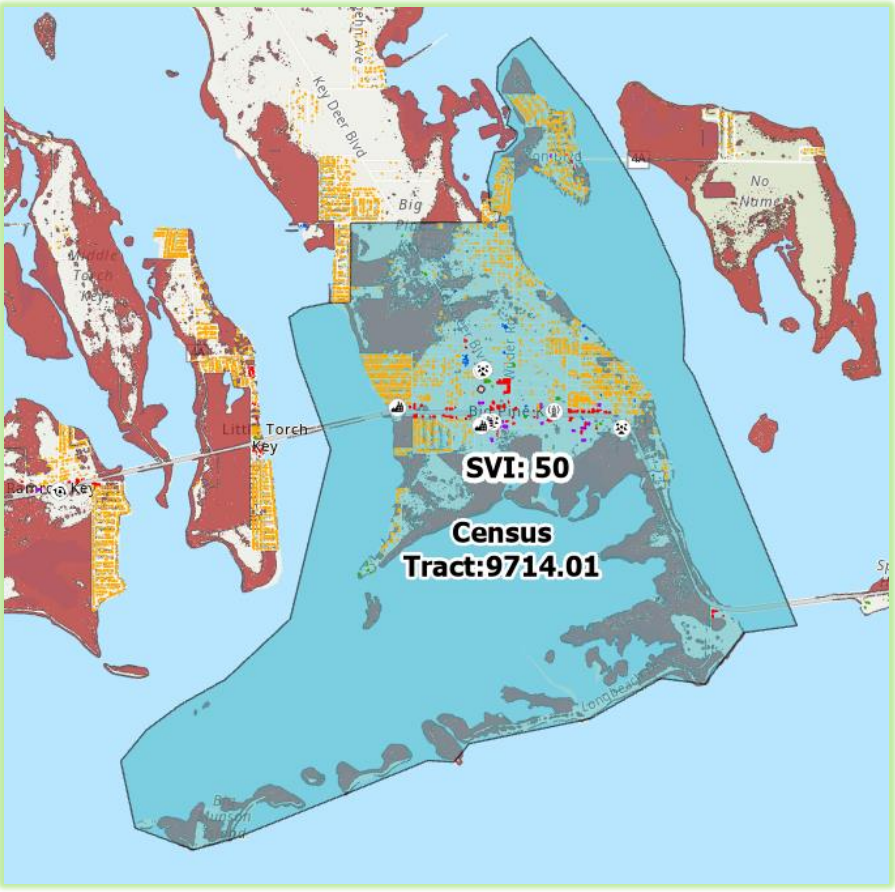
1. Housing Composition and Disability (91.33%)

Table 60: Household Composition & Disability (Percentage of people w/in census block)	
Age 65 or Older	16.8
Age 17 or Younger	19.8
Older than Age 5 w/ Disability	17.1
Single-Parent Households	21.7

2. Housing and Transportation (76.66%)

Table 61: Housing Type & Transportation (Percentage of people w/in census block)	
Multi-Unit Structures	14.5
Mobile Homes	28.1
Crowding	0.6
No Vehicle	8.2
Group Quarters	0.2

Census Tract 9714.01 | South Big Pine Key



For Census Tract 9714.01, a 5.8 sq mi area is identified at a rating of 50.43% total social vulnerability impact which is an average score of the four related theme groups. The total population of the census tract is approximately 3236. Below is a table with their ratings in each theme and the specific social factors with the highest vulnerability impact ratings.

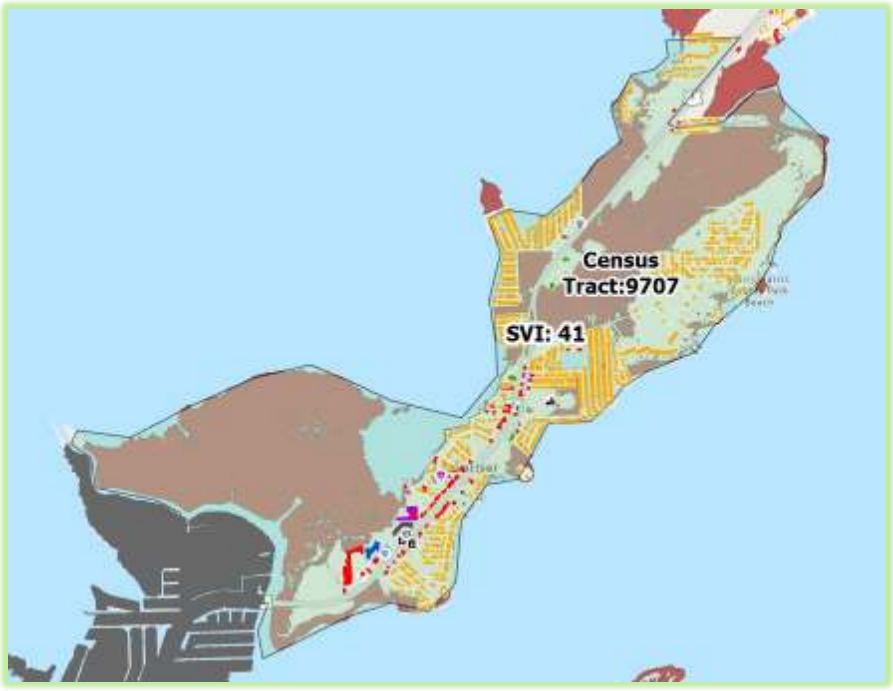
Table 62: South Big Pine Key SVI Summary

Theme	SVI Ranking
Socioeconomic	37.53
Household Composition & Disability	32.12
Minority Status & Language	31.85
House Type & Transportation	82.74

1. Housing and Transportation (82.74%)

Table 63: Housing Type & Transportation (Percentage of people w/in census block)	
Multi-Unit Structures	0.7
Mobile Homes	13.2
Crowding	6.2
No Vehicle	4.3
Group Quarters	2.6

Census Tract 9707 | Tavernier



For Census Tract 9707, a 2.5 sq mi area is identified at a rating of 41.49% total social vulnerability which is an average score of the four related theme groups. The total population of the census tract is approximately 2852. Below is a table with their ratings in each theme and the specific social factors with the highest vulnerability impact ratings.

Table 64: Tavernier SVI Summary	
Theme	**SVI Ranking**
Socioeconomic	14.28
Household Composition & Disability	27.77
Minority Status & Language	52.57
House Type & Transportation	**78.63**

1. Minority Status & Language (52.57%)

Table 65: Minority Status & Language (Percentage of people w/in census block)	
Minority	26.8
Speaks English "Less than Well"	4.6

2. Housing Type & Transportation (78.63%)

Table 66: Housing Type & Transportation (Percentage of people w/in census block)	
Multi-Unit Structures	13.4
Mobile Homes	21.9
Crowding	3.6
No Vehicle	2.7
Group Quarters	0.4

C. Modeling Discussion

The goal of a sea level rise vulnerability assessment is to identify areas of the community that may be vulnerable to rising sea levels. Efforts to improve a community's understanding of sea level rise involve continuously improving the County's elevation data for comparison with identified critical elevations, maintaining current sea level rise projections, understanding how the natural environment will be effected as salt water tides rise, understanding how the community stormwater system will function, identifying infrastructure and activities that may be affected by an increase in water level, and expanding on the basis of knowledge of actual field conditions using the model as a starting point for further exploration. Sea level rise impacts will take the form of both easily quantifiable (example: area of impact calculations) and abstractly measurable (example: biological activity changes due to an increase in water level and a decrease in habitat) as a combination of impacts to natural areas, man-made infrastructure, and various other socioeconomic factors set in.

However, the sea level rise projections and future flood condition modeling both contain various levels of uncertainty that should be acknowledged in the resilience planning process. This vulnerability assessment considers sea level rise in 2040, 2070 and 2100 for the range of projections selected by the Southeast Florida Regional Climate Change Compact. Projections of future sea level rise are driven by projections of future greenhouse gas emissions at a global level, as well as highly complex modeling of how polar ice sheets in Greenland and Antarctica will respond to climate change over the twenty-first century. While there is a high degree of scientific consensus that sea level rise is already accelerating and is likely to continue accelerating over the next several decades, the Southeast Florida Regional Climate Change Compact acknowledges that new data and better understanding of global climate change trends necessitate periodic updates of sea level rise projections for local government planning and project design purposes.

In addition, the future flood condition modeling and vulnerability assessment results are dependent upon the accuracy and precision of underlying data layers, including infrastructure inventories, digital elevation models, habitat delineations, and other information provided to the technical assessment team. The exact feature elevations, locations, and data classifications provided by the

modeling effort is provided as-is. While the sea level rise projections and estimated water depths consider specific feature elevations where practicable within the assessment period, the projections do not consider especially high tides, often referred to as King Tides, wind and other weather-related changes in water levels, local stormwater capacity, functionality, or drainage potential of nearby stormwater infrastructure or, for that matter, any specific floodproofing efforts.

Linkages

4. Linkages to Other Resiliency Work

In This Section:

IV. Linkages to Other Resiliency Work

B. Background

This Vulnerability Assessment can be used for many purposes relating to County decision-making and policy implementation. Examples include:

- Information to help manage risk, design or relocation of County infrastructure and assets;
- Policy development such as that to manage shorelines, target land acquisitions, or environmental restoration priorities;
- Revisions to regulatory requirements for how people develop and redevelop property;
- Service delivery for police, fire and other emergency management functions;
- Data to integrate into the Comprehensive Plan update; and
- Planning for equity in capital improvements by use of the CDC SVI data.

This updated Vulnerability Assessment for Monroe County was also conducted in part, to provide a basis for drafting example AAA to be considered for adoption within the Comprehensive Plan. Under Florida law, local governments have authority to do more in depth planning and prioritize infrastructure and adaptation in certain areas identified as AAAs.[19] The information gathered and evaluated for this Project will inform the County as to where those sensitive locations are that might be particularly vulnerable or otherwise appropriate to designate as an AAA.

Developing AAA example maps and language is a work product of this grant R2111. The final work products associated with that grant deliverable have been compiled in a separate report.

In 2011, the concept of AAAs was incorporated into Chapter 163, F.S. with the following provisions for Coastal Elements:

- **Definition**: "Adaptation action area" or "adaptation area" means a designation in the coastal management element of a local government's comprehensive plan which identifies one or more areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of 1) prioritizing funding for infrastructure needs and 2) adaptation planning. S. 163.3164(1), F.S.
- **Authority**: At the option of the local government, develop an adaptation action area designation for those low-lying coastal zones that are experiencing coastal flooding due to extreme high tides and storm surge and are vulnerable to the impacts of rising sea level. Local governments that adopt an adaptation action area may consider policies within the coastal management element to improve resilience to coastal flooding resulting from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sea-level rise. S. 163.3177(6)(g)(10), F.S.

[19] Section 163.3164(1), Fla. Stat. (2020).

AAAs are designated in the coastal management element of a local government's comprehensive plan. An AAA refers to one or more geographically-defined locations that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of sea level rise.

Local governments that adopt an AAA or AAAs may consider goals, objectives, and policies within the coastal management element of their comprehensive plans to improve resilience to coastal flooding resulting from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sea level rise. Florida law provides that criteria for the Adaptation Action Area may include, but need not be limited to, areas for which the land elevations are below, at, or near mean higher high water, which have a hydrologic connection to coastal waters, or which are designated as evacuation zones for storm surge.[20]

B. Policy Alternatives for AAAs

Any future AAAs adopted by the County would be included within the Conservation and Coastal Management Element of the Comprehensive Plan. The Project team evaluated several policy alternatives for structuring the examples for the County's goals, objectives, and policies related to AAAs and proposed two basic structures:

1. One (1) new Adaptation Action Area "Goal" with supporting "Objectives" and "Policies" related to three different types of AAAs
2. Three (3) new Adaptation Action Area "Goals" with supporting "Objectives" and "Policies"

The Project team recommended adopting a hybrid approach to AAAs based on the case studies of three Florida cities: Yankeetown, Satellite Beach, and Pinecrest. This would include 3 different types of AAA examples including Natural Resources, Infrastructure and Assets and Neighborhoods. These concepts evolved from particular case studies chosen based on the following factors:

- **Yankeetown** (Levy County) recognizes natural areas and their resilience benefits, where no other local government has taken that approach.
- **Pinecrest** (Miami-Dade County) established AAAs based upon those areas that are projected to be impacted by 6 or more inches of flooding. It adopted one map with water depths and sea level rise projections.
- **Satellite Beach** (Brevard County) established "erosion control" and "inland flooding" AAA recognizing that as a barrier island their impacts were actually worse on the western side that backs up to the Indian River Lagoon than the beach/dune side which had a higher elevation.

Three different types of AAA examples have been drafted under separate work products to address distinct approaches that may be necessary to facilitate adaptation and resilience. Results of the Vulnerability Assessment will be evaluated only for the year 2040 for the AAAs, planning horizon for the next Monroe County Comprehensive Plan update to be developed in the upcoming Evaluation

[20] Section 163.3177(6)(g)(10), Fla. Stat. (2020).

and Appraisal Report process. Those results and analysis will provide the basis for the mapping component of the AAAs. Key Project team discussions included the following basic parameters to guide the development of the AAA examples:

1. Residents and business owners should be able to look at the maps and easily determine if they are within or outside of a particular AAA.
2. Lines should generally follow streets or other easily understandable "markers." For instance, a demarcation of everything below a certain level of predicted inches of sea level rise by 2040 can serve as the basis for an AAA, but the actual "line" where that inundation falls based on tidal conditions and land elevation may have to be altered so it does not cut across someone's property where a portion of the property is in and also out of the AAA at the same time.
3. Generalized land area or specific structures can be identified within an AAA.
4. A process should exist where AAAs can be added or removed (Broward County includes this).[21]
5. Efficiency of map output so that there are a manageable number of maps, but at a scale to determine whether a property is in or out of the area.
6. Social Vulnerability model/map output could also be considered in the AAAs.
7. Give the large amount of data related to natural systems, species, marine ecosystems, shorelines, etc. in the Keys, the Natural Resources AAA map should be limited to terrestrial impacts (for now) and as more data becomes available regarding nearshore resources, this information can be integrated into the policies and/or map series.

C. Countywide Roads and Flood Mitigation Planning

In 2019, the County launched a countywide roads and flood mitigation planning program. The effort is robust in identifying road vulnerability, stormwater and flood mitigation projects to alleviate tidal flooding, cost estimates and funding strategies and supporting policy development to manage the overall approach to roads elevation in the Keys. Outputs from this Vulnerability Assessment can assist with that planning process by bringing new information to the table such as how exposure and risk of road segments may intersect with locations of public facilities or services or the socio-economic characteristics of neighborhoods that are vulnerable. While this Vulnerability Assessment does not include road or street impacts, because of the significant work being done under this Roads and Flood Mitigation planning process, the data from the Vulnerability Assessment should certainly be considered when prioritize road elevation and flood mitigation strategy from that planning process. The timing of this Vulnerability Assessment is also ideal in that the Roads and Flood Mitigation Planning process is just now getting into conceptual engineering design before final

[21] Nassau County: Areas to be designated as an AAA shall be created through a Comprehensive Plan amendment as an overlay district.
Broward County: An "Application process" for AAAs is described with noticing, etc. Broward County Planning Council or a municipality may apply. The application language within the Climate Change Element states (about this process): The Board, the Broward County Planning Council, or a municipality may apply for AAAs of Regional Significance designation if the problem(s) and proposed solution(s) of the proposed area demonstrate regional significance and conform with one or more of the criteria listed in Section 2.9 of the Broward County Land Use Plan. Areas designated by the County as AAAs of Regional Significance will be added to the Priority Planning Areas for the Sea Level Rise Map as part of the Broward County Land Use Plan. (Policy CC2.15 in Climate Element).

prioritization or funding decisions have been made. This Vulnerability Assessment will serve as a valuable tool to finalize that planning process.

5. Vulnerability Assessment Conclusions

In This Section:

V. Conclusions

The results of this Vulnerability Assessment enable the County to continue on its path of climate resilience within a data-driven framework. By continuously gathering and analyzing additional information about communities, natural resources, social vulnerability and infrastructure assets, the Keys is in an informed position to make smart investments and develop appropriate policy responses and outreach activities. The maps and tables created for this report represent a significant body of resilience work that should be utilized across County departments to consider sea level rise planning in an interdisciplinary manner. The full output of maps is available for review as Appendix B to this Vulnerability Assessment.

It is important for the community to understand what is at stake by diminishing efforts to proactively plan for sea level rise impacts. These include:

- The County will lose economic efficiency in the planning and response of adaptation projects, by waiting for more impact to occur than proactively setting forth on the path to proactively respond to sea level rise before damage is done.
- By not proactively planning based on consistency with other state federal policy, the County is likely to forfeit the ability to secure Federal or state cost share for adaptation projects.
- While the real estate market is “hot” right now, ultimately, property values will be impacted by more tidal flooding translating into reduced tax base necessary to fund adaptation projects.
- People will lose access to homes or businesses from deeper and longer tidal inundation, either permanently or portions of the year.
- While buildings may be elevated such as homes or businesses, the yards surrounding them or access to them may be permanently or semi-permanently inundated with seasonal saltwater flooding.
- Business owners will lose revenue from diminished access or the inability to provide services year-round.
- Residents and business owners will retreat from low areas subject more frequent saltwater flooding either to higher elevation areas within the Keys or outside of the Keys.
- Critical habitats and species that depend upon them will be “squeezed” between existing development and increased areas of tidal inundation.
- Residents and business owners that are located in socially vulnerable areas will feel these effects in a more pronounced way and may lack the full array of options to make decisions about their quality of life and properties that others may have.

Additionally, actionable recommendations can be developed from the Vulnerability Assessment to guide the County’s planning, policy development, and outreach efforts going forward. There are four broad categories of conclusions that can provide a basis for future specific recommendations described generally in this section: 1) County Assets and Infrastructure; 2) Land Development; 3) Natural Resources; and 4) Socioeconomic and

Outreach. Within the "County Assets and Infrastructure" category, conclusions are further divided into the following subsections: a) Technical Vulnerability Assessment; b) Economic Analysis; c) Policy Development; d) County, Agency, or Stakeholder Coordination; and e) Project Development and Flood Events. The Recommendations act as a roadmap for the County in its decision-making process as it steers its resilience work into the future.

County Assets and Infrastructure

- Technical Vulnerability Analysis

Incorporating this Vulnerability Assessment into the County's capital projects and emergency management planning will maximize the value of the detailed information provided. One mechanism for doing so is to review all existing projects within the Capital Improvement Program through the lens of the Vulnerability Assessment and identify opportunities to re-prioritize and otherwise plan to make them more resilient. By considering the useful life of infrastructure assets in tandem with future sea level rise, the County can ensure that new investments will withstand future conditions. Identifying earliest at-risk infrastructure can also yield cost-savings benefits. This is something that has been adopted as policy into the Comprehensive Plan already so the County should already be implementing this policy, but it should be underscored and utilize the most recent data from this Vulnerability Assessment. (See Policies 1502.1.1, 1502.1.1 and 1502.1.5, in the Energy and Climate Element of the Monroe County Comprehensive Plan, September 17, 2020 version).

Conducting site-specific vulnerability assessments can provide insights that are unique to a particular neighborhood, intersection, or structure. Detailed analyses can assist the County in designing solutions that are tailored to their contexts. Pilot projects are recommended as incremental implementation tools that can also test the effectiveness of a design solution. Moreover, performing cost-benefit analyses for pilot projects will aid in the County's decision-making processes as actual benefits are tracked and compared to projected outcomes.

The County should also continue its leadership in the practice of modeling future conditions. Enhanced sea level rise modeling for hurricane storm surge, rainfall, and shoreline vulnerability will serve to prepare the Keys for a variety of scenarios that may occur concurrently. Integrating a "parks" layer within the County's GIS database will provide new insight into land uses for potential adaptation strategies. Incorporating actual building and asset elevations into these models will improve their overall efficacy. As the County continues to fine-tune its approach to adaptation, analyses conducted for discrete categories of assets (e.g., private properties along canals, historic structures, and stormwater outfalls) will provide guidance for more impactful solutions.

- Economic Analysis, Policy Development, and Stakeholder Coordination

A Countywide property damage assessment from future flooding and other climate-impact conditions will serve as a foundation for useful economic analysis, project prioritization, and funding opportunities. The financial cost of sea level rise adaptation can be mitigated with creative funding solutions, partnerships, and grants: an economic vulnerability analysis will serve the County as it pursues all options. When ranking capital projects, the County should consider basing return on investment (ROI) calculations on criteria beyond property value, such as social vulnerability natural resources or endangered species present in the area. New datasets are available to the County in this Vulnerability Assessment that have never been available before to do exactly that.

The Monroe County Code of Ordinances and Comprehensive Plan should be reviewed for linkages with this Vulnerability Assessment in the upcoming Evaluation and Appraisal Report process. Conducting such a thorough review of local regulations will improve the County's overall policy consistency for resilience. New policies may be considered, such as determining whether new criteria need to be developed or existing language needs to be modified to address sea level rise, stormwater management, and erosion issues. The information from this Vulnerability Assessment should also be integrated into the County's Land Development Code to guide the future built environment toward long-term resilience.

Improving stakeholder communication regarding sea level rise vulnerability will increase the value of the County's investment in resilience planning. This includes evaluating critical infrastructure vulnerabilities and working with service providers to minimize gaps in services, such as utilities, schools, critical care, emergency, law enforcement, and facilities management. Internal communications across departments as well as external communication to residents, business owners, and visitors to the Keys should be proactive; the process for different modes of transmitting information to different groups should be institutionalized. This communication should focus on what's at stake and lost due to future sea level rise, how the County will pay for it and what the benefits of resiliency planning are to the overall community.

Emergency management and hazard mitigation plans should include sea level rise projections and Vulnerability Assessment data. Conducting annual reviews of sea level rise strategy in anticipation of the capital budgeting process may improve coordination on project funding and implementation schedules. The County should continue to monitor activity at the state level, such as legislative initiatives and agency rulemakings. Finally, social vulnerability data should be considered in as many decision-making processes as possible to ensure the County's approach to resilience is equitable for all stakeholder populations.

- <u>Project Development and Flood Events</u>

The County is prioritizing its preparedness for flood events and developing projects that mitigate the impacts from rising tides. In doing so, it might consider installing signage and wayfinding mechanisms that communicate alternate routes during flood conditions (if they exist) or other useful messages. Flood warning systems can also be employed to protect vulnerable residents. Developing localized flood mitigation master plans at the neighborhood scale will allow for the design of detailed adaptation strategies such as

infrastructure retrofits, enhanced storage areas, and habitat restoration. Recreational and open spaces can serve a dual purpose as water retention areas, and floodable park features can be installed along canals and coastal areas. Retrofitting infrastructure assets, such as with tidal valves, can provide cost savings in the long term to avoid flood risk.

Additionally, the County might consider creating staging areas for community resources and relief during flood events. These already appear to be mapped areas within the County's GIS system, but a more cohesive of when, how and what types of equipment or debris to be staged could be considered. The County should continue to consider land acquisition of repetitive flood-loss properties for ecosystem restoration or infrastructure adaptation. Finally, the County should continue to fortify existing infrastructure, investigate vulnerable facilities and potentially develop a comprehensive plan to harden public assets with backup power at all facilities, including those that serve vulnerable populations.

Land Development

The following recommendations apply to the County's Land Development Code and Code of Ordinances. Resilience to sea level rise and other climate impacts is accomplished through "big picture" planning for capital improvements, but slight revisions to existing ordinances can equate to higher levels of overall protection. For example, ensuring debris management policies reduce impacts to stormwater functions can lower the overall cost of stormwater improvements and the effectiveness of drainage infrastructure. Stormwater management quantity requirements on private property should be reviewed to determine whether revisions are needed to address modern rainfall trends harmonizing resiliency, water quantity and water quality goals.

Additional strategies that can be implemented through code revisions to improve onsite stormwater management include some of the following examples:

- Incentivize property owners to preserve open space and install bioswales and green infrastructure.
- Amend standards for parking lots to encourage permeable materials and discourage large paved areas.
- Review setback and buffering requirements along vulnerable canals and rights-of-way for opportunities to require additional space for stormwater management infrastructure.
- Revise "purpose and intent" language to include floodwater management and resilience policy goals.

The County might explore operationalizing vulnerability findings by establishing a process whereby permit applications are reviewed based on criteria or a threshold for inundation. For historic structures and affordable housing, the County should update or review policies that provide enhanced protection from future flood risk.

Natural Resources

Natural resources are protected by federal, state, and local regulations in the Keys. The following suggestions are consistent with the County's goal of preserving natural resources and incorporating their utility as another component of adaptation infrastructure into resilience planning. For example, promoting and further incentivizing rainwater harvesting can increase onsite retention of stormwater for beneficial reuse. Expanding the implementation of passive green infrastructure projects such as trails, swales, and wet retention areas can provide aesthetic amenities as well as flood protection.

Sensitive ecosystems can be preserved by clearly incorporating this Vulnerability Assessment into the County's overall land acquisition and management strategy to address changing habitat types as some may "migrate" landward. The County might consider developing plans for adaptation by conducting a natural resource adaptation planning process. Implementing living shoreline projects in vulnerable locations can assist in harmonizing natural resource restoration and resiliency adaptation strategies. In appropriate areas, the County should work with partner agencies to restore wetlands to provide more resilient habitats for listed species, slow floodwater, and improve water quality.

Socioeconomic and Outreach

Prioritizing the human element of resilience in the Keys requires both persistent community education and an equitable approach to project implementation. This Vulnerability Assessment includes elements of social vulnerability analysis never before completed within Monroe County in the resiliency context. With regard to community education, another option is to incentivize residents and business owners - through recognition or other programs - to encourage responsible inlet, gutter, and yard debris disposal. Technology now makes it possible for residents to document flood events such that "citizen scientists" can submit photos for real-time data collection which can lead to helping the County prioritize immediate adaptation needs. Volunteer flood watch programs, whereby local residents report observations to the County, increase the community's awareness and engagement.

Empowering an educated business community with regard to resilience will also expand the success of the County's efforts. By enhancing engagement with the business sector about the County's vulnerability (what's at stake) and adaptation strategies (how to respond), business disruption and profit losses due to floods, weather events, and natural disasters can be avoided or mitigated. An example is compromised access to businesses during tidal flooding events. Organizing stakeholder groups around property protection, worker safety, public/private partnerships, and the economic benefits of resilience can help convey the County's policy objectives to the community. For example, by providing or requiring training for landscapers and site maintenance professionals in recognizing stormwater practices and maintenance of vegetated stormwater assets, public rights of way will bear less of the burden from stormwater runoff from private properties.

The County should develop strategies to ensure an equitable approach to climate change adaptation. Inclusive communication and outreach to communities with lower social vulnerability "scores" produced by the CDC SVI analysis and maps series within this Vulnerability Assessment should be transmitted in the native languages of those communities where necessary. Events such as town halls, educational panels, and clean-up activities should be hosted in socially vulnerable areas at sites that are familiar to those communities. Linking flood insurance education with Community Rating System activities, the County can host meetings or distribute materials about federal flood insurance coverage and publicize information about funding resources for private property owners.

Finally, we know that resiliency is a good investment. The studies and statistics are consistent and telling. In 2017, the National Institute of Building Sciences (NIBS) released a report (The Natural Hazard Mitigation Saves: 2017 Interim Report) finding that every $1 invested in disaster mitigation by three federal agencies saves $6 (agencies include: FEMA, U.S. Economic Development Administration (EDA) and U.S. Department of Housing and Urban Development (HUD)) in recovery costs. Equally important, the same report found that the financial benefits of private developers exceeding local building resilience standards, such as elevating homes higher than required in flood-prone areas and building structures to be more resilient yields $4 for every $1 spent. This underscores the approach that investing in resilience pays dividends back to the community. These investments can provide a much different outcome than the potential impacts listed above. The County must communicate these issues clearly to the community to convey that long term planning must start now, it is much cheaper to devise a strategy and implement it, than to wait for the impacts to occur and respond once more damage is occurring. It is absolutely critical that the County maintain momentum on its resiliency planning efforts. This Vulnerability Assessment should be utilized to update the GreenKeys recommendations and chart a continued path forward to make the Fabulous Florida Keys a more resilient community overall.

6. Appendices

Appendix A: Species Impact Overview
Appendix B: Map Series