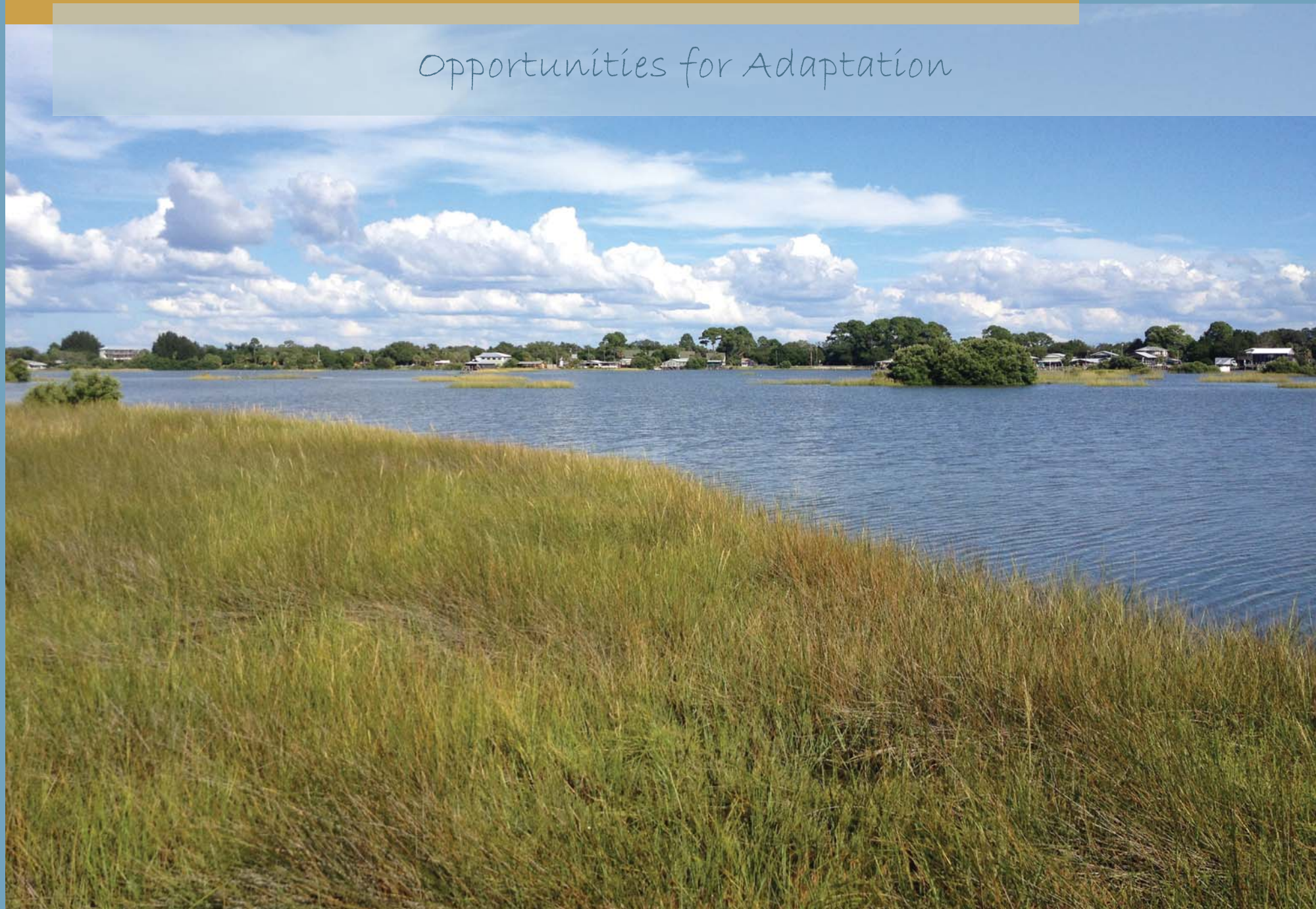
Planning for Coastal Change in Levy County

2014

Opportunities for Adaptation



Planning for Coastal Change in Levy County

Opportunities for Adaptation

Authors:

Kathryn Frank[1]
Dawn Jourdan[2]
Michael Volk[3]

October 2014

Funding was provided by the Florida Sea Grant. All images unless otherwise noted were provided by the authors.
For more information please contact: Kathryn Frank, Department of Urban and Regional Planning, University of Florida, PO Box 115706, Gainesville, Florida 32607, Phone: 352-294-1485, Email: kifrank@ufl.edu. Also please visit the project website at www. ChangingLevyCoast.org

[1]Department of Urban and Regional Planning, University of Florida, [2]Regional and City Planning, College of Architecture, University of Oklahoma, [3]Department of Landscape Architecture, University of Florida

Florida Sea Grant encourages student involvement in their funded projects to further the University's educational mission. This project embraced that objective, and the students and supporting instructors were an integral component of the project's success. Students were involved through "studio" practicum courses and teams for sub-projects.

Spring 2012 – Initiating Dialogue on Sea Level Rise Planning in Rural Levy County

Instructor: Ferdinand Lewis
Students: Brian Biada, Christian D'Alessandro, Ashley McGehee, Jennifer Rhodes, Jana Rosenbloom, Chern-huan "Andrew" Tsai, and Yehan Xu

Summer 2012 – Cedar Key Summer Youth Program

Leaders: Dawn Jourdan, Kathryn Frank, Gail Easley, and Sean Reiss
Assistants: Reba Abraham, Forrest Eddleton, Matt Janicki, Paulette McFadden, and Ashley McGehee

Fall 2012 – Public Outreach and Civic Engagement in Rural Coastal Communities

Instructor: Gail Easley
Students: Alexander Ahrenholz, Brian Bennett, Juan Castillo, Caitlin Cerame, Douglas McDuffie, Caitlin Murphy, Sean Reiss, Kevin Szatmary, Arianna Tehrani, and Stephanie Zarkis
Assistant: Kenwyn Harrilal

Spring 2013 Studio – Cedar Key-Rosewood Adaptive Design and Oral History Video

Instructor: Joseli Macedo
Students: Barbara "Rain" Araneda, Kevin Bennett, Juan Castillo, Mario Duron, Maria Gavidia, Sean Reiss, Valerie Voigt, Karlin Warkentin, and Rong Zeng

Summer 2013 – Yankeetown-Inglis Adaptive Design and Oral History Video Continued

Leaders: Michael Volk and Kathryn Frank
Assistants: Kevin Bennett, Sean Reiss, Jana Rosenbloom, Zachary Wignall, and Sean Reiss

Fall 2013-Spring 2014 – Art Exhibition, Youth Essay Contest, and Final Report/Guidebook

Leaders: Michael Volk and Kathryn Frank
Assistants: Alex Ahrenholz, Joshua Berry, Trey Bond, Belinda Nettles, Sean Reiss, Jana Rosenbloom, Sarah Thompson, and Rong Zeng

Table of Contents

List of Figures

List of Figures

List of Figures

Acknowledgments

We are grateful for the many people and organizations in Levy County, Cedar Key, Sumner, Rosewood, Yankeetown, and Inglis, who contributed their time, knowledge, ideas, and support to this project. Their involvement made the project possible, bringing it to life and giving it relevance.

Encouragement by local government officials and staff was vital. We are indebted to Shenley Neely, Levy County Planning Department; Sue Colson, City of Cedar Key; Larry Feldhusen, Town of Yankeetown; Larry Cohan, Town of Yankeetown; and Charles Botts, Towns of Yankeetown and Inglis. They were the project's local champions and our key points of contact from the project's beginning to end. We also sincerely appreciate the reception given to us by the Cedar Key City Council, the Yankeetown Town Council, the Inglis Town Commission, the Levy County Planning Commission, and the Levy County Board of County Commissioners.

Several people, through their generosity and expertise, became an informal support network. In Cedar Key, we extend our gratitude to Earl Starnes, Leslie Sturmer, Jennifer Seavey, Heath Davis, and Mandy and Frank Offerle. We also appreciated the interest of Andrew Gude, John McPherson, Kristin Ebersol, Greg Lang, and Laura Dedenbach. In Yankeetown and Inglis, we wish to thank Dawn Marie Clary, Glenda Kirkland, and Drew White for their continued engagement, as well Karen Chadwick and Ellen Raabe for their insights. Over the course of the project, we were saddened by the loss of three remarkable people who had assisted us: Jack Hotaling and Gene Hodges of Cedar Key, and Betty Berger of Inglis.

We appreciate each citizen who attended our public workshops and presentations to local officials. We listened and incorporated your input into this report. Thank you to the organizations who promoted the public workshops and raised awareness of the issues with their members: Cedar Key Chamber of Commerce, Cedar Key Arts Center, Florida's Nature Coast Conservancy, Withlacoochee Gulf Area Chamber of Commerce, and Friends of the Withlacoochee Gulf Preserve. And to the additional venues provided: Cedar Key Public Library, Cedar Key Seafood Festival, Cedar Key Arts Festival, Tidewater Tours, Inglis-Yankeetown Lions Club, A.F. Knotts Public Library, and Withlacoochee Gulf Preserve.

Some citizens contributed in unique ways as part of the special outreach activities:

We recognize Sue Colson for connecting the project with the Cedar Key Summer Youth Program, its directors Molly Cowart and Crystal Short who welcomed and helped us, and all the children (and their families) who enthusiastically took part in our activities and assured us that the future is in good hands. The youth essay contest entries were also inspiring and informative. The three winners were 5th and 6th grade students at Cedar Key School: Annie McCain, Kelli Mae Quinn, and Natalie Stewart.

Eight long-time residents of the Levy County coast volunteered their stories of coastal change for the oral history initiative, and the resulting video is more powerful than any maps or charts we could have assembled. We are much obliged to John W. Andrews, Charles Beckham, Ricky Cooke, Beth Davis, and Heath Davis of Cedar Key; and Anthony Green, Lester Green, and Thomas F. Thompson of Yankeetown and Inglis. Thank you also to the Samuel Proctor Oral History Program and the Senator George G. Kirkpatrick Marine Laboratory for their partnerships.

We greatly appreciate the Cedar Key Arts Center for hosting the coastal change art exhibition, and the participating artists for creating exceptional and diverse pieces: Donna Bushnell, Libby Cagle, Amy Gernhardt, Henry Gernhardt, Margaret Peggy Pulis Herrick, Debbie Weaver, and Russ Weaver. We also appreciated conversations with three additional artists who attended the artists' workshop, and everyone who came to the exhibition opening event.

The project was fortunate to have access to a wealth of locally specific scientific information, including two Sea Level Affecting Marshes Model (SLAMM) studies, which together covered the Levy County coast. We thank Laura Geselbracht and Doria Gordon at The Nature Conservancy, and Jonathan Clough on behalf of the Gulf of Mexico Alliance, for sending us the data. We also benefited from studies and projects conducted by other University of Florida researchers, including Tom Ankersen, Jack Davis, David Katz, Paul Monaghan, Jack Putz, and Ken Sassaman.

In conclusion, we thank Florida Sea Grant and the National Oceanic and Atmospheric Administration (NOAA) for valuing the resiliency of small town and rural areas and for providing the funding for this project.

Executive Summary

Coastlines are dynamic places. Not only do they experience dramatic events like storms, they can profoundly transform due to other kinds of changes such as natural resource management, development, and long-term sea level rise. Until recently, these kinds of changes were not considered together when planning for coastal communities and regions. Tide gage measurements over the past century show that sea levels have been steadily rising across Florida's coasts. Scientific models are anticipating that Florida's sea levels will continue to rise, and at accelerating rates. In Florida, the effects of sea level rise are already being felt as increased flooding and erosion, saltwater intrusion into aquifers, and shifts in the natural landscapes. These effects will become even more pronounced in the future. It is thus important that coastal communities begin planning now to understand their vulnerabilities, values and preferences, adaptive capacities (resources and flexibility), and strategies for adaptation, in order improve the resiliency of their built and natural environments, economies, and social and cultural assets.

The Planning for Coastal Change in Levy County project initiated planning for coastal change, with a focus on the potential impacts of future sea level rise, in Levy County, Florida, and its coastal communities: the City of Cedar Key and unincorporated Sumner and Rosewood (the Cedar Key-Rosewood area), and the Towns of Yankeetown and Inglis (the Yankeetown-Inglis area). Levy County is located in the southern part of the Big Bend region of the Gulf of Mexico. The Big Bend region is characterized by extensive seagrass beds, saltmarshes, freshwater wetlands, karst geology, an unconfined aquifer, and rivers. This water-dominated landscape, which lacks significant beaches and barrier islands, has experienced limited development. The values in this region are small town and rural,with iconic coastal villages, historic and archaeological resources, and working waterfronts, and vast tracts of lands and waters in public ownership and resource production (especially timber). This project thus applied a small town and rural perspective when planning for coastal change and sea level rise in Levy County, to improve its usefulness to local stakeholders, and to take lessons learned from this pilot study to other rural counties and small towns. These lessons are presented in a separate guidebook.

This report presents the methods, findings, and recommendations of Planning for Coastal Change in Levy County, a two-year planning and outreach project funded by the Florida Sea Grant and conducted by faculty, staff, and students at the University of Florida, in consultation with local stakeholders. Because the project was initiating planning for sea level rise at the community and county levels, broad public engagement was critical. The project included a wide range of methods of engagement: a project website and blog, presentations at local commission meetings, stakeholder and public workshops, activities at a summer youth program, a youth essay contest, information booths at local festivals, oral history interviews and video production, and an artists' workshop

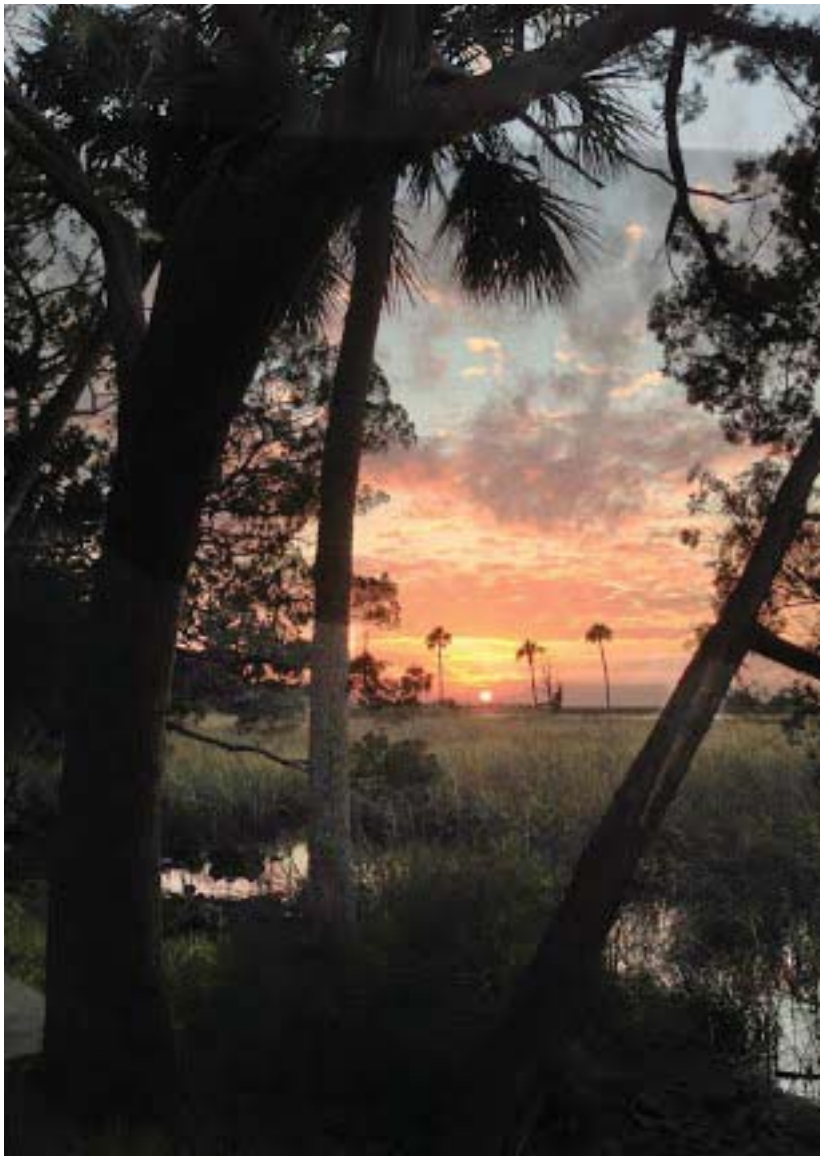
and exhibition. In addition to providing community input to the planning process, the engagement methods raised awareness of sea level rise, local impacts, and the need for planning.

The project's planning approach was comprehensive: casting sea level rise within the larger context of coastal change; considering the potential impacts to built, natural, economic, social, and cultural systems; and identifying diverse and coordinated adaptation strategies. The planning process was thorough, analyzing high quality existing, place-specific information/data and gathering stakeholder input in order to understand local vulnerabilities, values and preferences, adaptive capacities, and potential strategies for adaptation. The report presents spatially explicit findings and recommendations at the scale of Levy County, and for the two coastal community areas: Cedar Key-Rosewood and Yankeetown-Inglis. While these places are highly vulnerable to sea level rise and other coastal hazards due to their location in the Big Bend region, this project found that the coastal communities and jurisdictions of Levy County are resourceful and resilient, there is value in addressing the issue of sea level rise with locally specific information, and many options for adaptation exist. Most optimistically, it is possible that sea level rise could open stakeholders' minds to new possibilities and invigorate community development, economic development, planning, and design to yield other local benefits as well.

Wildlife along the Withlacoochee River

Introduction

This report presents the findings from the project, Planning for Coastal Change in Levy County, conducted from February 2012 to August 2014 by the College of Design, Construction and Planning at the University of Florida, with funding from the Florida Sea Grant. The objective of the project was to initiate proactive, community-based planning for adaptation to sea level rise and other coastal changes in Levy County, Florida, and its coastal communities of Cedar Key, unincorporated Sumner and Rosewood near Cedar Key, and Yankeetown and Inglis (see Figure 1). The findings cover the current and possible future impacts of sea level rise in Levy County, feedback from local commission meetings and public workshops, and design and policy recommendations for adaptation strategies. Prior to this study, there were scientific studies and modeling of past and future sea level rise impacts in the area, but there was not an organized initiative to apply this information toward community and regional planning. The primary audience intended for this report is anyone with an interest in, or a decision making role for, Levy County and its coastline, including public officials, local government/agency managers and staff, business and non-profit representatives, university researchers, and citizens.



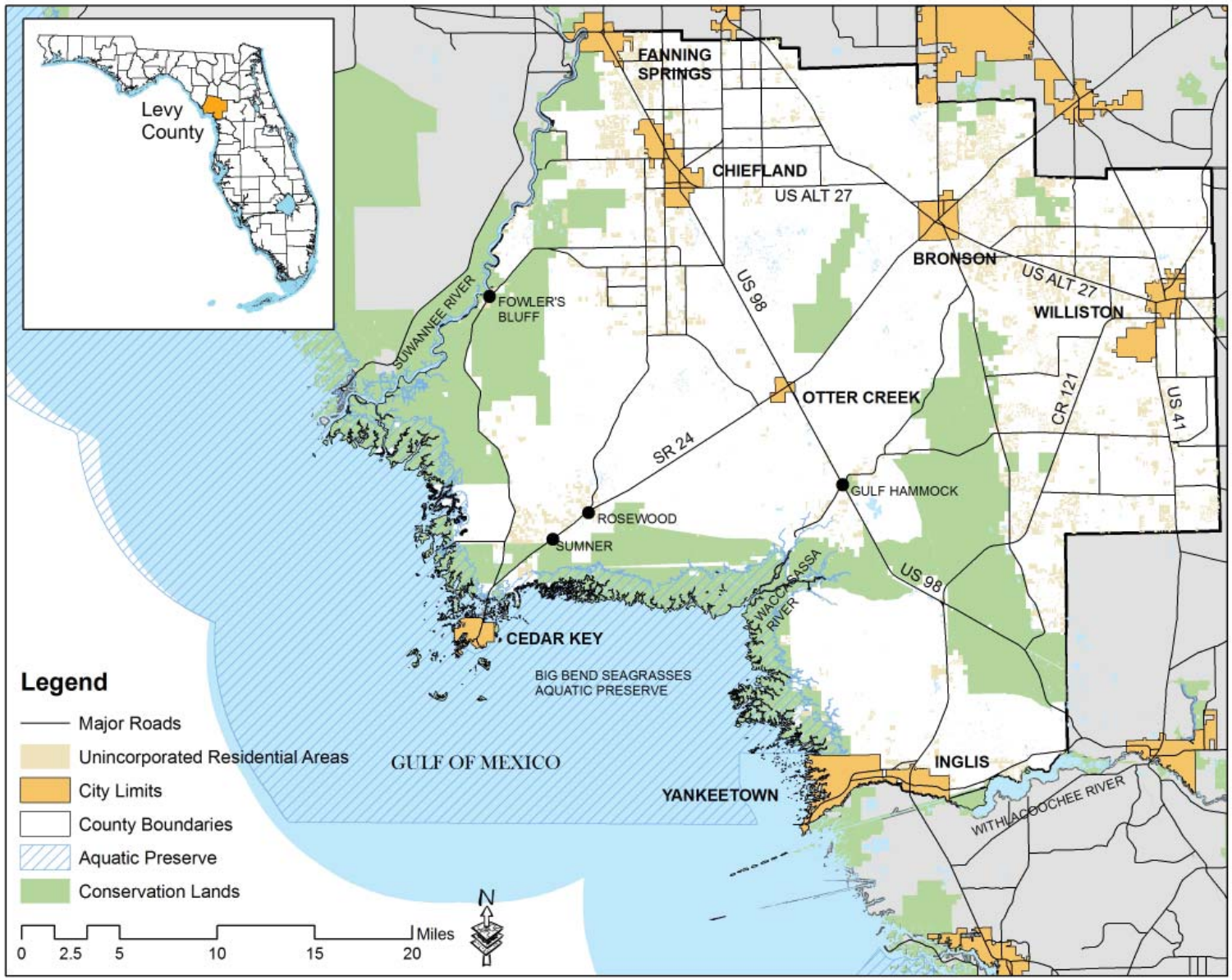


Figure 1: Project Study Area: Levy County

Introduction

Cedar Key. Courtesy of Steve Deam, seecedarkey.com

Yankeetown on the Withlacoochee River
(http://marinas.com/view/marina/2952)

Withlacoochee Gulf Preserve, Yankeetown

Sea Level Rise Scenarios

Global average sea levels in the past, present, and future are related to the temperature of the Earth's atmosphere (Mitchum, 2011). As the atmosphere becomes warmer, which has been occurring since the last Ice Age, the temperature of the ocean water increases, causing the water to expand and fill more volume. Additionally, ice on land melts and flows into the ocean, thus contributing to the amount of water in the ocean.

Specific places around the world can experience different rates of sea level change depending on regional factors, such as whether the land is sinking or lifting up (creating the effect of "relative" sea level rise), nearby river flows, and ocean currents. The land in Florida is fairly stable, but the other factors cause variations in the rates of sea level rise along the state's coastline. The only tide gauge in Levy County is located in Cedar Key. This tide gauge indicates that the average (or mean) sea level in the Cedar Key area has risen 7 inches in the past 100 years (see Figure 2) (NOAA/National Ocean Service, 2013). The next closest tide gauge, in Clearwater Beach, has been in operation since 1973. The Clearwater Beach tide gauge has recorded a sea level rise rate equivalent to almost 10 inches over 100 years.

Scientific modeling, which is accepted by universities, federal and state agencies, and large corporations, predicts that global average sea level will continue to rise

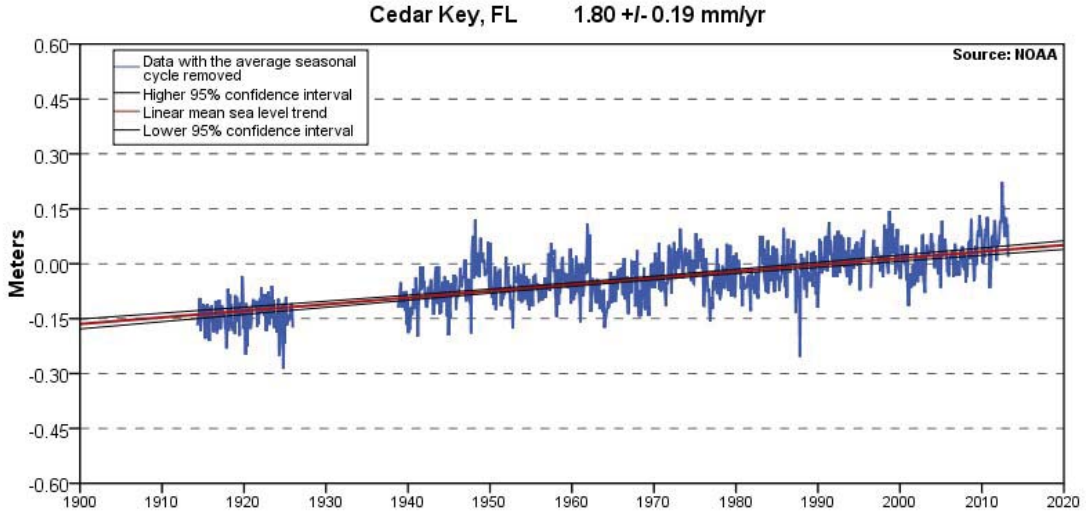
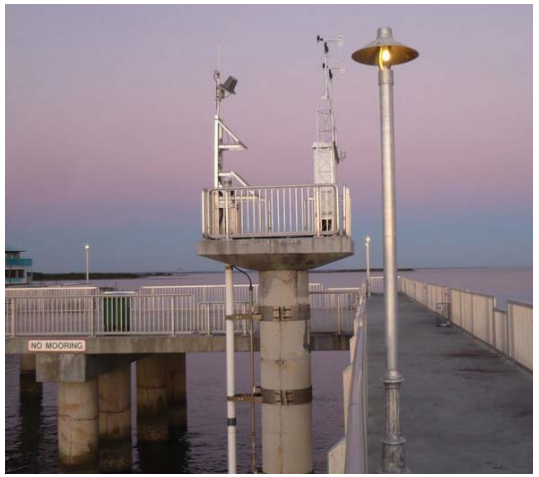


Figure 2: Tide gauge measurements in Cedar Key from 1913 to present. The mean sea level trend is 1.80mm/year from 1914 to 2006, which is equivalent to a change of 7 inches in 100 years. (http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8727520)



Cedar Key tide gauge (http://tidesandcurrents.noaa.gov/stationhome.html?id=8727520)

Introduction

into the future, and at an accelerating pace (U.S. Global Change Research Program, 2014). The anticipated acceleration of global average sea level rise is a result of continued atmospheric warming due to increasing levels of heat-trapping, or "greenhouse," gases. Satellite measurements of global average sea level have found that the rate of rise since 1992 is twice that observed over the past 100 years, thus confirming an acceleration. The Cedar Key tide gauge has shown a 5% increase in the rate of sea level rise from 2006 to 2013. Additionally, increased seasonal fluctuations in sea levels have been documented along the Gulf coast. Typically sea levels are lower in the winter and higher in the summer. Since 1990 these patterns have been amplified, with an average increase of 21% in the difference between summer and winter sea levels (Wahl, Calafat, & Luther, 2014).

A degree of uncertainty is associated with modeling future sea levels, therefore a range of future scenarios should be considered for planning purposes. The Planning for Coastal Change in Levy County project used locally specific and scientifically defensible future sea level rise scenarios for Levy County. In particular, the project calculated scenarios from the Army Corps of Engineers guidance (USACE, 2011), with input data from the Cedar Key tide gauge (see Figure 3). These sea level rise scenarios show an increase in average sea level expected for the year 2100, from a low of one-and-a-half (1.5) feet rise to a high of five (5) feet rise. These scenarios are two-and-a-half (2.5) to eight-and-a-half (8.5) times the rise experienced in the past 100 years, respectively.

All the scenarios (historic trend, and low-, medium-, and high-range models) predict rising sea levels into the foreseeable future. Therefore, a first step in planning is to ask: At what amounts of sea level rise do impacts occur for places and assets of concern? Once this is determined, the scenarios can then be used to answer: When might these sea levels occur? Many of the maps and analyses in this report focus on a scenario of three (3) feet of sea level rise by the year 2100. This scenario is particularly useful for planning, because three feet of sea level rise will result in clearly observable, community- and regional-level changes, and this scenario may reasonably occur within the longest timeframe considered for local land use and project planning, which is 100 years. At a finer scale of analysis, the rate of sea level rise becomes more important, such as in determining whether coastal wetlands will keep up with the rising waters (through soil formation, or "accretion") or whether they will be "drowned".

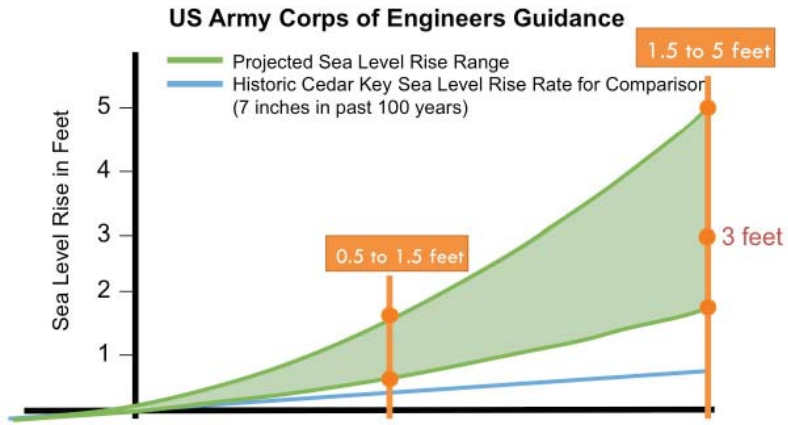


Figure 3: Sea level rise projection

Impacts of Sea Level Rise

The seemingly small rate of sea level rise in Levy County (seven inches in the past 100 years) has led to profound changes along the low-lying, gradually sloping terrain of the Big Bend region (see Figure 4). The U.S. Geological Survey mapped the changes in the natural landscape in the Big Bend that occurred between 1852 and 1995, and they found a substantial decline of coastal forests, and subsequent conversion to salt marsh and open water (see Figure 5)(Raabe, Streck, & Stumpf, 2004). The conversion was especially pronounced in the Waccasassa Bay between Cedar Key and Yankeetown. Researchers from the University of Florida have studied tree die-offs in the Waccasassa Bay since the mid-1990s, and they have concluded that the landscape changes were mostly due to sea level rise, combined with the periodic stresses of storms and droughts (Putz, 2012). Increases in the seasonal fluctuation as documented by Wahl et al. (2014) may have additional negative effects on ecosystems, upsetting the delicate balance of salinity that ecosystems depend on for stability, and increasing risks from summer storm surges.

In addition to transforming forests and salt marshes, sea level rise can negatively impact people and properties. Sea level rise can magnify erosion and flooding in coastal communities, because the sea level reaches increasingly higher elevations during normal tides and with storm surges. Higher sea level can also exacerbate flooding by blocking storm drain system outfalls, or by pushing up aquifers that are naturally connected with the land surface (called "surficial aquifers"), as is the case in Levy County. Sea level rise can move the interface between the ocean's saltwater and the freshwater aquifer farther inland, potentially jeopardizing the quality of groundwater withdrawn by communities and agriculture. Increased flooding, higher water tables, and saltwater intrusion can corrode infrastructure and release pollutants, from septic tanks and other underground sources.

Dying trees from salt water intrusion in Levy County

Introduction

Figure 4: Big Bend region

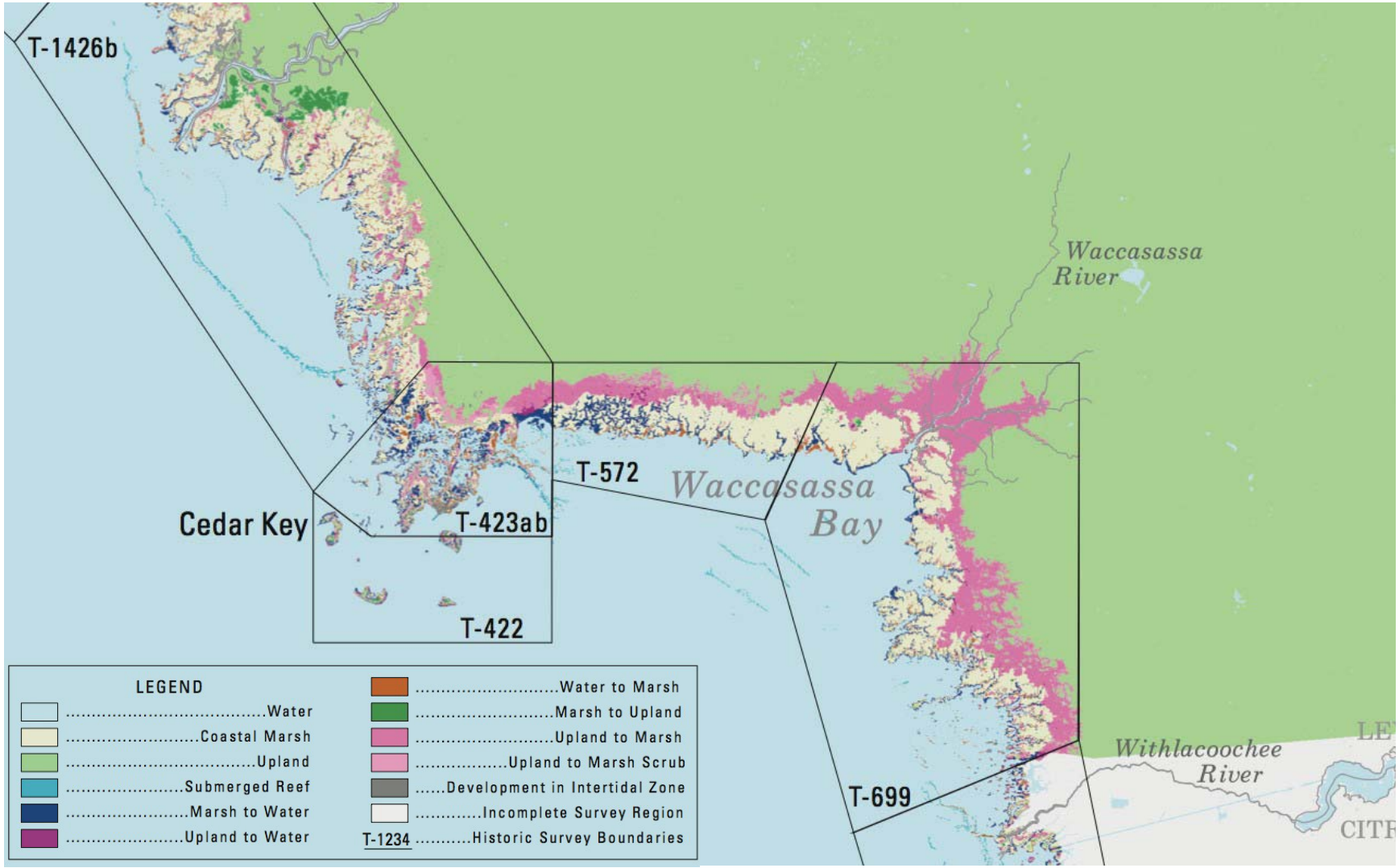


Figure 5: Past shoreline changes from 1852 to 1995 (U.S. Geological Survey, 2004)

Adaptation Strategies

Communities and regions have historically adapted to the incremental impacts of sea level rise as part of strategies known as "hazard mitigation," which respond to coastal dynamics, such as wave erosion and flooding from storms. These strategies have been applied in a reactive manner to observed changes and risks, or at opportunities for infrastructure upgrades, technological advancements, and environmental protection. Coastal planners have not typically taken into account the long-term trend of sea level rise.

When considering sea level rise, the hazard mitigation strategies may still be appropriate to consider, and other adaptation strategies can be included to take into account the long-term, irreversible impacts of permanently higher waters. Proactive planning for adaptation to sea level rise and other coastal hazards has the potential of reducing current and future risks to people and property, minimizing long-term public and private costs, and maintaining community identity and vibrancy.

Living shoreline (Florida Department of Environmental Protection)

Elevated structure

Sea level rise adaptation strategies have been identified for developed and future development areas (the "built environment"), and landscapes and natural resources. The strategies can be integrated and continually updated to achieve community and regional resilience. Adaptation strategies for the built environment can be categorized into three groups based on their objectives (Grannis, 2011): (1) Protection strategies reduce flooding and loss of land and property due to erosion or inadequate infrastructure, through engineered approaches such as the placement of riprap, beach renourishment, and flood control measures. (2) Accommodation strategies lower

the vulnerability of structures to flooding through design measures such as elevating buildings, and upgrading stormwater and wastewater systems. (3) Planned relocation reduces the exposure of people and development to hazards through the movement of buildings and infrastructure away from areas subject to current or future inundation. Additionally, (4) future development can be steered away from areas vulnerable to sea level rise and other coastal hazards. The third and fourth strategies can be implemented through land use plans, land acquisition/easement programs, and supportive policies such as transfer of development rights. Appendix B contains a graphic summary of potential adaptation options based on these primary categories, as shown in the *Sea Level Rise Adaptation Strategy for San Diego Bay* report, published in 2012.

Riprap armoring

Adaptation strategies for the landscapes and natural resources seek to maintain ecological and species resilience, and environmental quality (U.S. EPA, 2014a). Environmental quality provides important "ecosystem services" to people, such as water supply, supporting the local economy through tourism and fisheries, and offering coastal residents a high quality of life. Specific adaptation strategies for landscapes include natural corridors for habitat and species migration to higher elevations via land conservation and ecological restoration. Ecological and species resilience can also be maintained by reducing other stresses to the natural system, such as urban development and watershed modifications. Concerns regarding water resources, including the threat of saltwater intrusion, may be addressed by conserving land important for water recharge, and by implementing adaptation strategies for water utilities under similar principles as for the built environment (U.S. EPA, 2014b). Increasingly, "integrated" strategies are being designed that serve multiple purposes. One kind of integrated strategy is "living shorelines" that create habitat while also protecting coastal development.

The particular adaptation strategies chosen for a given place, time, and purpose(s) depend on local conditions, community priorities, legal requirements, program incentives, technologies, and funding. Strategies should be assessed for suitability to address a given need based on their pros and cons, and in comparison with available alternatives. The identification, selection, implementation, and evaluation of adaptation strategies should be a part of ongoing community and regional planning.

Planning for Coastal Change in Rural Areas

Sea level rise is only one of many changes anticipated for coastal areas, and adaptation planning should take these into account. Coastal communities are threatened by storms, including hurricanes, and a changing climate could lead to different storm intensities, frequencies, and paths (U.S. Global Change Research Program, 2014). Climate and ocean changes are affecting coastal vegetation, wildlife, and fisheries, such as in the case of the northward migration of mangroves in Florida, which displaces salt marshes (Gillis, 2013).

Cedar Key storm surge (AP Photo/The Gainesville Sun, Brad McClenny)

Climate also plays a role in droughts, which led to salt-water intrusion into Cedar Key's drinking water supply in 2012. Continued urban development and watershed modifications, including wetland drainage and water withdrawals, also produce dramatic changes in the landscape. Factors combine, leading to tipping points, such as the collapse of oyster reefs in the Big Bend region (Seavey et al., 2011). These changes bring a less predictable future, as well as expected costs and risks, which add up to economic and social impacts. For example, legislative revisions to the National Flood Insurance Program, based on concerns for the financial viability of the program, have decreased flood insurance availability and increased rates, thus significantly affecting coastal residents and property owners in Florida (Florida Sea Grant, 2014). Proactive, integrated planning, however, may lessen these risks, avoid irreversible negative impacts, and take advantage of opportunities to make communities more resilient and vibrant.

Sea level rise and other coastal changes affect all kinds of places, including small towns and rural areas; however, most sea level rise adaptation planning in Florida has focused on urban areas. Small towns and rural areas have residents and important assets for which to plan, yet these communities and regions do not usually have large in-house staffs to plan for emerging issues. Moreover, lessons learned from adaptation planning in urban areas have limited applicability to small towns and rural areas, since these places have qualitatively different types of conditions, concerns, planning methods, and adaptation strategies. For these reasons, the Planning for Coastal

Change in Levy County project was created to serve a vital place, and to develop and test an approach for sea level rise adaptation planning tailored to small towns and rural areas. The project findings specific to Levy County are detailed in this report. A separate guidebook is being created to explain the planning approach for potential transfer to other small towns and rural areas, especially within the Big Bend region of Florida.

Home in Cedar Key (Juan Castillo Jr.)

Project Approach and Scope

The Planning for Coastal Change in Levy County project operated under several beliefs and principles grounded in professional literature and latest best practices: (1) Small towns and rural areas have unique characteristics and assets to which adaptation planning should be tailored. (2) Proactive planning has significant benefits and should be started as soon as possible. (3) Planning should be conducted at multiple scales, from site to community to county to region, and across different timeframes. (4) Planning for sea level rise should be integrated with planning for other concerns, seeking opportunities for improving overall resilience and vitality. (5) Multiple forms of knowledge and reasoning should be brought to bear, including scientific research and local experiences. (6) Adaptation planning should be conducted in a highly engaging, collaborative, and community-based manner. (7) Uncertainty is unavoidable, but it can be managed through adaptive governance and capacity building.

The beliefs and principles led the project to conduct a wide variety of research, analysis, and outreach activities (see Figure 6). Several activities occurred continuously throughout the project, such as building relationships between the project team at the University of Florida and community and regional leaders in Levy County, gathering information about sea level rise and coastal change locally as well as keeping abreast of emerging science

Introduction

and professional practices, and maintaining a project website. The timeframes of other activities fit the university semester schedule, because several activities were conducted as applied learning ("studio") courses during the school year, or as special sub-projects, including during summers.

Project oversight and general assistance were provided by: Principal Investigator - Dr. Kathryn Frank; Co-Principal Investigator - Dr. Dawn Jourdan, Esq.; Project Manager - Prof. Michael Volk, MLA; and Graduate Assistant - Sean Reiss, Masters in Urban and Regional Planning. Faculty and instructors who taught the studio courses were: Gail Easley, FAICP; Dr. Ferdinand Lewis; and Dr. Joseli Macedo. The involved graduate and undergraduate students were majoring in various fields, including urban and regional planning, landscape architecture, building construction, sustainability and the built environment, architecture, law, business, engineering, anthropology, and others. Additionally, supporting researchers at the University of Florida included: Dr. Zhong-Ren Peng, Dr. Paul Zwick, Prof. Robert Grist, Dr. Robert Ries, Dr. Esther Obonyo, Thomas Ruppert, Esq., Dr. Anna Linhoss, and Dr. Greg Kiker.

The studio courses and sub-projects were:

- The project team maintained a website (ChangingLevyCoast.org) and Facebook page to share information about the project with the public.

- The "start-up" studio course in the spring of 2012, led by Ferdinand Lewis, gathered background information about Levy County and developed a plan for initiating civic engagement.

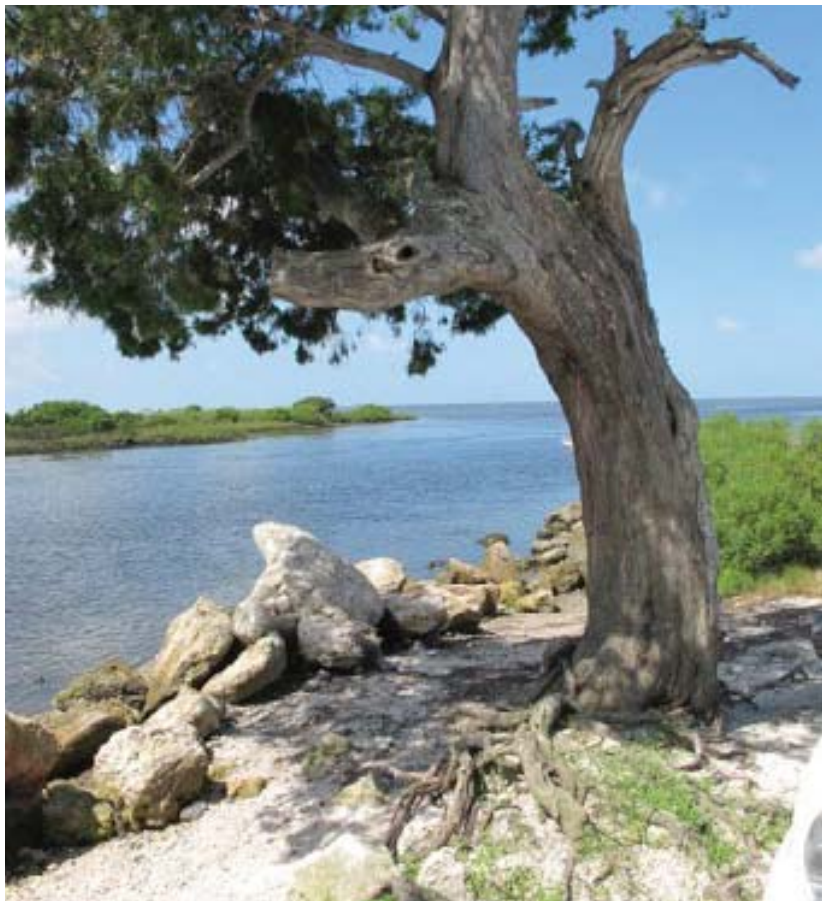
- During the summer of 2012, under the direction of Dawn Jourdan and project management by Sean Reiss, team members provided educational activities about planning for sea level rise and coastal change to the City of Cedar Key's Summer Youth Program. The team also asked the children for their opinions about planning for coastal change.

- The studio course in the fall of 2012, led by Gail Easley, delivered information about sea level rise and coastal change, and gathered input, at public workshops and local festivals. Kathryn Frank also presented this information to local public officials.

- The studio course in the spring of 2013, led by Joseli Macedo, focused on the Cedar Key-Rosewood area and identified community-based strategies to adapt to sea level rise and other coastal changes. The students presented the results at workshops and the Cedar Key Arts Festival. During this studio, the students also conducted oral history interviews, which were donated to the University of Florida's Samuel Proctor Oral History Program.

- In the summer of 2013, the project team identified strategies for adaptation to coastal change in Yankeetown and Inglis. Also during this time, the team compiled the oral history interviews into a 15-minute video.

- During the fall of 2013 and spring of 2014, the project team hosted an art exhibition at the Cedar Key Arts Center, and a youth essay contest open to 5th-8th grade students in Levy County. Both activities explored a coastal change theme. The project team began writing the findings report and guidebook, and Kathryn Frank presented draft project synthesis results to local officials.



Yankeetown shoreline

Organization of Report

The next section, Project Methods, details the project's organizational approach and local partnerships, literature reviews, technical data collection, public input gathering, and information analysis and synthesis.

Then the Findings and Recommendations section provides information about local vulnerabilities to sea level rise and other coastal changes, and adaptation strategy recommendations. This information is presented at the county scale (Levy County) and the community scale (Cedar Key-Rosewood and Yankeetown-Inglis).

Last, the Conclusion summarizes the accomplishments of the project, local capacity for continued sea level rise adaptation planning, and key next steps.

The report also contains appendices with information to support use of this report and to reference during planning.

Activity	Timeframe	Results
Ongoing research and communication	Spring 2012-Summer 2014	University-local relationships, 9 commission presentations, press coverage, ChangingLevyCoast.org, literature reviews and local information
Start-up studio	Spring 2012	Baseline information and outreach plan
Cedar Key Summer Youth Program	Summer 2012	Six-week coastal change curriculum - 90 children, camp celebration, public input
Levy County outreach studio	Fall 2012	3 workshops - 30 participants, 2 festival booths, public input
Cedar Key-Rosewood adaptive design studio	Spring 2013	Local analyses, 2 workshops - 22 participants, 1 festival booth, public input, design recommendations
Oral environmental histories	Spring-Summer 2013	8 people interviewed, 15 minute video
Yankeetown-Inglis adaptive design	Summer 2013	Local analyses, two workshops - 20 participants, public input, planning and design recommendations
Youth essay contest	Fall 2013	About 15 essays from 5th and 6th graders, awards for top 3
Cedar Key Arts Center exhibit	Fall 2013-Spring 2014	7 artists, month-long show
Project synthesis, conclusion, and sharing	Spring-Summer 2014	Levy County findings report and planning approach guidebook

Figure 6: Major project activities, timeframes, and results.

Project Methods

The project's methods provided the basis for the recommendations in this report. As mentioned in the previous section, the project had many different activities. The functions of these activities were to: (1) yield findings, including information about vulnerability and local preferences, and the project team's recommendations for adaptation; and (2) build local capacity for continued adaptation planning and implementation of strategies. This report focuses on the findings, but the descriptions of outreach methods also note potential contributions to local capacity building.

The project generated the findings through a planning process composed of several phases conducted in an iterative manner: project team capacity building, information inventory, analysis, synthesis, and implementation support (see Figure 7). Project team capacity building included activities to build relationships between the project team and local partners, and to improve team members' knowledge of topics related to the project. Inventory was the collection of information (data) about the study area, including the potential impacts (vulnerability) from sea level rise and other coastal changes, from quantitative and qualitative sources, and public outreach. Quantitative data sources included geographic information systems (GIS), scientific modeling, and agency monitoring programs. Qualitative data sources included descriptive information about the place and policies, such as was found in local comprehensive plans, organization websites, and news stories. Public outreach yielded input from public officials, stakeholder groups, and citizens regarding observed trends and desired adaptation strategies. Analysis was the examination of the inventoried data to look for patterns and insights, in order to "know the place" as fully as possible. Synthesis was the step of combining the results of the inventory and analysis phases, and applying the project team's professional and scientific expertise, to make recommendations for adaptation. Implementation support involved publicly reviewing draft recommendations, and identifying potential next steps. The phases were conducted at different scales, for Levy County, and for Cedar Key-Rosewood and Yankeetown-Inglis. Each phase is discussed below.

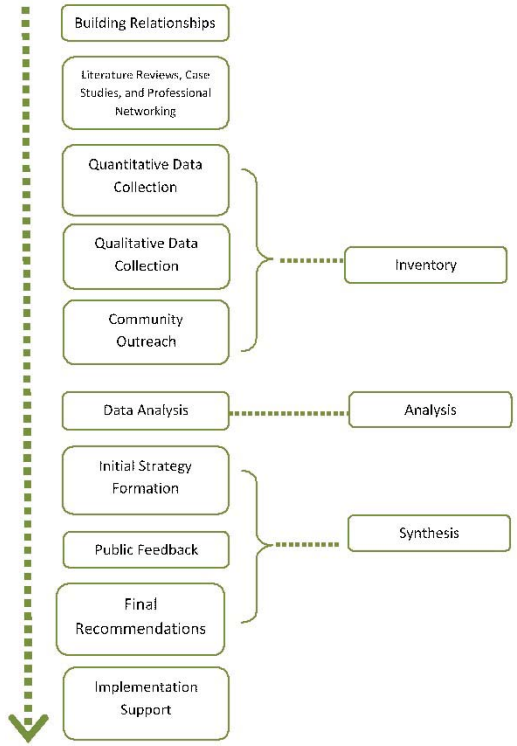


Figure 7: Phases of iterative planning process

Project Team Capacity Building

The project team faced an initial "learning curve," because the team had not worked in Levy County before, and planning for adaptation to sea level rise was a relatively new practice, especially in small town and rural areas in Florida. The team members thus made significant efforts to build relationships and develop their expertise, which continued throughout the project.

Building Local Relationships

The project's Principal Investigator, Kathryn Frank, and Co-Principal Investigator, Dawn Jourdan, initially reached out to local government staff and community leaders through persons they knew with ties to the University of Florida. For example, Earl Starnes is a resident of Cedar Key and a Professor Emeritus with UF's Department of Urban and Regional Planning. At the county level, one of the first people contacted was Shenley Neely, Planning Director for the Levy County Planning Department. These initial contacts suggested names of other people who may be interested in the project, and the project team contacted them. Many of the initial contacts were made in person by team member visits to Bronson, Cedar Key, Yankeetown, and Inglis. Additionally, the project team met local leaders at community and regional planning events, such as a Nature Conservancy presentation in Crystal River, and a Waterfronts Florida Program workshop in Steinhatchee. The many local leaders involved

have provided significant social support and key information for the project, without which the project would not have been successful.

Literature Reviews, Case Studies, and Professional Networking

To improve team members' knowledge of topics related to the project, the project team gathered professional and scientific information across a wide range of disciplines and in a variety of ways. The project team conducted numerous literature reviews, covering broad topics, such as small town and rural planning, sea level rise adaptation planning, coastal planning, and climate change, and narrow topics related to specific project activities, including how planning can incorporate youth participation, oral histories, and art exhibitions.

Additionally, case studies of community adaptation to sea level rise were conducted in the Spring 2013 Cedar Key-Rosewood Adaptive Design Studio. Each studio member focused on one particular city or region and outlined its adaptive design process, strategies, and final outcomes or costs. The case studies were Miami-Dade and Sarasota Counties in Florida, Worcester County in Maryland, and the City of Norfolk in Virginia. One case study in particular, the Sea Level Rise Adaptation Strategy for San Diego Bay report, provided many alternative approaches that ranged from the hard barrier approach of sea walls to complete withdrawal.

The project team also met locally involved persons and gained expertise through professional networking across Florida, including with state agency staff, university researchers, and Florida Sea Grant extension agents. The Florida Department of Economic Opportunity has been a key resource, with Kathryn Frank participating in the agency's Community Resiliency initiative. Project team members have attended and presented at several statewide conferences. Kathryn Frank is also active in the University of Florida's Water Institute and the Florida Climate Institute, and team members are involved in other sea level rise research projects across the state. The research on sea level rise impacts and adaptation is rapidly expanding, including within Levy County by other researchers and projects, therefore professional networking was critical to sharing results and coordinating activities.

Yankeetown wetlands

Inventory

The inventory phase was the collection of information specific to the places: Levy County, Cedar Key-Rosewood, and Yankeetown-Inglis. The information addressed current and past conditions, potential impacts from sea level rise and other coastal changes, as well as community preferences, constraints, and opportunities for adaptation. The types of information can be roughly organized as quantitative and qualitative, with a special kind of the latter type being input from community outreach.

Quantitative Data Collection

Quantitative data involved measurements from a wide variety of government and university sources available on the Internet, such as the U.S. Census. Most significantly, because sea level rise impacts and adaptation strategies vary spatially across communities and regions, the project team used computer-based geographic information systems (GIS) to create maps from datasets maintained by the University of Florida's GeoPlan Center and other sources. The project team used two primary forms of data to examine direct sea level rise impacts to the land surface: (1) an elevation-based, tidally adjusted "bathtub" inundation model, and (2) outputs from the Sea Level Affecting Marshes Model (SLAMM)(see Appendix A).

Bathtub models are based on digital elevation data and assume that all land below a specified elevation, and that has a hydrologic connection to the coast, would be inundated when sea level rise equaled the specified elevation. Normal tide range may also be included in the analysis of potentially affected lands (called a "tidally adjusted" bathtub model). This project identified low-lying areas below 1.5, 3, 4, 5, and 6 feet elevations that would likely be vulnerable to sea level rise using the best available LiDAR based digital elevation models at a 5 meter cell size. Additionally for Cedar Key, digitized contour maps based on a 2 foot contour interval were reviewed to aid analysis of the hilly islands.

Sea Level Affecting Marshes Model (SLAMM) is a software tool that can be used to simulate potential changes in shorelines and coastal habitats under various sea level rise scenarios (Warren Pinnacle Consulting, Inc., 2014). The project received SLAMM outputs from two studies: the Lower Suwannee River produced by the Gulf of Mexico Alliance (Warren Pinnacle Consulting, 2011a) and the Waccasassa Bay produced by The Nature Conservancy (Freeman and Geselbracht, 2011). The project used SLAMM outputs to assess potential changes in the coastal landscape using a scenario of 3 feet of sea level rise by the year 2100. Areas where dry or upland areas converted to new wetlands were considered areas likely to be impacted by future sea level rise.

The project team also used the Federal Emergency Management Agency's (FEMA) Hazus model to generate a 100-year storm surge area for Levy County. The project team did not conduct Hazus model runs of storm surge with sea level rise.

As part of the analysis phase, the project team examined the attributes of the lands potentially affected by sea level rise and storm surge using additional GIS data from the Florida Geographic Digital Library (FGDL), maintained by the Geoplan Center, including for property parcels, conservation lands, land-use, hydrology, and streets. The project team also created spatial data for building footprints in Cedar Key, Yankeetown, and Inglis.

Qualitative Data Collection

Qualitative data collection involved gaining an understanding of local policies, history, character, and values. Understanding the policies that govern and physically shape communities, as well as the character and values found in a community, are critical components for understanding how an area is vulnerable to changes in sea level and the ability to adapt to future change.

Adaptive design workshop

The project team analyzed current policy with regard to community vulnerability to sea level rise and implications for potential adaptation strategies. Municipal and County comprehensive plans, land development codes, zoning, and local mitigation strategies were examined. The analysis considered questions such as whether new development and capital investments are being directed towards vulnerable or hazard prone areas. Land-use and zoning policy were identified with regards to their flexibility and application for future adaptation. One example is Yankeetown's Transfer of Development Rights program. Policy analysis also examined the vulnerability associated with current water and wastewater policy, as well as the relationship between existing water infrastructure, policies, and potential adaptation strategies, e.g., their ability to accommodate changes in spatial organization of the built environment (changes in density and intensity of development).

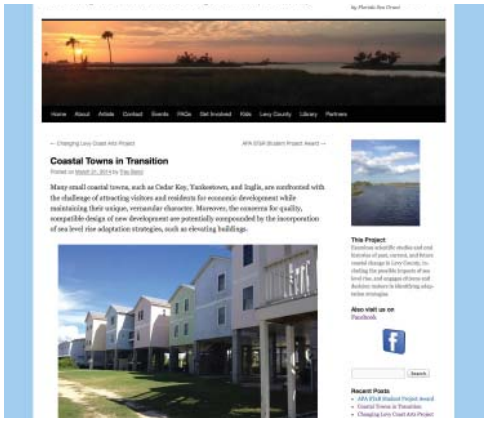
The social aspects of sea level rise adaptation were informed through local oral histories on changes to the coastal landscape, input at public workshops and meetings, and through personal conversations. Additionally, the project team researched local history, culture, and other social, economic, and organizational aspects of Levy County and its coastal communities. This social analysis served to inform the project team's views and understanding of the coastal communities and areas in Levy County and relate their local character, history, and values to opportunities for adaptation.

Project Methods

Community Outreach

Community outreach methods had two functions: to facilitate input to the project from community leaders and citizens, and to share information about the project and its findings to build local capacity for adaptation planning. Community input was important for understanding coastal changes and their potential impacts on social, economic, and environmental systems, as well as local values, preferences, and "adaptive capacity." The project team conducted outreach through casual conversations and a wide variety of structured activities. These methods involved people at the scales of one-on-one (casual conversations), dozens (community workshops), hundreds (festival booths, oral history video, and art exhibition), and thousands (project website). Each structured activity is described below.

Project Website - The project's Wordpress website (ChangingLevyCoast.org) was created in June 2012 and updated throughout the project. The website included a blog devoted to project activities and relevant topics, pages containing information about the project and team, and links to project presentations, videos, documents, maps, news articles, and other resources. There were also pages supporting the youth essay contest and the artists preparing for the coastal change arts exhibition. Additionally, updates to the blog were automatically posted to the project's Facebook page (https://www.facebook.com/ChangingLevyCoast). The project website was viewed over 7,600 times.



Project website

Public Media and Communications The project team reached community members and visitors by posting event fliers, personally emailing key community supporters, creating project briefs (fact sheets) and business cards available at events, and writing press releases about significant outreach activities, such as the children's summer program and the arts exhibition. The project team also answered questions from local and regional media. The project team connected with larger audiences by writing professional articles for the newsletter of the local chapter of the American Planning Association (APA) and a blog post on youth participation for the national APA, as well as professional presentations via a webinar and at conferences.

Public Workshops and Festival Booths - The project team held a number of public workshops throughout the

project, reaching a variety of local officials and groups. Towards the beginning and end of the project, the project's Principal Investigator, Kathryn Frank, presented information about the project and its findings to the Levy County Board of County Commissioners, and the Levy County Planning Commission, as well as to the city commissions for Cedar Key, Yankeetown, and Inglis. These nine presentations were conducted during regular meetings, with the exception of the final presentation to the Inglis and Yankeetown commissions, which occurred as a separate workshop prior to the regular Inglis commission meeting. This workshop also included a presentation about the National Flood Insurance Program by Thomas Ruppert of the Florida Sea Grant. At each of these presentations, Dr. Frank answered questions from the commissioners and the public, and she asked the commissioners for input regarding the project.

The Fall 2012 studio course led by Gail Easley conducted the initial round of three general public workshops in Cedar Key and Yankeetown-Inglis, with a total of 30 participants. The local groups organizing their members' attendance were the Cedar Key Chamber of Commerce, Florida's Nature Coast Conservancy, and the Withlacoochee Chamber of Commerce. These workshops included short presentations of the science of sea level rise and coastal change, the potential impacts to local social, economic, and environmental values, and the importance of proactive planning. The workshop facilitators directed discussion following the presentations and took notes of the community input received. This studio course also held manned booths with posters and handouts about the project and its findings, and simple children's activities, at the Cedar Key and Yankeetown seafood festivals in 2012.

Public workshops were also held in conjunction with the more advanced "adaptive design" work focused on Cedar Key-Rosewood in Spring 2013 and Yankeetown-Inglis in Summer 2013. The adaptive design component moved the project past identifying vulnerabilities to sea level rise toward making specific recommendations for adaptation. The Cedar Key-Rosewood adaptive design studio course led by Joseli Macedo conducted two public workshops

Project Methods

ADAPTIVE STRATEGIES WORKSHOP

Planning for Coastal Change in Levy County

Wednesday, February 27, 2013
2:00-4:00PM
Cedar Key Public Library

Agenda

I. **Welcome and Workshop Goals** (Kathryn Frank and Joseli Macedo, UF) – 5 min
II. **Participant Introductions** (All) – 10 min
III. **Project Update and Sea Level Rise Scenarios** (Kathryn Frank) – 10 min
IV. **Detailed Geographic Analyses of Potential Impacts of Sea Level Rise in Cedar Key-Rosewood Area** (Sean Reiss, UF) – 15 min
V. **Current Impacts and Planning Priorities** (Small Groups) – 20 min
VI. **Adaptive Planning and Strategies Overview** (Kathryn Frank) – 10 min
VII. **Adaptive Strategies Interactive Game** (Small Groups) – 45 min
VIII. **Closing Remarks and Next Steps** (Kathryn Frank and Joseli Macedo) – 5 min

Workshop agenda example

at the Cedar Key Library with a total of 22 participants. The workshops were advertised to attract participants from Sumner and Rosewood, as well as Cedar Key, and they were successful in this regard. The workshops were designed to be highly interactive. The first workshop held in February 2013 included participant introductions intertwined with a discussion of the importance of planning for sea level rise and coastal change in small town and rural areas, a mapping exercise to identify current local changes and planning priorities, and an adaptive strategies role-play game. The second workshop held in April 2013 presented the students' findings and adaptive designs (adaptation strategies) in presentation and poster formats, and notes were taken of community input. The studio also presented its findings at a manned booth at the Cedar Key Arts Festival in 2013.

The Yankeetown-Inglis adaptive design work included two public workshops at the Lion's Club building in Yankeetown with a total of 20 participants. The first Yankeetown-Inglis adaptive design workshop held in July 2013 was similar to the first Cedar Key-Rosewood adaptive design workshop, except a SWOT (strengths, weaknesses, opportunities, and threats) exercise replaced the mapping exercise. The second workshop held in August 2013 presented the team's adaptive design recommendations and received community input. The findings from the Yankeetown-Inglis adaptive design work were documented in a report to the communities. This report received a national award from the American Planning Association's Small Town and Rural (STaR) Division in April 2014.

Summer Youth Program - To reach local children and their families, the project team partnered with the City of Cedar Key during Summer 2012 to provide coastal change themed activities (or curricula) for the six-week Cedar Key Summer Youth Program (also called "summer camp") held from July 9 to August 15. Over 90 children, mainly grades K-6, from Cedar Key, Sumner, and Rosewood participated. Specific topics of the activities were

Students work on “Box City”

the role of children and youth in community decision making, coastal dynamics and Cedar Key's history, community planning and adaptation to changes in coastal areas, mapping using geographic information systems (GIS), and envisioning Cedar Key's future. Specific activities, which were designed to be engaging, included inspecting local Native American artifacts and reconstructing pottery from sherds, viewing historical maps and interviewing family elders about coastal changes, building a "box city" affected by sea level rise, creating maps of the school neighborhood using aerial images and tracing paper, conducting a photo journal walking tour of Cedar Key, and painting hanging wooden "quilts" to show the future of Cedar Key. At the camp's conclusion, the project team hosted a celebration for the children and their families, which included a presentation of the children's art, photos, maps, and other products. The children's products documented their understanding of sea level rise and coastal change, and ideas for adaptation, thus providing children's input to the project.

Youth Essay Contests - In addition to involving children through the Cedar Key Summer Youth Program, the project hosted a youth essay contest in Fall 2013. The contest was open to any child in 4th to 8th grades, with the contest posted on the project's website and shared with teachers in the local schools serving the Cedar Key-Rosewood and Yankeetown-Inglis areas. The contest instructions were to write a one- to three-page essay explaining "why you think planning for sea level rise and coastal change is important in Levy County." To assist the writers, youth-oriented background information about sea level rise and coastal change was posted on the project website's "Kids" page. Fifth and sixth grade science teachers in Cedar Key incorporated the essay contest into their classes, and 15 students submitted essays. The project team selected first, second, and third place winners based on how well the essays addressed the stated theme. Cash awards were given to the winning students, and all students received certificates of participation. All the youths' essays served as public input to the project, including providing information about locally observed coastal change, and youth concerns and preferences.

Oral History Interviews and Video - To gain local knowledge about coastal change, and to engage long-time residents, the Spring 2013 studio course students conducted oral history interviews of eight persons from the Cedar Key-Rosewood and Yankeetown-Inglis areas. The Samuel Proctor Oral History Program (SPOHP) at

Oral history interviewee

Project Methods

the University of Florida provided their informed consent process and basic information about the oral history approach, and SPOHP will transcribe and archive the interviews. The interview questions covered observed environmental changes, personal and community impacts, and suggestions for future adaptation and community planning. The project team edited the recorded interview footage into a 15-minute video. The team posted the video on the project's website, where it has received over 170 views, and the team showed the video at the project's public workshops and art exhibition opening.

Art Exhibition - Art is a method for engaging community members in emotional and conceptual ways. Since artists are prominent in the coastal communities of Levy County, the project partnered with the Cedar Key Arts Center and local artists to create a visual art exhibition with the themes of coastal change and sea level rise. The initiative began with a call to artists across the Levy County coast and was followed a few weeks later by a day-long workshop and coastal tour to educate and inspire the participating artists. The artists could learn more about sea level rise and coastal change on the project website's "Artists" page. The artists had two months to complete their artwork. Seven of the ten artists participating in the workshop submitted 15 pieces for the month-long exhibition, including paintings, jewelry, an interactive notebook, and sculptures. About 100 persons attended the exhibition opening, which also included a second art exhibition related to coastal change (the "Homage to the Honeymoon Cottage") and other project materials (the summer camp "wooden quilt", a laptop playing the oral history video, and project posters and handouts). Following the exhibition, the project team met with the artists to reflect on the experience.

Analysis

The analysis phase was the interpretation and combination of the inventoried data to determine vulnerability to sea level rise and coastal changes, and options for adaptation planning. Analyses occurred at the scales of Levy County and the communities of Cedar Key-Rosewood and Yankeetown-Inglis.

Basic principles of sea level rise impacts, especially in regards to land use, infrastructure, and water resources, were guides to specific analyses. Sea level rise may flood low-lying areas adjacent to the coast, and this can cause changes below the surface as well, due to Levy County's karst geology and surficial aquifer. The sea level rise scenarios from the Army Corps of Engineers Guidance indicated the ranges of sea level rise that may occur in the future. Some analyses thus identified areas at elevations below the potential future sea levels, determined what was located there, and assessed the vulnerabilities. Furthermore, analyses examined how land elevation varied across the landscape to ascertain "tipping points" of possible rapid change as sea level rises. The tidally adjusted "bathtub" model was applied across the Levy County coast and in Cedar Key-Rosewood.

More complex modeling of habitat changes was also available via previous Sea Level Affecting Marshes Model (SLAMM) studies, and this suggested impacts to wildlife and natural resources. The project team deemed these results to also be useful for analyzing the Yankeetown-Inglis area, because SLAMM is especially accurate in the gradually sloping, marsh-dominated landscape in this area. Storm surge from a 100-year storm event was also mapped and overlaid with land features.

The potential impacts of sea level rise on surface water and groundwater systems were approximated from overlay analyses, such as for locations of public water supply and domestic wells, water and wastewater treatment facilities, domestic septic systems, and groundwater recharge areas. Existing water quality and well level monitoring data provided more insights into the vulnerability to saltwater intrusion, as well as anecdotal evidence of excursions, such as in Cedar Key's public water supply. No hydrology models existed to indicate the location and trends of the saltwater-freshwater interface.

Erosion was not modeled or analyzed beyond referencing state agency lists of highly erodible areas and field observations and public input in the coastal communities. Other coastal changes, such as future development patterns and climate change effects, such as changing average temperatures or storm/rainfall patterns were not modeled, but the regionally specific scientific understanding of these potential changes to the natural and built environments were considered qualitatively based on the available scientific literature.

Levy County Analyses

Analyses at the scale of Levy County occurred early and

throughout the project to provide the context for the community level analyses, and to understand potential sea level rise impacts and adaptation strategies for the unincorporated areas of the coast. Many of these areas are in public ownership for ecological conservation; however, there are some rural developed areas farther inland that can be affected by storm surges, such as Sumner-Rosewood near Cedar Key, Fowler's Bluff along the Suwannee River, and Gulf Hammock at the headwaters of the Waccasassa River. The Levy County analysis included the interpretation of GIS data at the county scale, especially the results of the Sea Level Affecting Marshes Model (SLAMM) and changes in freshwater flows, the county's comprehensive plan, and the input of public land managers, county officials, and planners.

Community Analyses

The community level studies included additional analytic techniques for the built environment. The Cedar Key-Rosewood adaptive design work was conducted under an "urban design" studio course that possessed a standard step-wise approach consisting of several types of analysis: site and visual, SWOT, physical design, and spatial. This adaptive design process also served as template for the Yankeetown-Inglis study.

Site and visual analysis consisted of multiple project team trips to the communities for first-hand observations and assessments of conditions and place character, using photography for documentation. SWOT analysis was the identification of "strengths, weaknesses, opportunities, and threats" for each community with regard to sea level rise. Strengths and weaknesses were internal to a community. Opportunities and threats were external factors. SWOT analysis laid a foundation for understanding community values, assets, concerns, priorities, ideas, and "adaptive capacity," for use in the synthesis phase of making recommendations for adaptation strategies. For the Cedar Key-Rosewood study, the studio students conducted the SWOT analysis. For Yankeetown-Inglis, the SWOT analysis was a participatory exercise at the first adaptive design workshop.

Physical design analysis was the characterization of the physical elements of a community and their corresponding functions using the methodology in *Urban Design Reclaimed* (Talen, 2009). The physical elements examined were neighborhoods, transects, and connections; community centers, edges, mix of uses, and proximities; and density, parking, and traffic. For this analysis, the Cedar Key-Rosewood adaptive design studio divided the Cedar Key community into four study areas, with the methodology applied to each area. The Yankeetown-Inglis adaptive design work also identified physical design elements, such as community districts, corridors, and amenities, but without formally applying Talen's methodology.

Spatial analysis overlaid the results from the inventory phase (e.g., building footprints, roads, and critical facilities), site and visual analysis, and physical design analysis on the maps of low-lying areas (for Cedar Key-Rosewood) or SLAMM changes (for Yankeetown-Inglis) to identify the potential impacts of sea level rise.

Synthesis

The synthesis phase identified adaptation strategies based on the project's objective and stated beliefs/principles, the place-specific analyses, community input, and the project team's professional expertise. The synthesis phase was necessarily creative and iterative, through the processes of conducting additional detailed research (e.g., literature reviews and case studies) of promising adaptation strategies and presenting preliminary results for community feedback.

The synthesis phase was conducted using a combination of individual and group synthesis methods. The individual synthesis method was used in the Cedar Key-Rosewood studio, where each student independently created initial recommendations for his or her study area in poster format. These recommendations were then transmitted to the larger project team for vetting and discussion. For the Yankeetown-Inglis synthesis, the project team initially conducted the synthesis phase as a group, with some follow-up on specific issues or places by individual team members.

The resulting project recommendations applied to different scales, from site to neighborhood to community to county, and related to land use, infrastructure, and water planning and management, as well as approaches for continued planning and decision making processes, economic development and fiscal responsibility, intergovernmental coordination, and additional research. The project team aimed to produce recommendations that were specific, well developed, and realistic for the county and communities to implement, but also acknowledging that the actual path forward will depend on leadership, new information, evolving communities, constraints, and opportunities.

Visitor to the project booth at the Cedar Key seafood festival

Implementation Support

The project's recommendations are advisory and not binding. The project team hopes, however, that local leaders will use the information and consider implementing the recommendations in some form. Towards this end, this report's recommendations sections discuss aspects of implementation, including further study, planning, entrepreneurship, and community development.

The project timeframe was extended six months (at no additional cost) to enable greater attention towards transfer of the project's findings to the county and community stakeholders, as well as statewide agencies, other university researchers, and professionals. The Principal Investigator, Kathryn Frank, and other members of the project team were available during this time to present to the local government commissions, follow up with the report and answer questions on a one-on-one basis, and attend related community meetings, such as Cedar Key's public workshop concerning a new water treatment plant (in May 2014).

Furthermore, the relationships formed between the county/communities and the University of Florida's faculty in the College of Design, Construction and Planning, will continue beyond the project, because both groups have an interest in partnering on future projects to address the issues of sea level rise and coastal change. Most significantly: Florida Sea Grant is funding a research project led by Kathryn Frank and other members of the project team to take Cedar Key-Rosewood to the next level of sea level rise adaptation planning, by identifying and integrating designs for adaptation strategies from four sub-fields of planning: social-cultural, hazards, built environment, and natural environment. This project will occur from May 2014 to September 2015.

The UF School of Landscape Architecture and Planning is currently partnering with Levy County to apply for a grant to assist the County in updating its comprehensive plan (the Evaluation and Appraisal Report), and this effort would incorporate the Planning for Coastal Change in Levy County project's findings.


NEPTUNESPRIDE

Findings and Recommendations

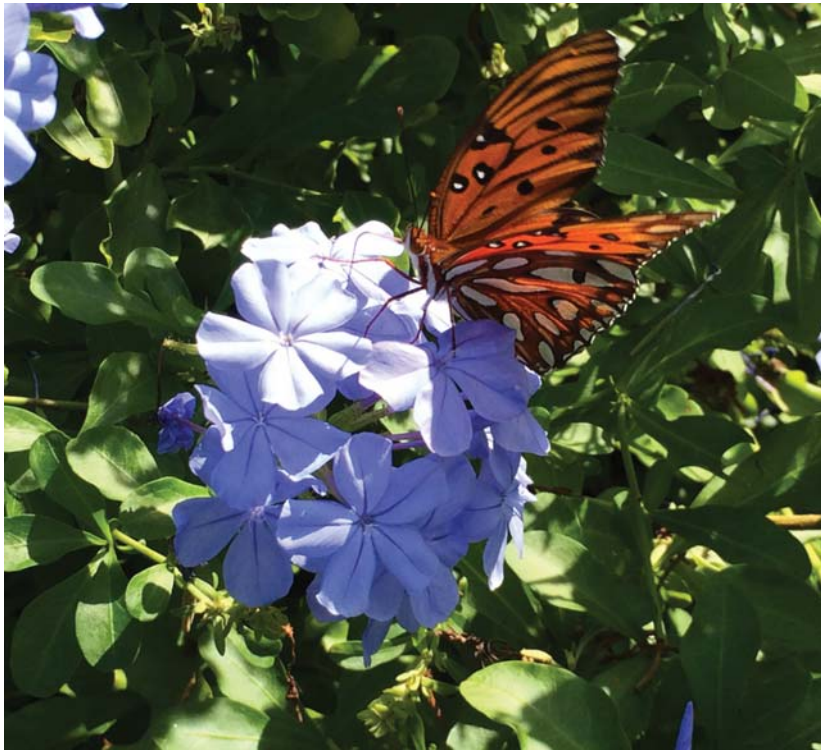
Findings and recommendations are presented at the county scale, for Levy County, and at the community scale, for the Cedar Key-Rosewood and Yankeetown-Inglis areas. For each place, the findings include an overview of the place, its vulnerability to sea level rise, community input, and recommendations for adaptation.

Levy County

This section examines the potential impacts of sea level rise across the county. There is particular focus on the unincorporated areas, some of which are developed, and most of which are in public ownership for conservation.

Overview of Levy County

Levy County (see Figure 8) is rural, with about 40,000 people living in the county's 1,412 square miles (U.S. Census). Its growth rate is moderate, with a projection of 57,000 residents by 2040 based on the past population growth trends (Florida Bureau of Economic and Business Research (BEBR)). The county's largest cities are Williston and Chiefland, with populations of about 2,700 and 2,200 people, respectively. The county seat, Bronson, has close to 1,100 people. The coastal municipalities of Cedar Key, Yankeetown, and Inglis have a combined population of 2,500 (700, 500, and 1,300, respectively). Unincorporated areas potentially vulnerable to storm surge or other coastal changes include Sumner and Rosewood near Cedar Key, Fowler's Bluff along the Lower Suwannee River, and Gulf Hammock at the headwaters of the Waccasassa River. The population in these unincorporated areas is relatively low with a total around 2,000 people. These communities are culturally and historically significant.



Findings and Recommendations: Levy County

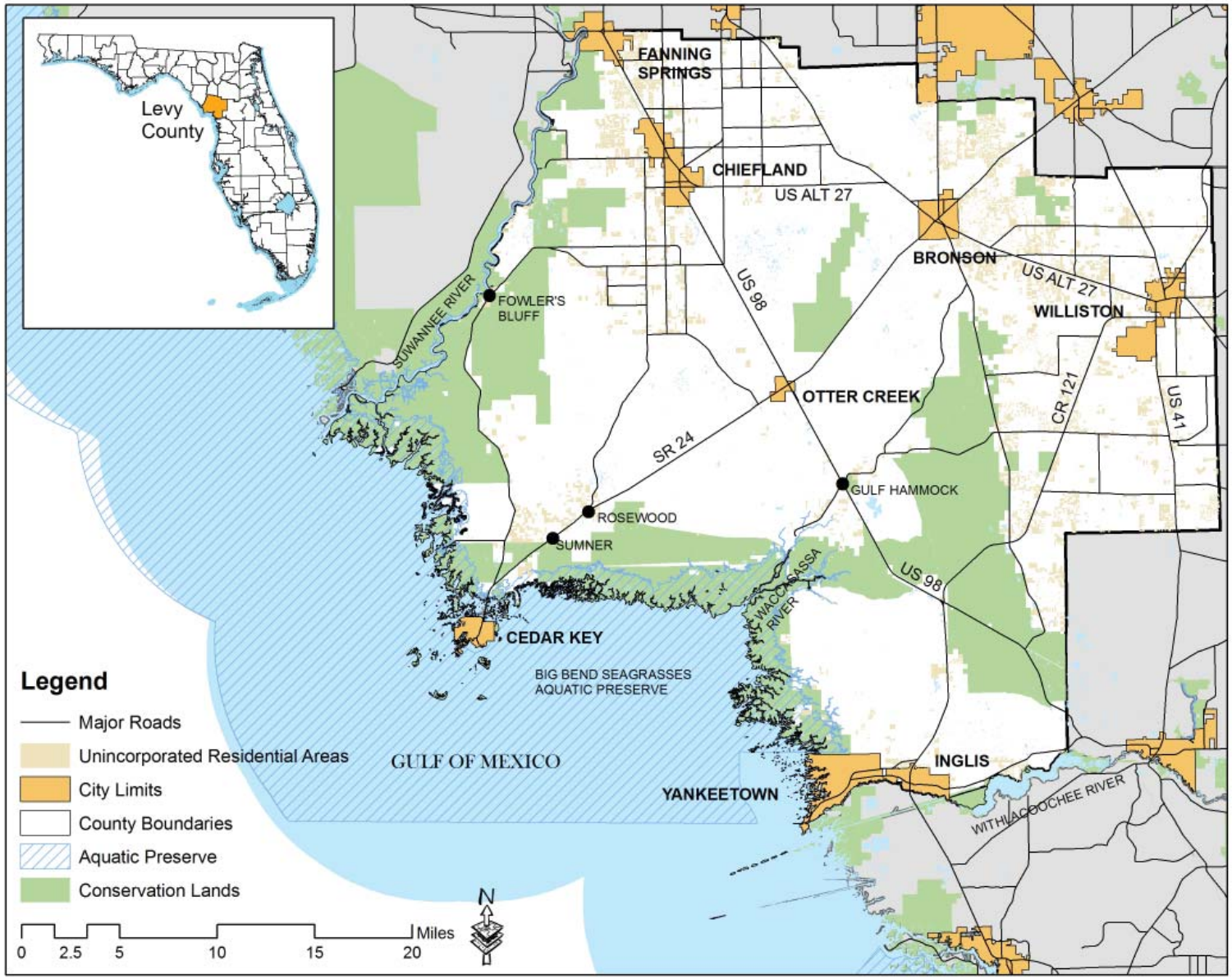


Figure 8: Levy County cities, unincorporated communities, major roads, and conservation lands

The county's economy is characteristically rural, with crops, livestock, forestry, and fisheries each being important industries, and to a lesser extent, manufacturing, construction, and recreation/tourism. Levy County is part of an economic development region known as "Florida's Nature Coast," which is an alternative name for the Big Bend region, to promote the nature- and culture-based economy. The county is connected to the larger region by two U.S. highways, 19/98, which passes through Inglis, and 27, which serves Williston and Chiefland. State Route 24 provides access to Cedar Key-Rosewood. A single rail line, CSX, runs through Williston on the eastern edge of the county.

The county contains about 81 miles of coastal areas along the Gulf of Mexico, in addition to riverine coastline. The rural character of Levy County's coastline is largely due to the gradually sloping landscape dominated by small islands, extensive saltmarsh, freshwater marsh, and wet forests, as is characteristic of the Big Bend region, thus making it unsuitable for significant urban development (see Figure 9). Three major rivers flow through the county: the Suwannee River, the Waccasassa River, and the Withlacoochee River (see Figure 10). The rivers' flows along with substantial "sheet flow" across the flat landscape and freshwater discharge from the surficial Floridan aquifer create an estuary along the county's coast that supports oyster reefs. According to the statewide Critical Lands and Waters Identification Project (CLIP), the coastal lands in Levy County have a high conservation priority based on their biodiversity, ecological features, and quality surface water and groundwater resources (see Figure 11).

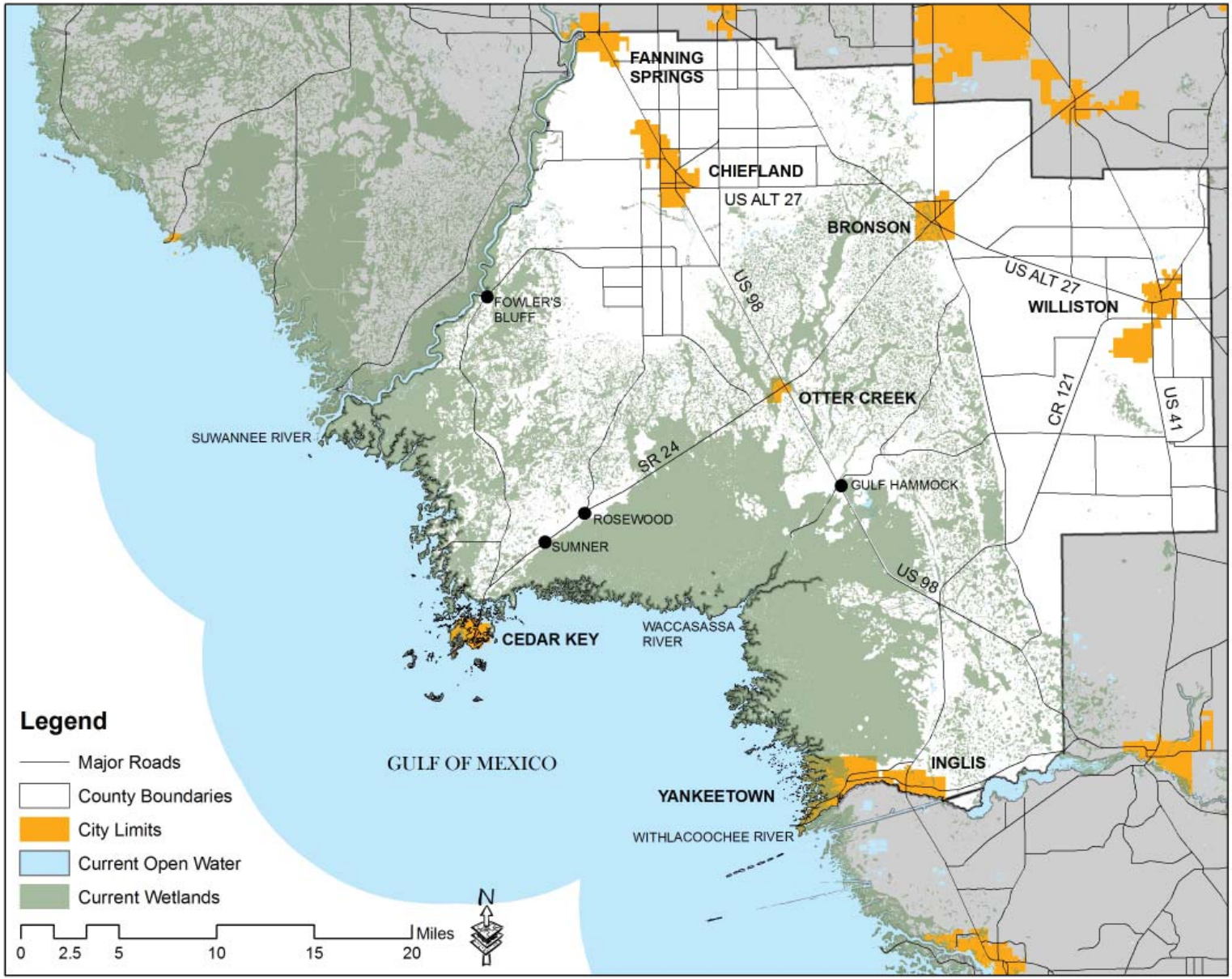


Figure 9: Levy County wetlands

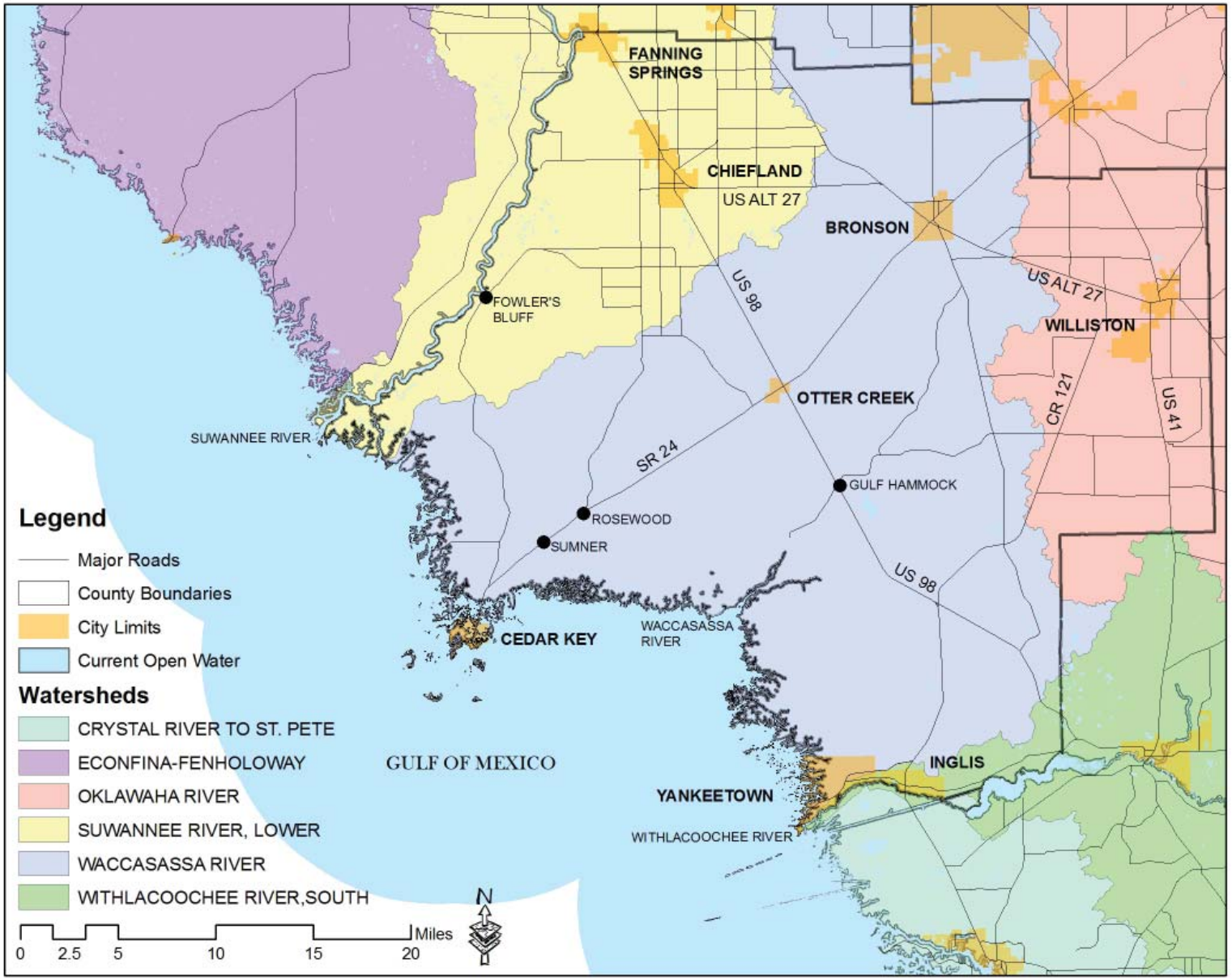


Figure 10: Levy County rivers and watersheds

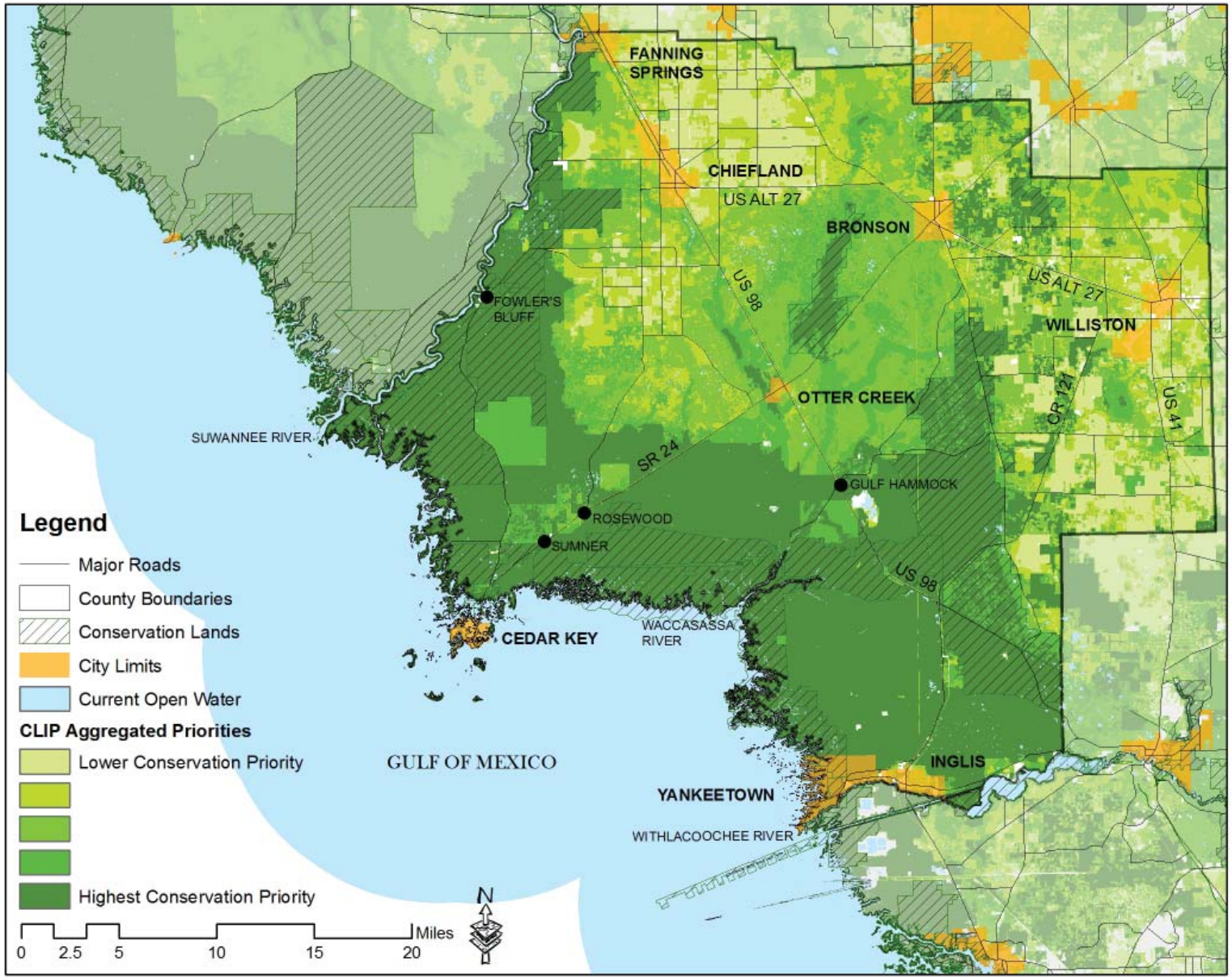


Figure 11: Levy County conservation priorities identified by the Critical Lands and Waters Identification Project (CLIP)

Levy County Coast

Much of the Levy County coastal lands and near-shore waters are in public ownership for environmental conservation (see Figure 8), natural resource management, and outdoor recreation, such as sport fishing and boating. The regional Big Bend Seagrasses Aquatic Preserve covers the ecologically productive waters adjacent to most of the county's shoreline to about 10 miles out into the Gulf. The Lower Suwannee National Wildlife Refuge protects the river's undeveloped delta and a large Native American shell mound. The Cedar Keys National Wildlife Refuge consists of 13 small islands, including Seahorse Key, which are important to a wide range of migratory and shore birds. The Cedar Key Scrub State Reserve provides habitat for protected species such as the gopher tortoise and Florida scrub jay. The Waccasassa Bay Preserve State Park contains a significant remnant of the "Gulf hammock" ecosystem.

Over the past 150 years, Levy County's economy has seen many changes that have tested the resilience of the coastal communities. Cedar Key and Inglis were important port towns since the mid-1800s and early 1900s. The original sites of Atsena Otie and Chambers Island, respectively, were later abandoned as the towns moved to less hazard-prone areas, since major storms have taken their toll on the county. The economy has shifted as natural resources were depleted, and twenty years ago in 1994, a statewide gill net ban effectively ended commercial fishing in the county, although crab, oyster, and shrimp harvesting have continued. In the Cedar Key area, the clam aquaculture industry took hold and has thrived. Just four years ago in 2010, the BP oil spill in the Gulf of Mexico led to concerns about seafood safety and negatively affected the local economy over the short term. Coastal areas in the county also face plans for large-scale projects, including a 3,900-acre lime rock mine and a new nuclear power plant, both near Inglis, although the latter is on hold indefinitely. Boosters' visions of a "Port Citrus" along the remains of the Cross Florida Barge Canal in Citrus County to the south, or residential development moving north from Crystal River, may eventually bring population growth to southwestern Levy County, but this is not imminent.

This overview indicates that the Levy County coast has important communities, infrastructure, resources (natural, archaeological, historic, and cultural), and economic sectors, as well as proposals for major development projects. Management and decision making for these assets need spatially explicit information about sea level rise and other anticipated coastal changes.

Coastal view from shell mounds

Vulnerability to Sea Level Rise

A comprehensive understanding of the county's elevation, ecology, storm surge, and geology/hydrology can give a sense of which areas are more and less vulnerable, and how the impacts may proceed over time as sea level rises and other coastal changes occur. The various aspects, as well as a combination of analytic methods, yield different insights into vulnerability.

Vulnerability Based on Elevation

Levy County's gradually sloping terrain is shown in Figure 13. The Suwannee River delta and the Waccasassa Bay are especially low lying (darkest green in the figure), and these places are where future changes due to sea level rise will be the most immediate and rapid, followed by the areas with slightly higher elevation (medium to lighter shades of green). The coastal landscape has the most rapid elevation gain to the east of Inglis, thus providing a location relatively close to the coast that has less exposure to sea level rise and other coastal hazards. This area, for example, is where the new nuclear power plant was sited (but is now on hold).

Levy County's coastal plain has nearly 70,000 acres below three feet in elevation; Figure 13 shows these lands relative to the conservation area boundaries. A chart of the number of acres below a given elevation versus elevation (see Figure 12), indicates that initial amounts of sea level rise, between one-and-a-half feet and three feet, will lead to the most rapid increases in affected acres of land in the foreseeable future. To interpret the graph the impacts should be "tidally adjusted." For example, a scenario of a three-feet rise in the average sea level plus a high tide two feet above the average level means all lands less than five feet elevation (all green and yellow lands in Figure 13) would be regularly flooded with tides. In Levy County, there are about 97,000 acres below five feet elevation. These sea level rise scenarios are possible within the 21st century.

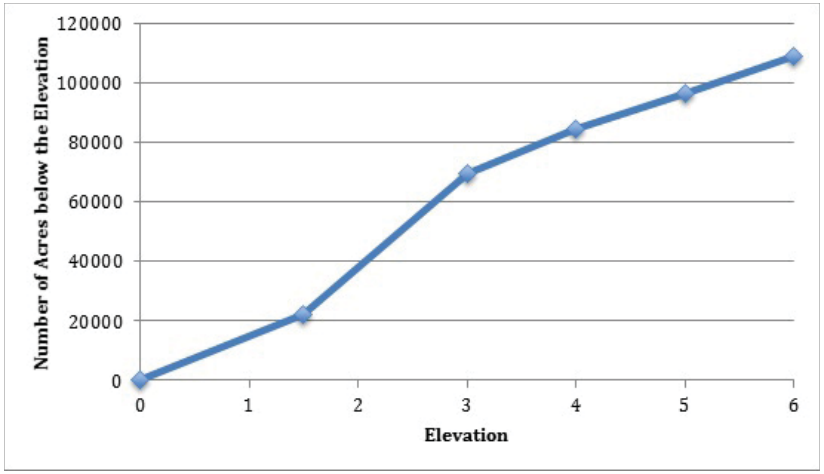


Figure 12: Levy County low lying areas

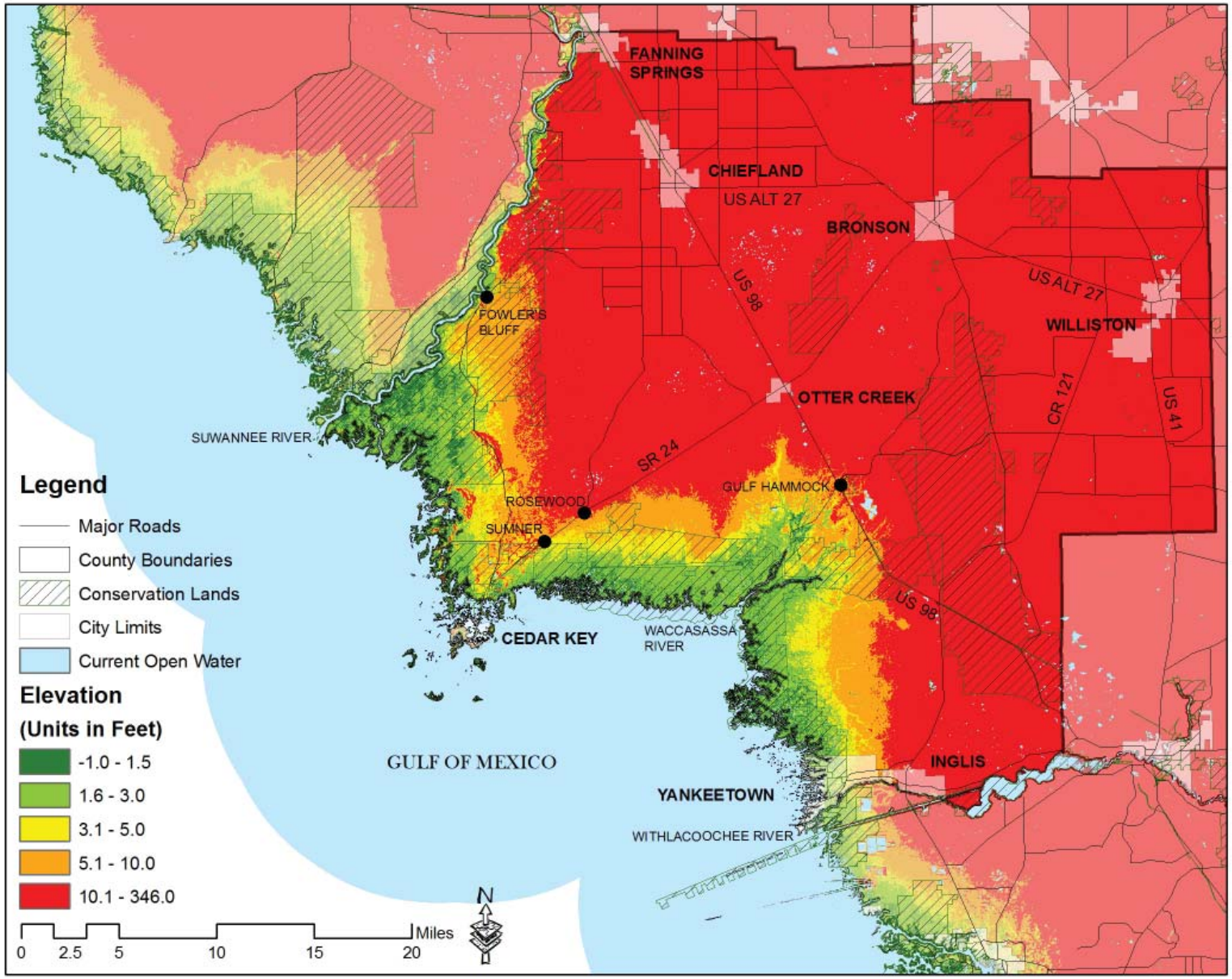


Figure 13: Levy County elevation

Vulnerability Based on Ecological Modeling (SLAMM)

The increases in coastal flooding and higher salinity levels associated with sea level rise causes changes in the natural landscape. Areas of salt marsh may become open water, and forests may die and be replaced by salt marshes. These changes give the appearance of the salt marshes "migrating" and the forests "retreating" (see Figure 14). The changes have been observed in the recent past and are expected to continue into the future at an accelerating rate (see Figure 5).

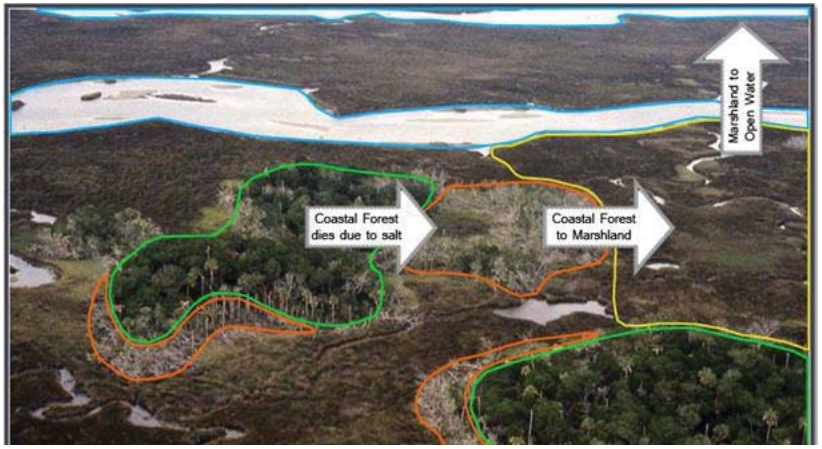


Figure 14: Coastal forest transitioning to marsh in Waccasassa Bay

Previous studies modeled future landscape in the Lower Suwannee National Wildlife Refuge and the Waccasassa Bay State Preserve using the Sea Level Affecting Marshes Model (SLAMM) (Warren Pinnacle Consulting, 2011a, and Freeman and Geselbracht, 2011). Together, these studies cover the entire Levy County coast. Figures 15 & 16 show the SLAMM results comparing current habitats and land uses to those predicted to occur with a three-feet sea level rise by the year 2100. The sea level rise and year together represent the rate of change. If sea level rise occurs faster, the marshes may not be able to keep up through soil formation (accretion) and the result will be open water.

The differing inland topography combined with existing land uses at higher elevations that prohibit migration of natural habitats, such as development and timber production, create the potential for significant losses of certain types of ecosystems, which in turn significantly affects the ecosystem services provided by these natural lands, such as wildlife habitat and value for recreation. The most immediate changes will occur in public conservation lands, thus having implications for their management and possibly desirable reserve boundaries. The previous studies' reports discuss these changes and implications in greater detail, such as substantial losses of coastal forest habitats in the Lower Suwannee and Waccasassa Bay basins, and of tidal flats around Cedar Key and the Cedar Keys National Wildlife Refuge. A recent statewide review of sea level rise impacts to wildlife and habitats recommended the expansion of the regional "critical linkage" along almost the entire Big Bend (Noss et al., 2014). SLAMM changes predicted for developed areas (shown in black in Figures 15 & 16) or working lands (such as those in timber production) could affect these lands' ability to serve those purposes. Along the coast, Cedar Key and Yankeetown are the most affected developed areas, with the details covered in later sections.

In addition to sea level rise changes, coastal habitats and watersheds are stressed and transitioning due to other environmental changes, such as regional upland activities and droughts impacting freshwater surface and groundwater flows. These stresses can combine and accumulate to lead to major ecosystem changes, such as the recent ecological collapse of off-shore oyster reefs along the Levy County coast (Seavey et al., 2011).

Vulnerability Based on Flood Zones and Storm Surge

Much of Levy County is already vulnerable to flooding from rain events and storm surges. FEMA "V" and "A" flood zones in unincorporated areas contain 2,061 residential parcels, having a total value of $225 million, and infrastructure, including roads, water wells, septic systems, electrical lines, and other facilities (see Figure 17). Since 1994, almost $6 million in flood damage has occurred in Levy County (including in inland areas), with an additional $439 million in property damage and $15 million in crop damage occurring from tropical storms and hurricanes (FEMA, 2012a).

Sea level rise, combined with the loss of coastal forests and oyster reefs, will cause storm surge flooding to be higher and more frequent, and to reach some places not currently affected. This project did not model storm surges with sea level rise; however, the current storm surge map is evidence of the large extent of vulnerable areas and infrastructure, including highways that serve as storm evacuation routes and state corridors (see Figure 18). The map is also suggestive of possible new flood risks in Otter Creek and Inglis due to sea level rise impacts on storm surges.

Rising flood water (http://www.newscasterarchives.com/history/wp-content/uploads/2011/03/history-3-16a.jpg)

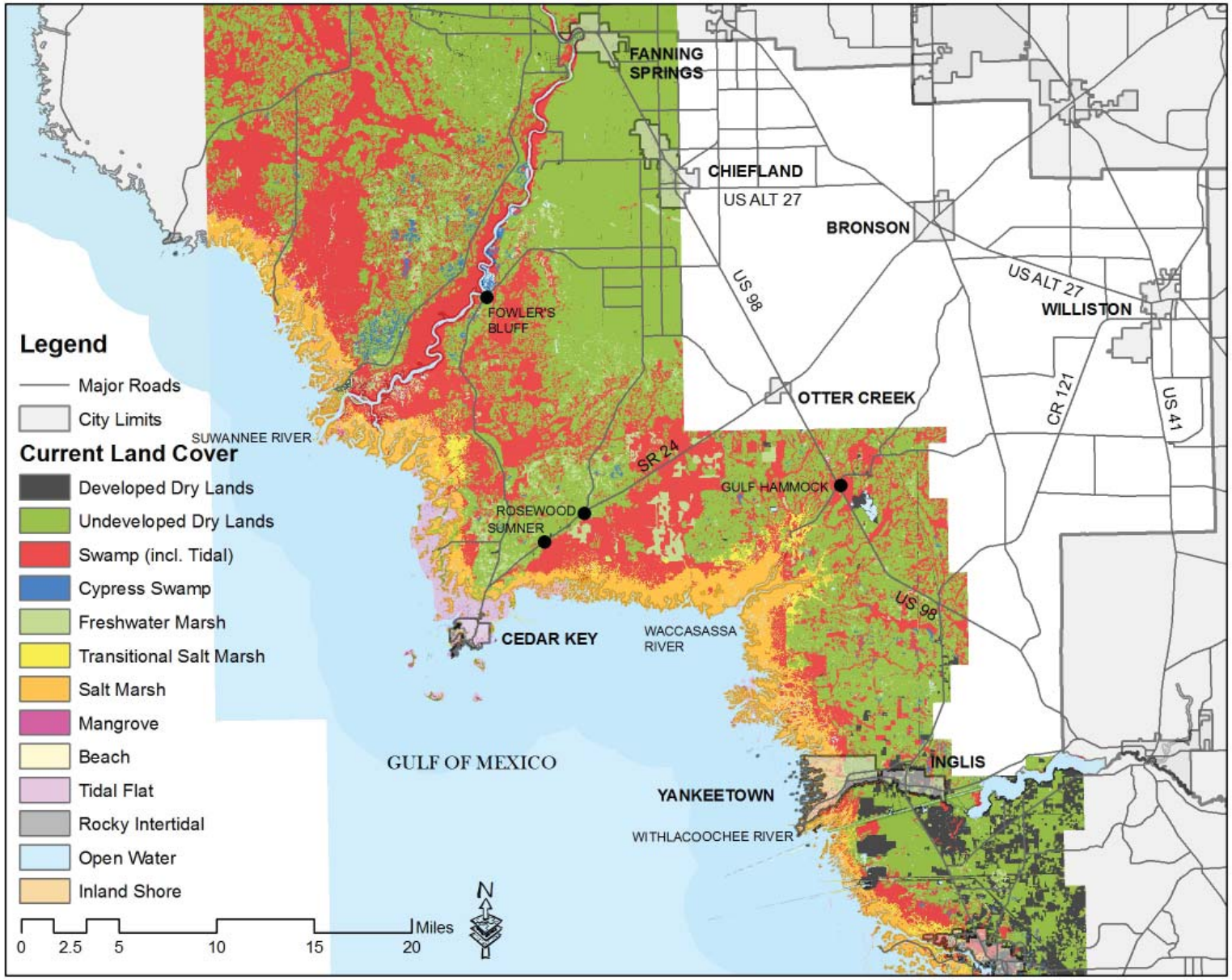


Figure 15: Current land cover in coastal areas of Levy County
(Warren Pinnacle Consulting, Inc. 2011a and Freeman, K. & Geselbracht, L. 2011)

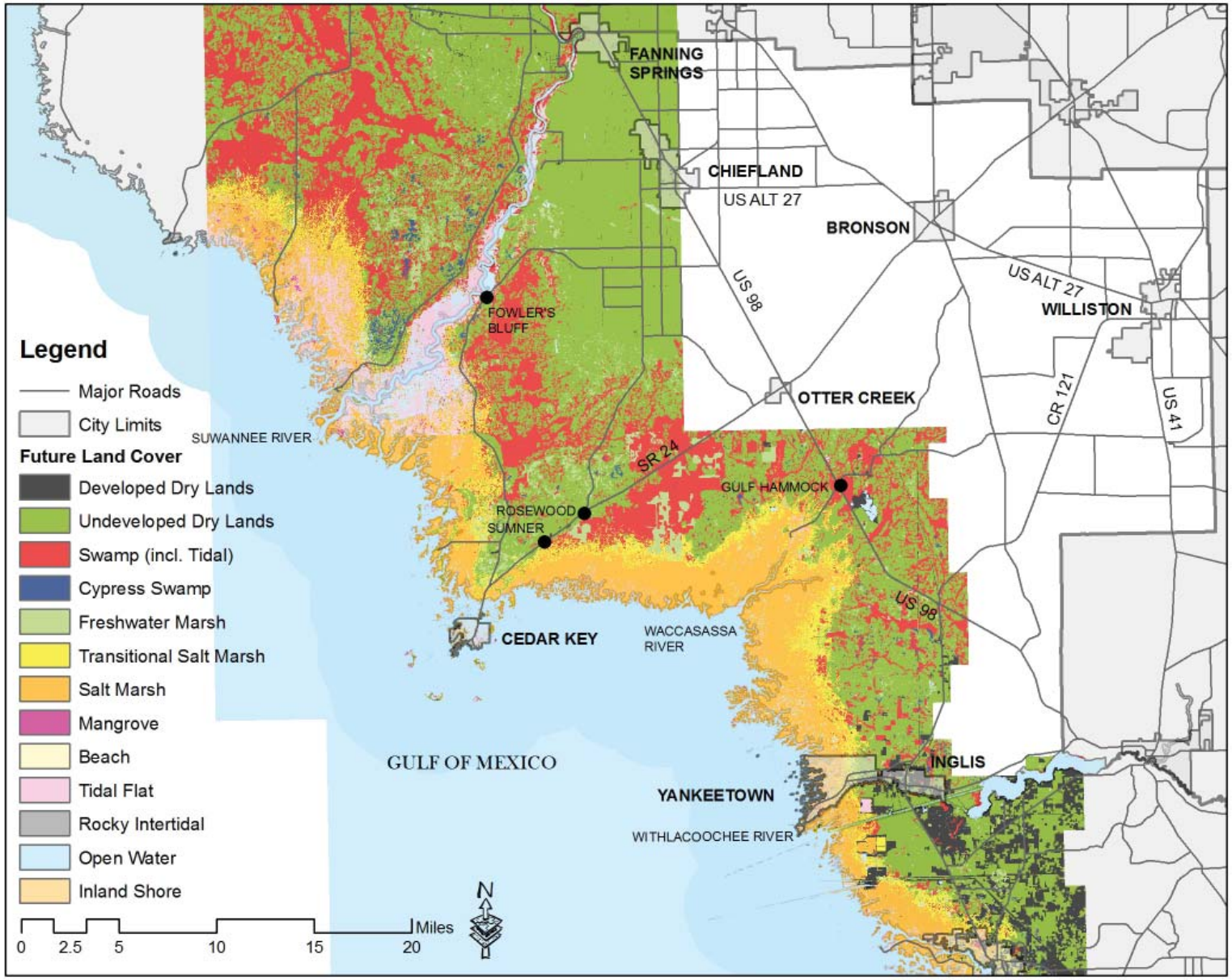


Figure 16: Projected land cover in coastal areas of Levy County with 3 feet of sea level rise by the year 2100 (Warren Pinnacle Consulting, Inc. 2011a and Freeman, K. & Geselbracht, L. 2011).

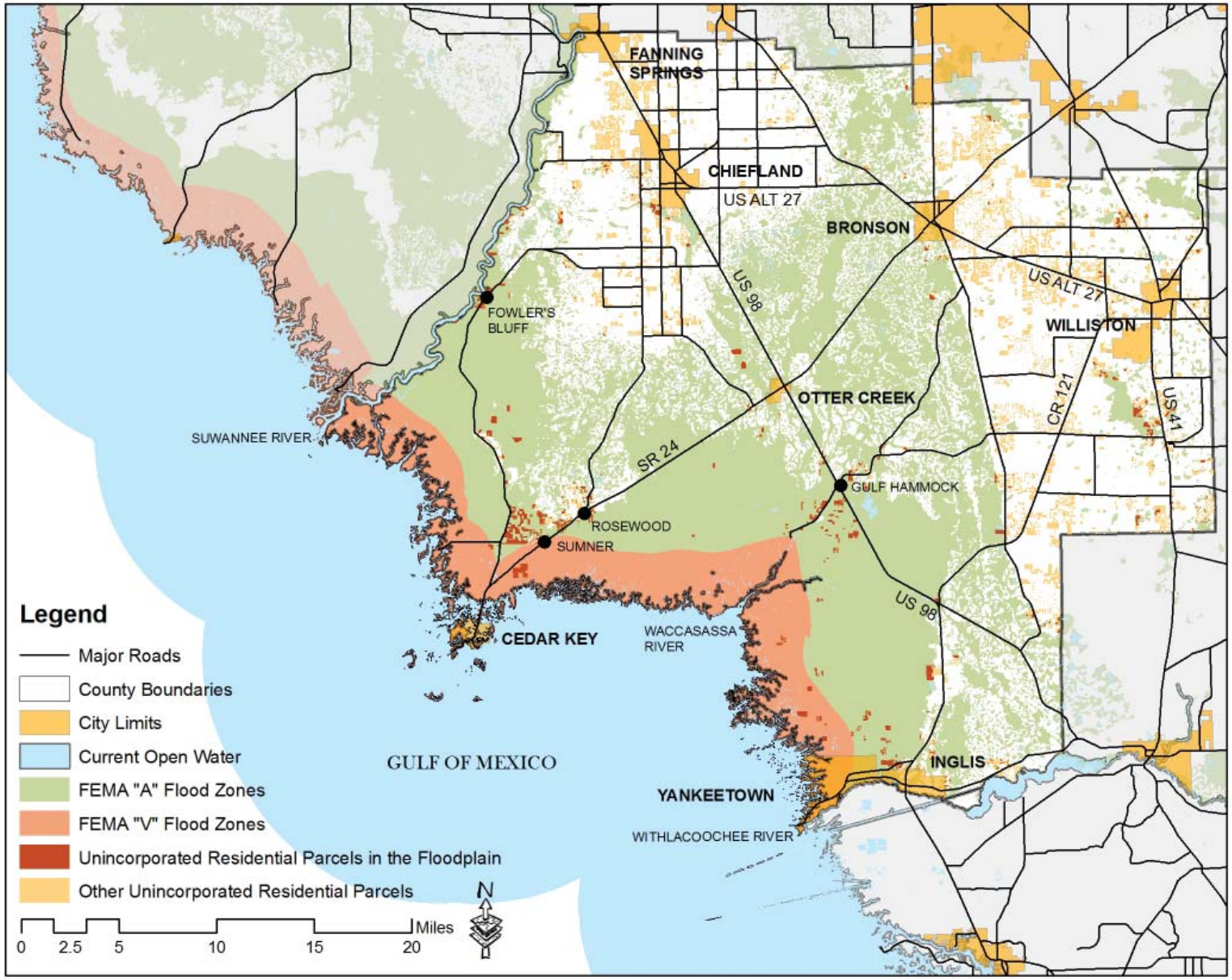


Figure 17: Levy County flood zones

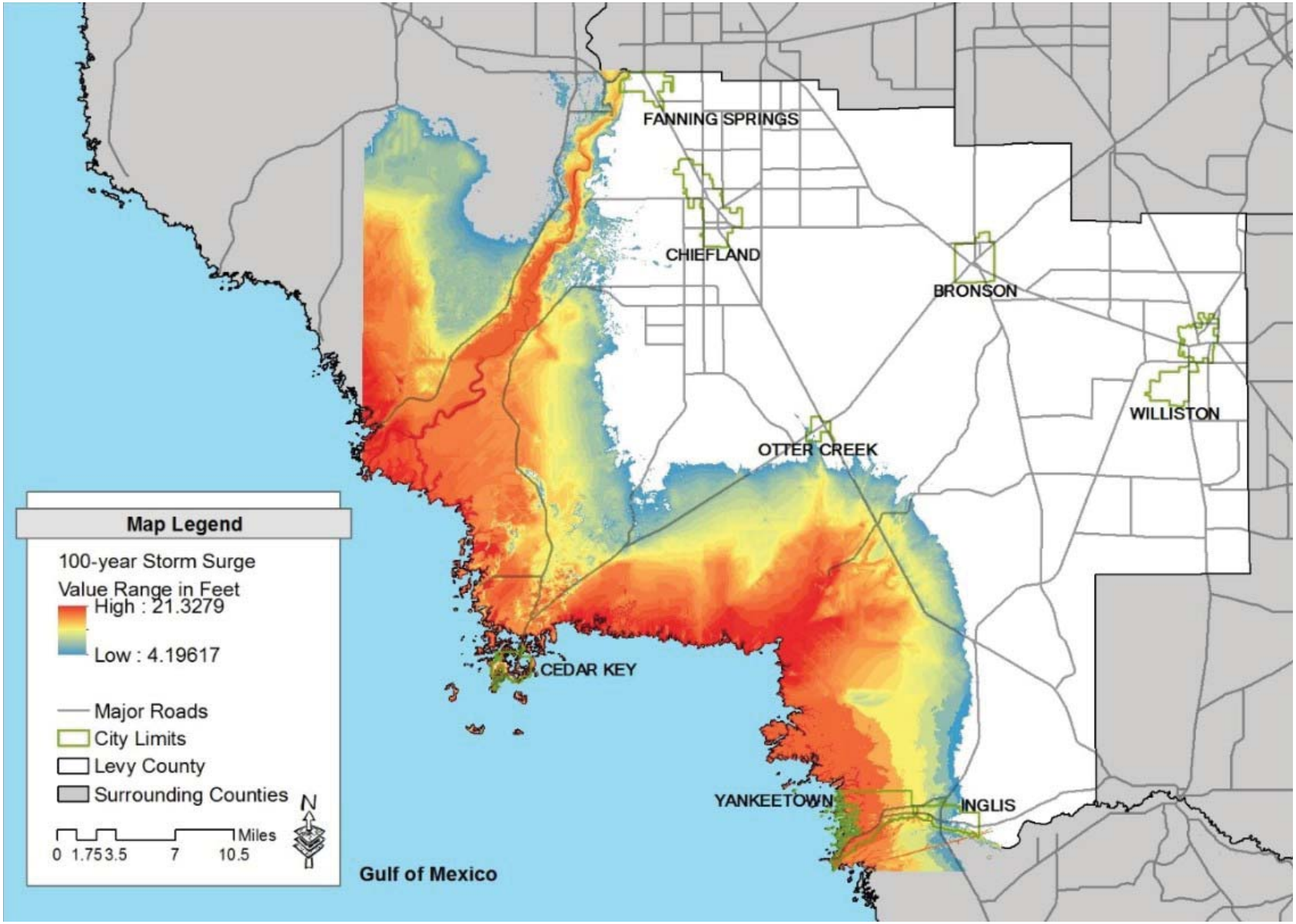


Figure 18: 100 year storm surge elevations

Vulnerability Based on Geology and Hydrology

The porous nature of the area's limestone foundation leads to several concerns. Saltwater intrusion into the freshwater aquifer impacts public water supply and domestic wells. Figure 19 shows the locations of current public wellfields within the county. Those near the coast, particularly the wellfields for Yankeetown, Cedar Key, and Inglis will likely be vulnerable to saltwater intrusion. Figure 20 shows aquifer recharge priorities within the county based on Critical Lands and Waters Identification Project (CLIP) analyses. This indicates that some of the most important areas for aquifer recharge lie near the coast between Fowler's Bluff, Rosewood, Gulf Hammock, and Inglis. Maintaining low intensity development uses and maximizing aquifer recharge in these areas will help combat issues of saltwater intrusion into freshwater supplies.

Additionally, sea level rise can push the surficial (unconfined) aquifer up through the ground to increase flooding. Figure 21 shows the average depth to water table. Areas with a shallower depth to water table are more vulnerable from flooding from this phenomenon.

Fiscal and Economic Vulnerability

Consideration of fiscal and economic impacts to communities resulting from sea level rise and other coastal changes must be an integral part of adaptation planning. Fiscal and economic impacts may result from a myriad of factors: the ecosystem's changing ability to support waterfront industries, such as fishing and tourism; storm property damage and repair costs; and changes to flood insurance and property values that affect the tax base. In particular, the federal government has been adjusting the National Flood Insurance Program, including through the Biggert-Waters Flood Insurance Reform Act of 2012, and a repeal and modification of certain provisions of this act by the Homeowner Flood Insurance Affordability Act of 2014. Property insurance reform efforts will likely continue at the federal and state levels due to increasing risks from sea level rise and climate change, greater asset exposure as coastal properties continue to develop, and mounting debt of the agencies (such as FEMA) due to large disasters (such as hurricanes Sandy and Katrina).

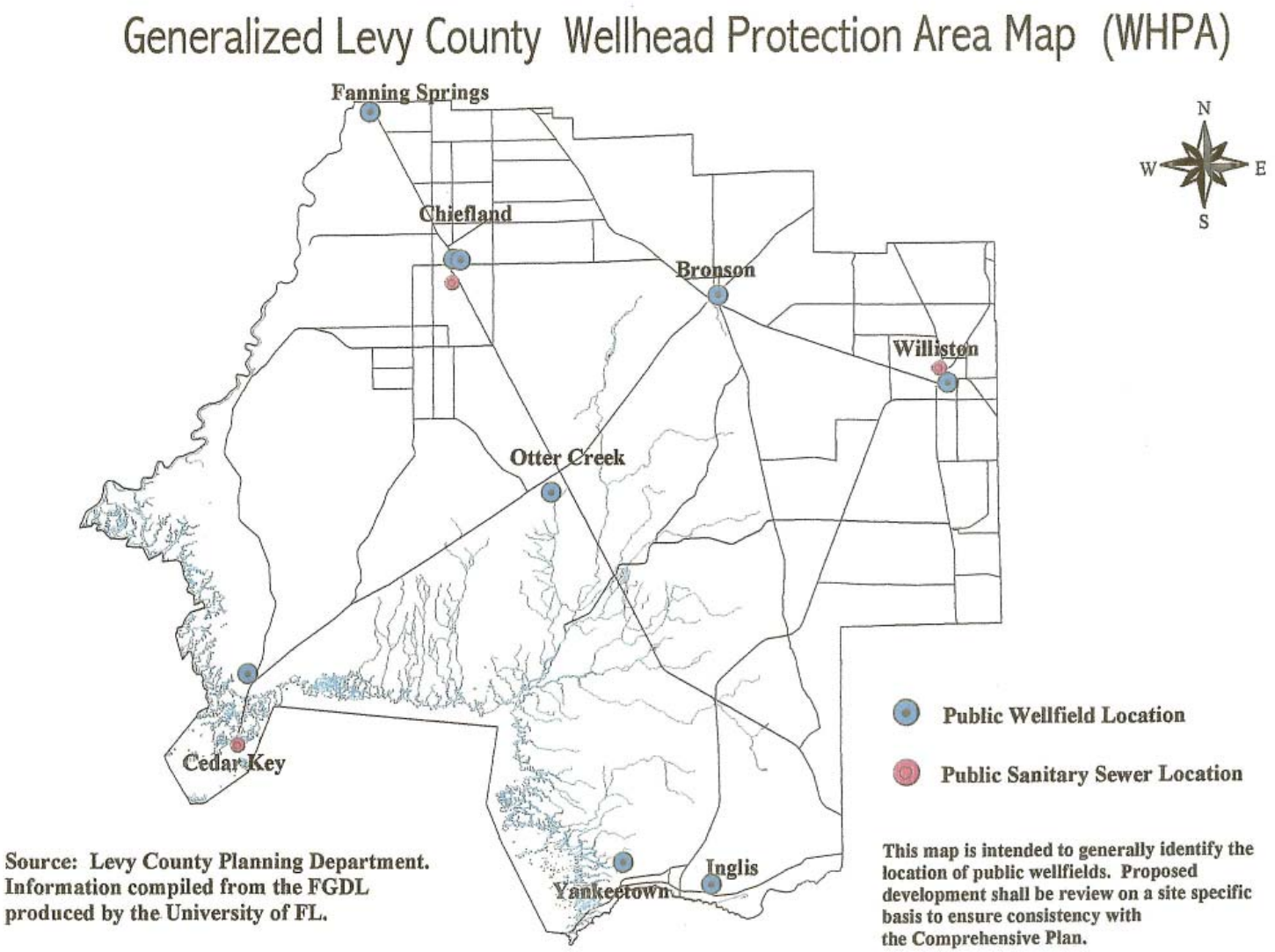


Figure 19: Levy County wellhead protection (http://www.levycounty.org/Planning/map-wellhead.jpg)

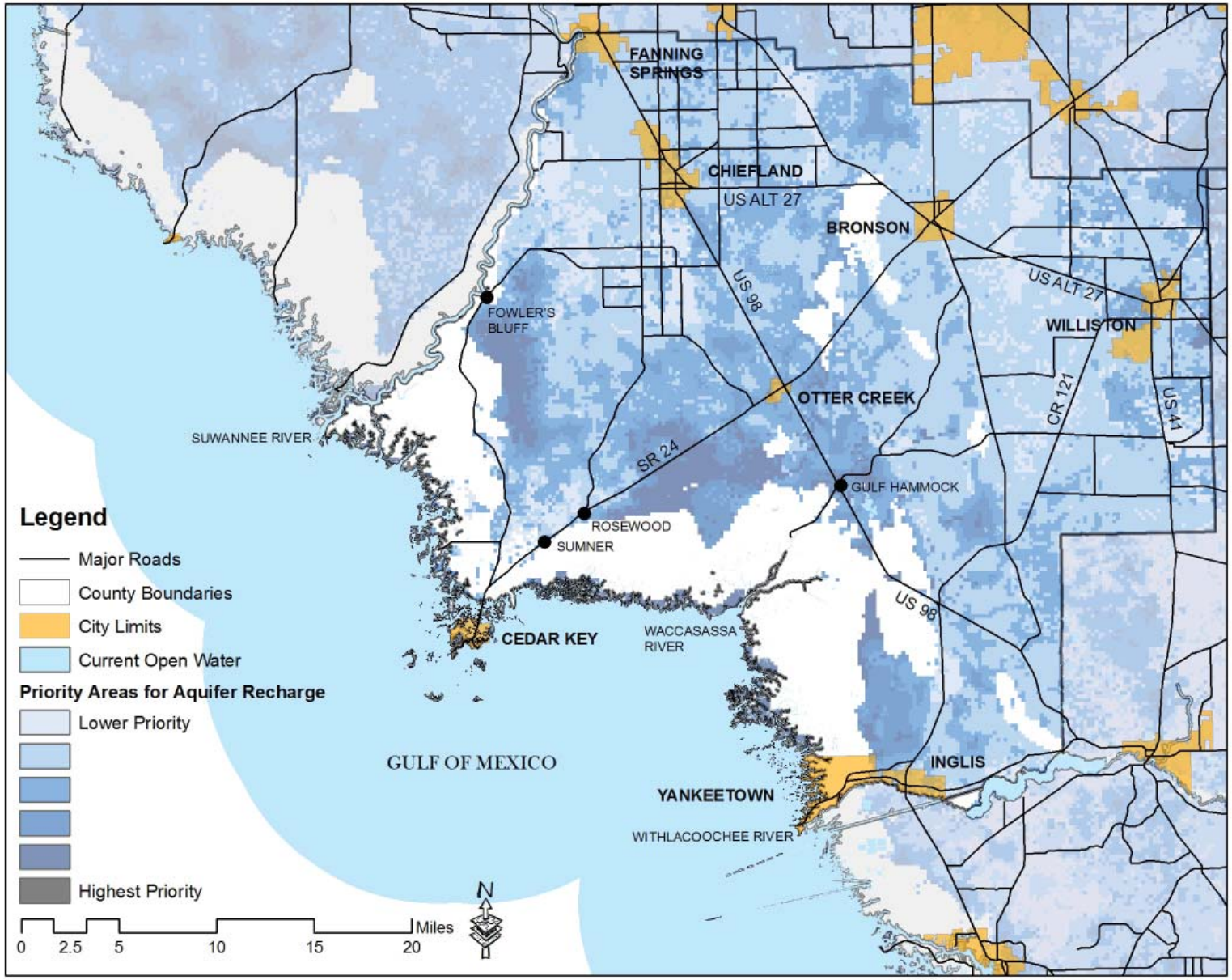


Figure 20: Levy County aquifer recharge priorities as identified by the Critical Lands and Waters Identification Project (CLIP)

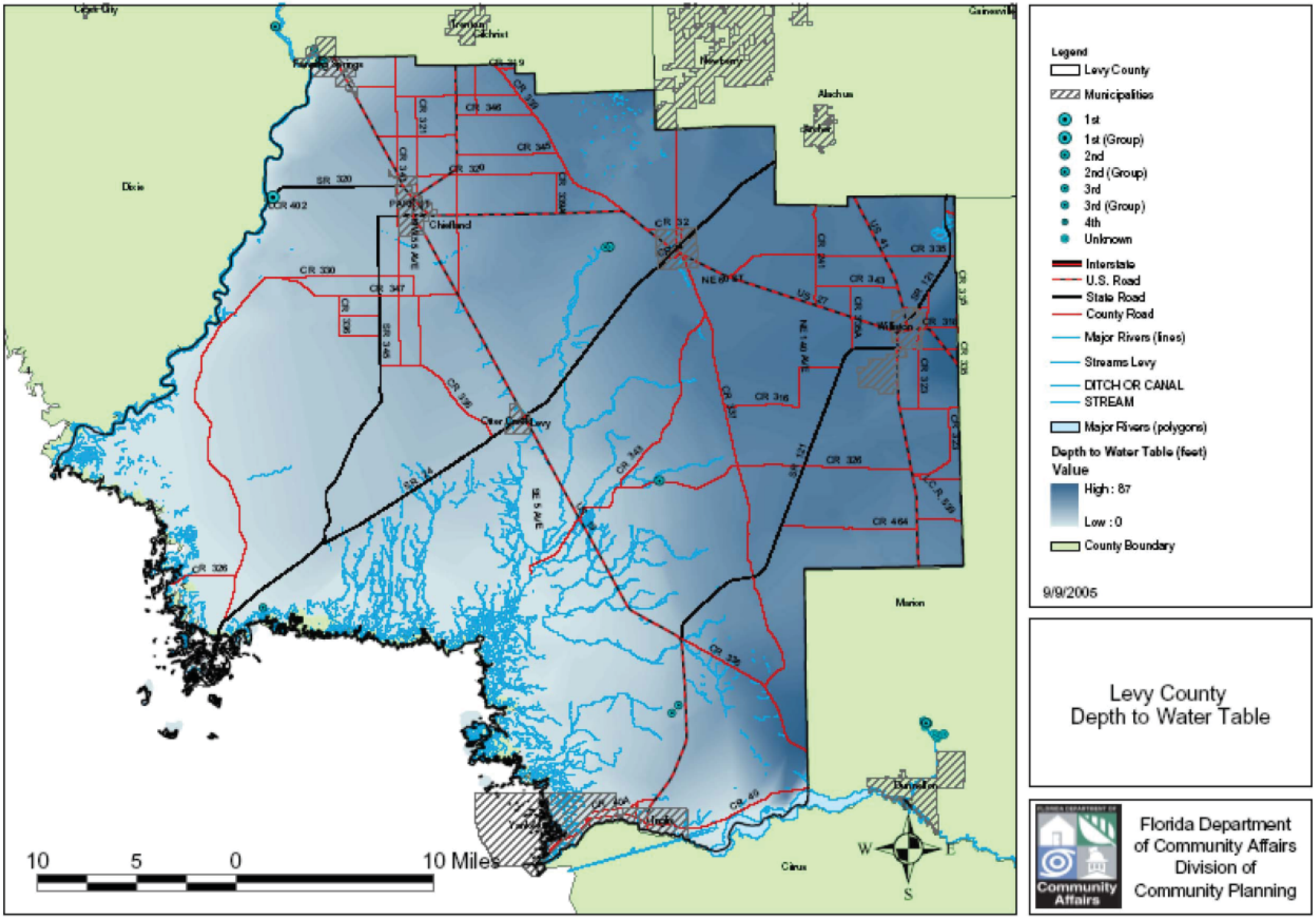


Figure 21: Levy County average depth to water table (Levy County, 2005) (Circles in map represent springs.)

Community Input

The foundation for adaptation planning should be at the citizen level with guidance from local leaders and professionals. Community input across Levy County is summarized here, contributing information about observed coastal changes, community values, and local capacity for adaptation planning, including beliefs about sea level rise and climate change. In discussions of currently occurring coastal changes, several themes resonated with local residents.

The first theme, mentioned by long-time coastal residents, was the inherent dynamics of the coast and community resilience. These residents described islands that had disappeared, even without a storm event, the movement of sediments and channels, and vegetation transformations such as the establishment and die-offs of mangroves. Community resilience was demonstrated in the face of internal and external changes, such as exhaustion of resources, hurricanes, the gill net ban, and the BP oil spill, as a result of dedicated local leaders and residents with a strong sense of place and community.

The second theme was the values of small town and rural character, and community identities. Residents expressed being torn between wanting to remain in the communities and maintain what they appreciate about their places, while also being cognizant of the need for hazard mitigation and adaptation. For example, several residents were concerned about raising houses up on stilts, because it would change community character and would pose a mobility challenge to older persons.

The third theme was water. Coastal residents had observed saltwater intrusion of domestic water wells, the City of Cedar Key had a significant intrusion event during Summer 2012, and there were reports of salinity increases in the Withlacoochee River, as indicated by the growth of barnacles. Water quality of the near shore waters was also a concern, since many coastal residents make their living through aquaculture, fishing, and ecotourism. Issues included maintenance of freshwater flows, and potential release of pollutants from underground sources (septic systems) and land disturbance from development and timber production.

The fourth theme was the protection of natural resources in general. In this regard, participants were concerned with nature and wildlife for its own sake, as well as its importance for residents' quality of life, recreation and hunting, and the local economy and property values.

Across the county, communities were open to discussing the topic of sea level rise; however, some commissioners and citizens doubted the scenarios of future sea level rise and its contribution to historical changes. The issue of climate change, which came up in relation to the future sea level rise scenarios, was also questioned, with some wanting to know more about the scientific basis of the claims. Other commissioners and citizens, however, accepted sea level rise and climate change as a reality, be-

cause they had experienced coastal changes first-hand or trusted the scientific reports. These persons desired more locally specific, detailed information and research about the environmental systems and changes, and the potential social and economic impacts.

Waccasassa River

Adaptive Capacity

The term "adaptive capacity" represents the myriad local resources that communities and jurisdictions can apply to adapt to externally imposed changes such as sea level rise. Adaptive capacity also takes into account local barriers to adaptation. By understanding Levy County's current resources in physical, legal, civic, political, technical, and financial arenas, the project team and other leaders can establish realistic adaptation goals, identify adaptation strategies with a greater likelihood of success, lay out implementation steps, and target aspects of adaptive capacity that can be improved.

Physical Adaptive Capacity

The ability for both the natural and built environments to adapt to environmental changes, in this case sea level rise, is its physical adaptive capacity. The adaptive capacity of the natural environment relates to its quality, or ecological "health," and the availability of contiguous, suitable upland places for habitats and species to "migrate" without encountering built structures such as roads or buildings. In Levy County, physical adaptive capacity of the natural environment is favorable, since most of the coastal lands are under public ownership for conservation, the landscape is gradually sloping, and limited developments does not impede habitat migration. However, there are stresses on the natural environment, especially with regards to upstream watershed and aquifer changes.

The adaptive capacity of Levy County's built environment refers to the ability of unincorporated developed areas in the low-lying coastal areas to protect buildings and infrastructure against flooding, modify them to accommodate flooding, or relocate them to avoid flooding. Given the vast amount of land that is low-lying, the significant amount of water in the landscape, and the porous surficial aquifer, establishing effective barriers to flooding would be challenging. Modifying the built environment to accommodate increased flooding is more feasible, but it is expensive. Relocating buildings is also expensive, and with the low rates of population growth and capital investment, it is not an easy solution either. On the positive side, Levy County's unincorporated developed areas are at relatively higher elevations, and there are fewer highly vulnerable areas. The availability of higher, drier land near the coast, especially in Rosewood and unincorporated areas near Inglis, provides the opportunity for future coastal-dependent development to be located in places that are less vulnerable to future flooding taking into account sea level rise.

Legal, Civic, and Political Adaptive Capacities

To understand the current legal, civic, and political adaptive capacity of Levy County, the project team examined local policies, assessed leaders' and citizens' knowledge and opinions concerning sea level rise and adaptation, and identified key actors and organizations with the potential to lead adaptation.

Currently, Levy County has several plans pertaining to emergency management, coastal planning, and land use planning. Levy County has a Local Mitigation Strategy Plan as directed by the Federal Emergency Management Agency (FEMA). Levy County also participates in the national Community Rating System (CRS) that incentivizes jurisdictions to take extra measures to manage floodplains above the minimum requirements. Levy County's comprehensive plan includes a Coastal Element, Future Land Use Element, and Springs Protection Element. The Coastal Element includes specific objectives regarding hazard mitigation, hurricane, and post-disaster redevelopment plans. Levy County's policies dictate much of how growth is managed in areas that are subject to coastal issues such as flooding and saltwater intrusion. The comprehensive plan is maintained and administered by

the Levy County Planning Department, which performs regular questionnaires to identify inadequacies in the plan. Most Levy County communities provided positive answers when asked if local hazard mitigation plans were prepared in coordination with their comprehensive plans (FEMA, 2012b). A list of county-wide hazard mitigation projects and initiatives can be found under the Local Mitigation Strategy.

Levy County policies discourage incompatible future growth and limit development in Coastal High Hazard Areas (FEMA V Zones). Coastal setback guidelines and standards for construction near or on the shoreline are also in place. Additionally, there are policies for protecting environmentally sensitive land, including those in the Coastal High Hazard Areas. While the comprehensive plan does have a lot of the language associated with coastal hazards reduction and adaptation planning, it tends to be written in a general way. Amending the comprehensive plan to make its wording more specific would likely increase the county's potential adaptive capacity.

The Federal Emergency Management Agency (FEMA) is currently updating their digital Flood Insurance Rate Maps (FIRMs) for Levy County as part of their coastal flood risk discovery study of the Big Bend area. The updated FIRMs will use current sea levels but will not take into account future sea level rise projections. Instead, FEMA will issue information about sea level rise, including maps known as "Coastal Increased Inundation Areas," which graphically show base flood elevation plus sea level rise. Once prepared, the FIRMs report for Levy County will be found at the FEMA Map Service Center website. These studies and reports are an invaluable resource for the entire Big Bend area, and they greatly increase adaptive capacity of Levy County because of the knowledge that has been gathered and updated.

On the issue of civic capacity for sea level rise adaptation, county leaders, including the Levy County Board of County Commissioners and Levy County Planning Commission, were aware of the topics of sea level rise and coastal change, and their impacts on Levy County, as a result of this project. Both commissions' members were interested in receiving more information about the topics. The Planning Commission, in particular, identified local issues needing detailed scientific study, such as aquifer modeling. Some commissioners, as well as Levy County citizens, were skeptical of the explanation that sea level rise was causing the observed coastal changes and that human activities were causing climate change. Despite the difference of opinion compared to the premise of this project, these leaders and citizens demonstrated willingness to publicly discuss the issues. In addition, the Levy County planning staff has expressed interest in updating the county's comprehensive plan to address sea level rise and other coastal changes.

In addition to public officials and local government staffs, many interest groups are locally and regionally active and can advocate on behalf of awareness of coastal changes and adaptation to them. These groups include local chambers of commerce, local environmental groups (such as Friends of the Withlacoochee Gulf Preserve and

the Florida's Nature Coast Conservancy), and Extension offices. At the county level, the Redevelopment Task Force, made up of the Levy County building official, the Division of Environmental Health, and the Chairman of the Board of County Commissioners could be a major player in adaptation planning in unincorporated areas.

Technical and Financial Adaptive Capacities

Participants in public workshops generally agreed that small towns and rural areas should seek support from regional, state, and federal government agencies when addressing coastal change and sea level rise. These agencies, along with large public interest group organizations (such as The Nature Conservancy), can provide technical assistance and financial support, and they have already substantially contributed to the local scientific information, as documented in this report. However, the ability to make policies and direct projects based on this information is somewhat restricted due to limited funds and local staff. The greatest technical and financial capacities exist in the strong place-based, inter-organizational and civic networks that exist, and the leadership and entrepreneurship of individuals.

Fowler's Bluff along the Suwannee River

Recommendations for Adaptation

Levy County is highly vulnerable to sea level rise and other coastal changes, yet the county possesses strengths that have limited its vulnerability, such as the public acquisition of most of the coastline for environmental conservation, and opportunities for adaptation, including resilient coastal communities and strong regional and statewide leadership networks.

The Levy County government possesses several roles related to adaptation to sea level rise in the county: to create land use policies for unincorporated areas, to manage the countywide emergency response and hazards mitigation programs, and to promote intergovernmental coordination at the county, regional, and state scales. The federal and state public lands managers are also key decision makers for the Levy County coastal zone. These governments and agencies, along with other stakeholder groups and civic organizations, can lead a variety of initiatives related to advocacy, building local capacity, and planning for coastal change. The project's recommendations for adaptation to sea level rise and coastal change address these roles and also provide general planning principles.

Comprehensive Planning and Hazard Mitigation

Comprehensive planning for future sea level rise must address both coastal and upland zones, including guiding future development away from vulnerable areas and towards safer places. This process begins with a basic assessment of land uses and allowable densities in the county's Future Land Use and Zoning Maps. Figure 22 shows the current Future Land Use Map for the county with current FEMA V and A flood zones overlaid. This indicates that a significant portion of the county lies within a flood zone. Most of the future land use designations in current flood zones are "forestry/rural residential" or "natural preservation", with some areas of commercial, the Town of Otter Creek, and several rural unincorporated communities. Currently the vulnerable population within flood zones is not significant, and the future land uses projected within these areas are also generally low intensity. Given the fact that flood hazards will likely increase with sea level rise, it is important for the county to maintain these patterns. Additionally, the county may want to consider current unincorporated development clusters for designation as adaptation action areas, with consideration of vulnerability, current and future land use, and other spatial characteristics such as contiguity.

Land development codes and other related planning documents should be examined to determine the degree to which they encourage resilient development along the coastline, such as by accounting for rising base flood elevations. Current and future plans for both the construction of new development and traditional shoreline armoring measures, such as seawalls and bulkheads, should be assessed. Strong consideration should be given to adaptation methods that reduce the intensity of buildings, infrastructure, and land-modifying economic activi-

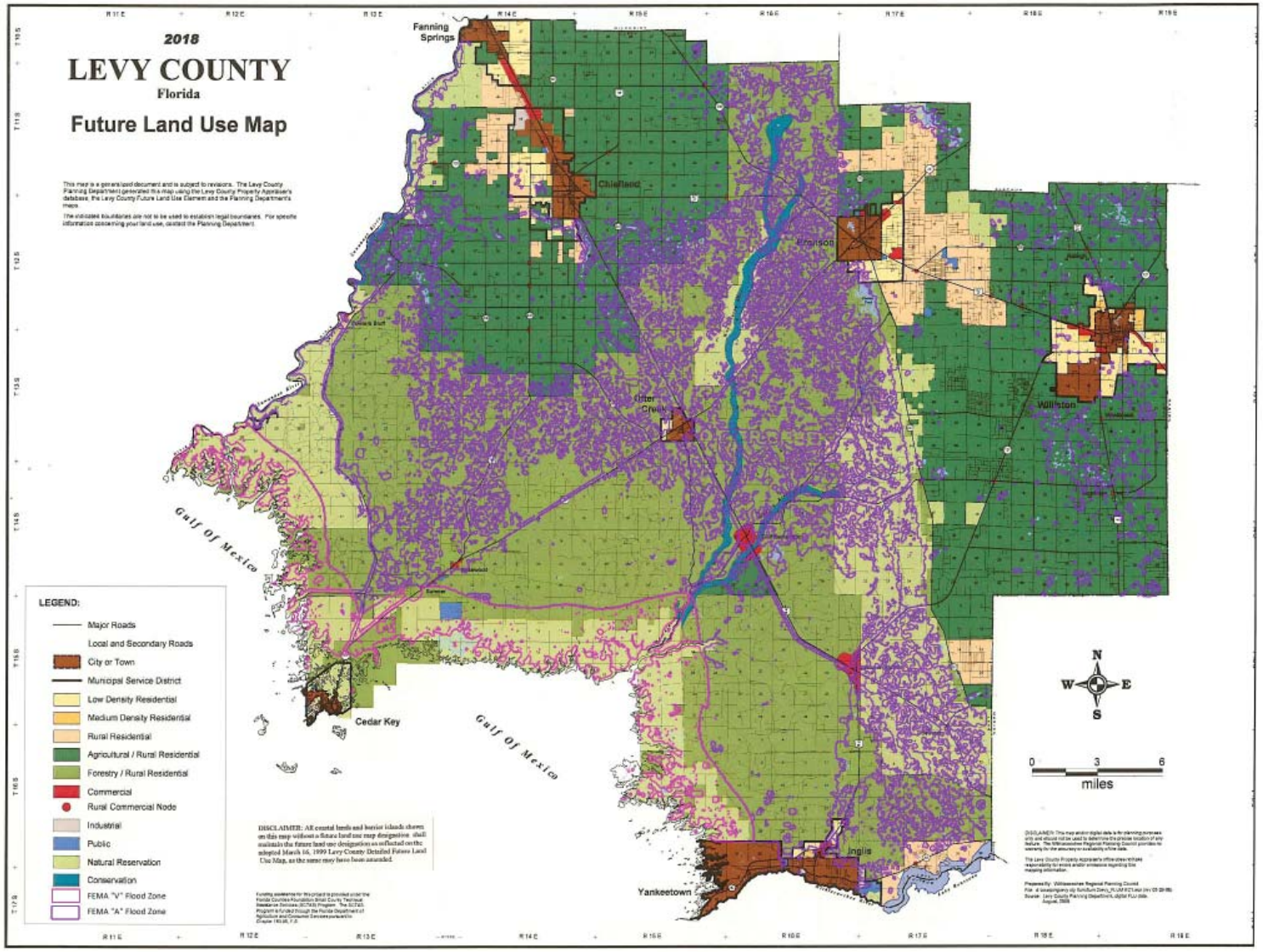


Figure 22: Future land use map for Levy County. Pink and purple lines added to illustrate potions of the county within existing flood zones. (http://www.levycounty.org/Planning/map-futurelanduse.jpg)

ties in coastal areas with the greatest risk, and that find compatible, low impact, and passive uses. Buildings and infrastructure sited in high-risk areas should be designed to accommodate frequent flooding and allow habitat and species migration, as well as natural freshwater flows.

Where coastal land has been protected by "hard" measures in the past, or accommodation strategies will not be sustainable into the future, limits can be imposed using setbacks, rolling easements, or laissez-faire market strategies. Each has its application under specific circumstances, but it is generally recognized that rolling easements can offer combined benefits. The U.S. Environmental Protection Agency (EPA) has a primer on the details and use of rolling easements as they might be applied to planning for sea level rise (see http://water.epa.gov/type/oceb/cre/upload/rollingeasementsprimer.pdf).

Adaptation planning should go hand-in-hand with upland redevelopment and revitalization in areas identified in comprehensive or special plans. Additional redevelopment, infill, and development incentives in upland areas can provide an attractive relocation area for coastal property owners, and a method for combating the loss of the tax base. Any potential tax surplus can be allocated toward additional adaptation and mitigation activities as needed.

Fine-scale analysis and policy examination for adaptation in unincorporated "rural clusters" deserves further consideration. This would include areas such as Sumner-Rosewood, Fowler's Bluff, Gulf Hammock, and unincorporated development north of Yankeetown-Inglis. For these types of locations, emphasis should be placed on maintaining rural character while applying rural- and coastal change-appropriate technologies and available funding. In addition, the county has several means for providing financial assistance to property owners impacted by coastal changes. These include:

Special Flood Hazard Areas (SFHA' s) assistance: The county and coastal municipalities have tools to help reduce impacts from higher flood insurance rates or unavailable insurance, including actions to improve their Community Rating System (CRS) rating (see http://www.fema.gov/national-flood-insurance-program-community-rating-system for more information) and applying for federal and state mitigation funds. Florida Department of Economic Opportunity has produced a document that lists potential funding sources for adaptation planning as well as physical hazard mitigation projects. This is available through the Florida Department of Economic Opportunity's Community Resiliency Office website at http://www.floridajobs.org/fdcp/dcp/AdaptationPlanning/AdaptationFundingOpportunities.pdf.

Relocation assistance: Local governments could provide assistance to homeowners to offset the costs of relocating from their current home in a hazard area into upland areas within the same jurisdiction. Assistance could be provided in at least two ways: 1) via grants that provide direct assistance for a down payment on new upland properties based on financial need, or 2) through incentives that would be provided to coastal property

owners that relocate to an upland parcel, such as property tax credits, tax reductions, or additional development rights. From the long-range planning perspective, relocation assistance, in either form, is potentially the most desirable option because it incentivizes relocation away from hazardous areas.

Hazard mitigation assistance: Local governments could also provide hazard mitigation assistance for existing or new homeowners within hazard areas who want to stay in place. This could take the form of direct need-based grants to pay for mitigation measures, such as structure elevation. These measures can help reduce the flood insurance rate on a property. Another option is ongoing tax reductions/credits for a limited number of years that either 1) help offset the cost of higher insurance rates, or 2) potentially makes the property more marketable and valuable by keeping tax reductions in place after the sale of the property.

Another issue for which the county has an important role is in ensuring the ability of coastal natural environments to adapt to sea level rise. The natural environments are an important driver of economic activity, including tourism, fishing, and aquaculture. The state and federal agencies and county government can do this by adding conservation areas to the reserve network, in order to allow wetlands, beaches, and wildlife to move naturally inland, and to protect upland forest habitats, such as coastal hydric hammock. Attention should also be given to maintaining natural water flows within the three watersheds of the county (Suwannee, Waccasassa, and Withlacoochee) and the Floridan aquifer. In this way, emphasis is placed on ecosystem health, integrity, and resiliency, which in turn preserve ecosystem services and the local economies. Expanded conservation areas would also support the statewide ecological greenways network (see Figure 23).

Maintaining freshwater quality and flows is also critical to reducing impacts to potable water supplies, such as saltwater intrusion. The county can incentivize or require low impact timber management, agricultural, and development strategies that provide for sustainable treatment of stormwater on developed sites and reduce off-site runoff and impacts. These include storing, treating and allowing stormwater to infiltrate on-site; reusing stormwater for irrigation and other uses; and implementing stormwater and

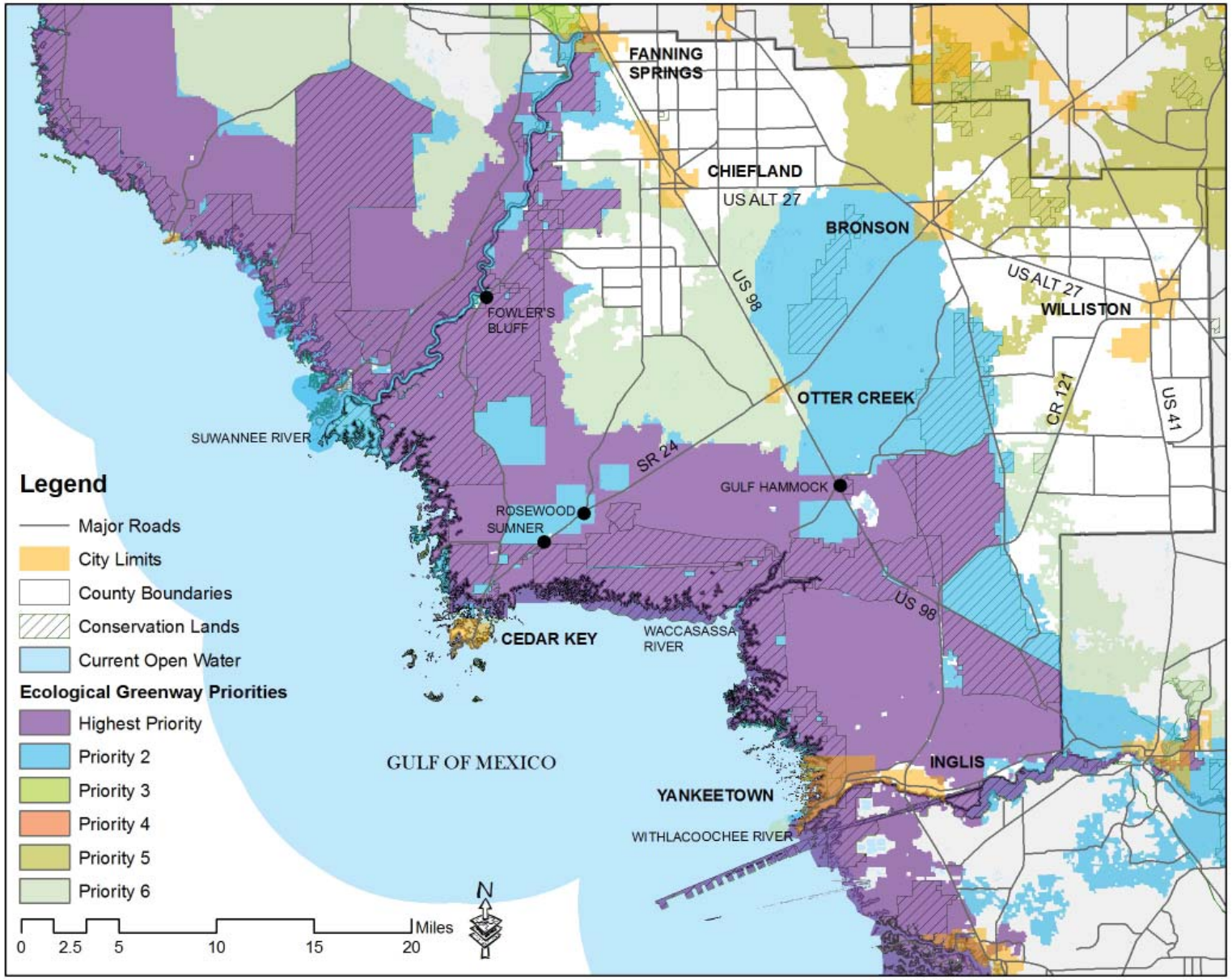


Figure 23: Ecological greenway priorities in Levy County as identified by the Florida Ecological Greenways Network dataset

landscape design strategies to reduce erosion and runoff that can impact surface water bodies (see Glossary for Low Impact Development).

The county, in partnership with the water management districts (Suwannee River WMD and Southwest Florida WMD), can also incentivize or require less water consumption of the aquifer, because there is a relationship between surface and aquifer flows on the coast and inland land uses such as timber and agriculture. The county or WMDs can also purchase, lease, incentivize, or use existing county lands for surface water storage and treatment. The goal would be to mimic historic natural flows, and to reduce flooding in developed areas. Water storage areas can also be used for nutrient reduction in stormwater prior to release into surface water bodies, helping reduce impacts on estuaries and coastal ecosystems.

Finally, the county can be involved in increasing the resiliency of their water related infrastructure (stormwater, sewer, and drinking water), as well as reducing potential hazards from current systems. This may include conducting a water infrastructure assessment to identify current vulnerabilities and areas for improvement, including potential impacts on private wells and stormwater outflows, from a higher water table and saltwater intrusion. It may also include addressing resiliency at a private property owner scale, such as incentivizing the maintenance or removal of septic tanks where city water is available. This is an important action, as coastal septic systems are likely to be at increased risk of polluting the groundwater as sea levels rise.

Planning Principles

Planning for sea level rise is an iterative process that must involve local citizens, stakeholder groups, and organizational leaders throughout each phase. It is imperative for intergovernmental coordination to be cultivated between state, county, and community agencies managing public lands and waters. Adapting to coastal change requires interrelated plans to represent Levy County as a highly connected system internally as well as one that is interactive with the larger region.

Among the broader considerations for sea level rise planning is the need to address uncertainty and cost tradeoffs. For instance, the lifespan of a structure relative to anticipated coastal changes, such as sea level rise, and the benefits of temporarily maintaining development in coastal areas must be considered in relation to the long-term risk. Return on investment must be considered when allocating mitigation/adaptation funds. For example, is elevation of a structure in a hazardous area a worthwhile use of funds if that structure will still be at risk of a catastrophic loss? Such a calculation might be relatively easy to include in the selection process for allocating mitigation/adaptation funds. Various documents are slowly becoming available that discuss how to estimate the costs of adaptation. One of these is a report titled "What Will Adaptation Cost: An Economic Framework for Coastal Community Infrastructure", which is available from NOAA (Eastern Research Group, Inc., 2013).

It is important to remember that planning involves both short-term and long-term changes. Sea level rise planning, in particular, requires an additional understanding that the pace of change will accelerate by mid-century. As such, phased plans are a viable option, assuming plans are revised frequently to incorporate new information and respond to changing conditions.

Selected adaptation strategies should be prioritized so that resources for implementation may be sought efficiently. Priority can be given to strategies that address the least-cost but highest benefit areas, "low hanging fruit," in other words. Initial policies that address changes that stakeholders currently identify as important issues and meet multiple objectives are also critical as a means of engendering public support and addressing "no-regrets" policies. Additionally, policies and plans should be actionable, and where possible, provide tangible results.

It is also recommended to take opportunities to incorporate the information from this report into existing planning processes. Current plans and projects the county has underway can be further enhanced by consulting the spatial analyses of vulnerability to sea level rise, storm surge, water issues, etc., included here. An example is the update to the Levy County Comprehensive Plan, which is planned for 2015, and for which specific work related to coastal resiliency is being considered by county planners. We encourage additional project-specific research to be conducted whenever possible.

Community Development and Capacity Building

The scope of sea level rise planning requires local governments, agencies, and advocacy groups to incorporate the issues of coastal change into broader community concerns. This can be particularly challenging. Therefore, it is highly recommended to seek out resources, including funding and partnerships, early in the planning process. Immediate options for Levy County include the UF/IFAS Extension Office and the Withlacoochee Regional Planning Council. Joining and becoming active in larger networks creates a pool of shared knowledge and resources, which offers many benefits.

As was previously recommended, additional local research on a project-to-project basis should be pursued as well as the monitoring of large scale trends. Possible partners for such research include the University of Florida, Florida Sea Grant, and state agencies such as Water Management Districts. There are many topics which merit further consideration, such as land-water-coastal connections, impacts to transportation networks and properties located within the coastal hazard zone, and potential risks to tax base, tourism, and other revenue sources resulting from coastal changes and/or fiscal and policy changes, such as flood insurance.

Innovative local funding mechanisms, such as tax increment financing via Community Redevelopment Areas (CRAs), may also be relevant and should be explored. Preliminary study has indicated that coastal adaptation could fall within the range of activities for which a CRA could use blight mitigation funds, but this requires further investigation. The CRA would need to include both upland areas that are being redeveloped and coastal areas where adaptation is taking place in order to generate TIF funds. Municipalities within Levy County, such as Cedar Key, already have CRAs, and this is something the county could develop as well. In general, we strongly encourage community leaders to stay up to date on current sea level rise and climate change information, as well as technical and financial support opportunities, with online resources and agencies. Multiple resources exist such as Climate Central (www.climatecentral.org), the Georgetown University Climate Center (www.georgetownclimate.org), NOAA's Coastal Services website (www.csc.noaa.gov), the Climate Adaptation Knowledge Exchange (www.cakex.org), and the Florida Department of Economic Opportunity Adaptation Planning website (www.floridajobs.org).

Finally, efforts to raise awareness among the general public about sea level rise and climate change should be continued. A combination of outlets such as news, social media, and community events is optimal in order to reach as many residents as possible and to ensure a clear message. This report has presented efforts undertaken during the project on each of these items, and we recommend their respective sections be reviewed as a starting point for further consideration. Community education on the issues of sea level rise need not simply be a passive endeavor. In fact, options that encourage public involvement, such as citizen science monitoring, have the potential to yield strong results.

Levy County Conclusion

Levy County has a higher capacity than many coastal regions to adapt to coastal change. The high percentage of coastline in conservation will help coastal natural communities adapt to sea level rise. The relative lack of major infrastructure or development near the coast means that fewer residents and infrastructure are at risk from coastal change, that hazard mitigation planning should be less complicated compared to highly urbanized areas, and that economic costs resulting from adaptation, mitigation, and impacts should be reduced. If Levy County proactively pursues measures to reduce current and future risks, the county and its residents will likely have a more prosperous future with lower risks to health, safety, and property, greater certainty for residents and planners, and more opportunities for economic development, environmental protection, and cultural preservation. This project and report is a major first step towards adaptation planning, and it can serve as a resource for the Levy County government, state and federal agencies, local communities, and interest groups as they move forward with adaptation planning, either individually or in coordinated initiatives.

The deep green of the Suwannee River's edge

Cedar Key - Rosewood

This section examines the potential impacts of sea level rise on the central Levy County coastal communities of Cedar Key, Sumner, and Rosewood, with particular focus on the incorporated area of Cedar Key because of its island location. The entire area is referred to as Cedar Key-Rosewood in this report.

Overview of Cedar Key - Rosewood

The Cedar Key-Rosewood area comprises a group of coastal islands and the nearby mainland area (see Figure 24).

The inhabited coastal islands, collectively referred to as "Cedar Key" in this report, extend about 3 miles into the Gulf of Mexico and are comprised of about 525 acres of dry land including incorporated and unincorporated areas. The City of Cedar Key proper has approximately 700 people occupying about 420 acres of dry land (U.S. Census Bureau, 2010a). Residential properties within the city limits of Cedar Key include approximately 450 single family houses, 225 condominium units, 40 mobile homes, 5 multi-family parcels, and 340 vacant residential parcels. Wetlands and open water areas are located within the city limits and add additional acreage. Unincorporated areas include Havens Island to the north, the airport area, and the areas southeast of Hodgson Hill and northwest of Hodges Avenue not within the city limits (see Figure 25). These areas add just over 100 acres to the total land area of Cedar Key. The unincorporated areas contain approximately 90 additional households, which are primarily single family houses, and 40 vacant residential parcels.

Historical map of Cedar Key (Library of Congress, Geography and Map Division)

Sumner and Rosewood are unincorporated areas that lie 7 and 10 miles northeast of Cedar Key, respectively. The combined population in Sumner and Rosewood is about 1,100 people (500 households), and these communities occupy approximately 2,200 acres.

The Cedar Key-Rosewood area's transportation network is restricted by extensive wetlands (see Figure 26). State Route 24 is Cedar Key's connection to the mainland, and this route directly links Cedar Key, Sumner, and Rosewood to U.S. Routes 19/98. Two other county roads service this area and both connect to U.S. Routes 19/98

Findings and Recommendations: Cedar Key - Rosewood

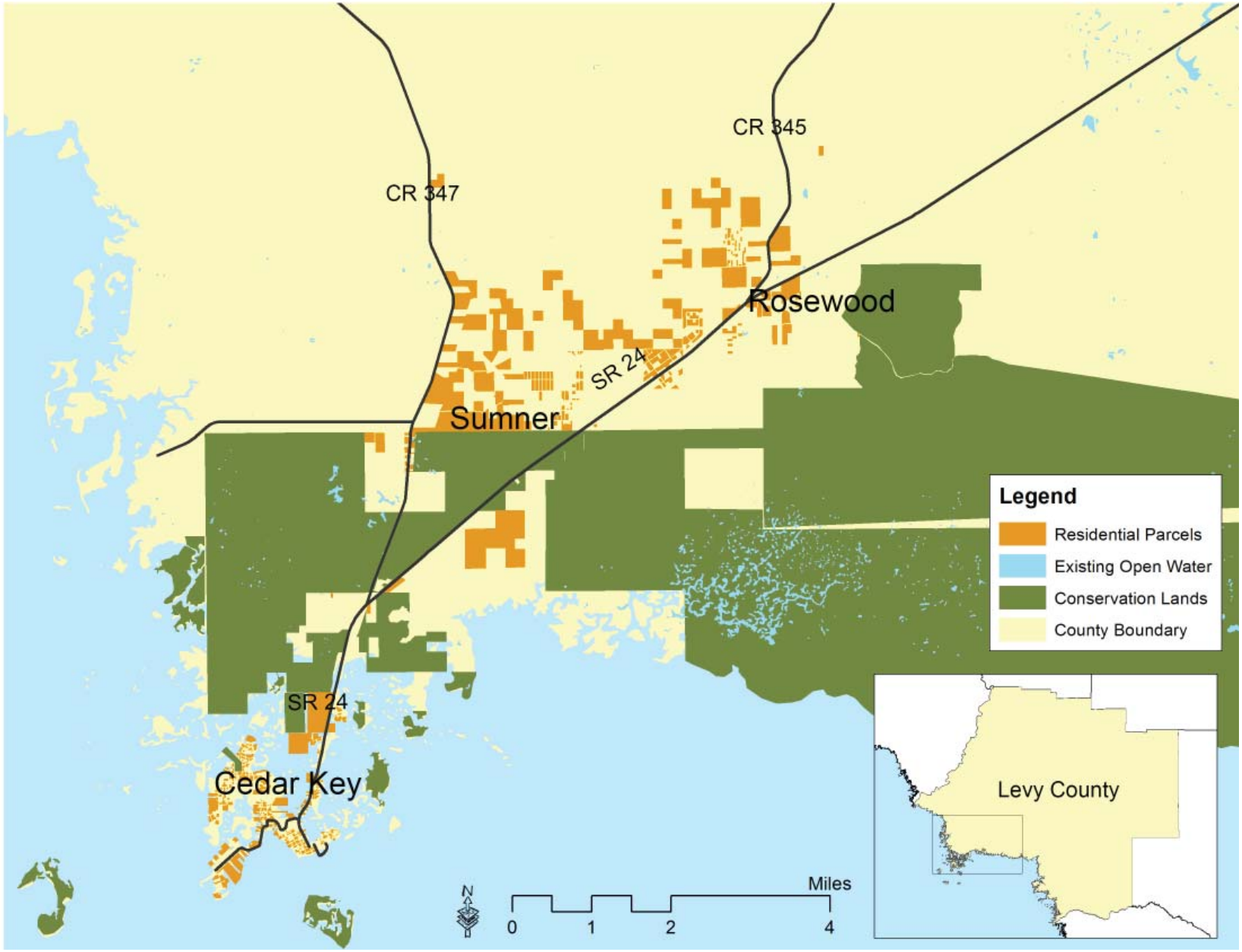


Figure 24: Cedar Key - Rosewood area

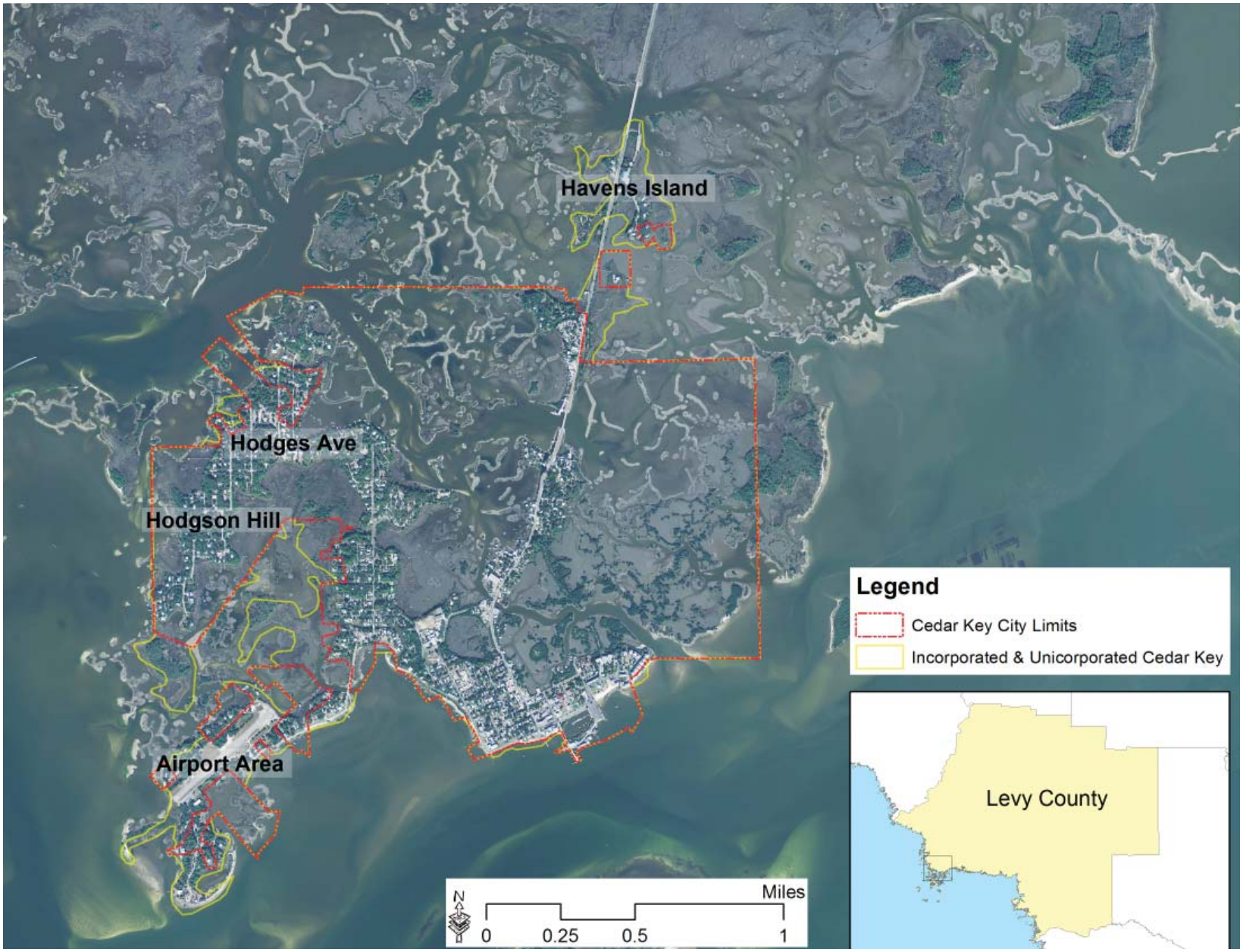


Figure 25: Cedar Key incorporated and unincorporated areas

Findings and Recommendations: Cedar Key - Rosewood

Figure 26: Cedar Key-Rosewood wetlands

near Chiefland. County Route 347 meets State Route 24 between Cedar Key and Sumner, and County Route 345 connects to State Route 24 near Rosewood. The majority of residences in Sumner and Rosewood lie north of State Route 24 between these two county roads (see Figure 27).

(https://skml.clas.ufl.edu/outreach-2/)

The Cedar Key-Rosewood area's economy is dependent on its coastal resources. Clam aquaculture and wholesaling are important industries, followed by recreation and tourism. Shellfish aquaculture was introduced to the area in the early 1990s to retrain oyster harvesters after local harvesting grounds closed due to pollution. Net fisherman were similarly retrained in the late 1990s following the state's gill net ban (Colson & Sturmer, 2000). To improve water quality in the surrounding Gulf waters (standards for shellfish harvesting for human consumption require very clean water), the City of Cedar Key transitioned from onsite, septic tanks to a central sewer treatment system. Currently, more than thirty locally owned seafood businesses are located in the Cedar Key-Rosewood area. Restaurants, lodging facilities, stores, and other entertainment and recreation businesses, such as charter boats, are supported by tourists drawn to the area's natural, cultural, and historic resources.

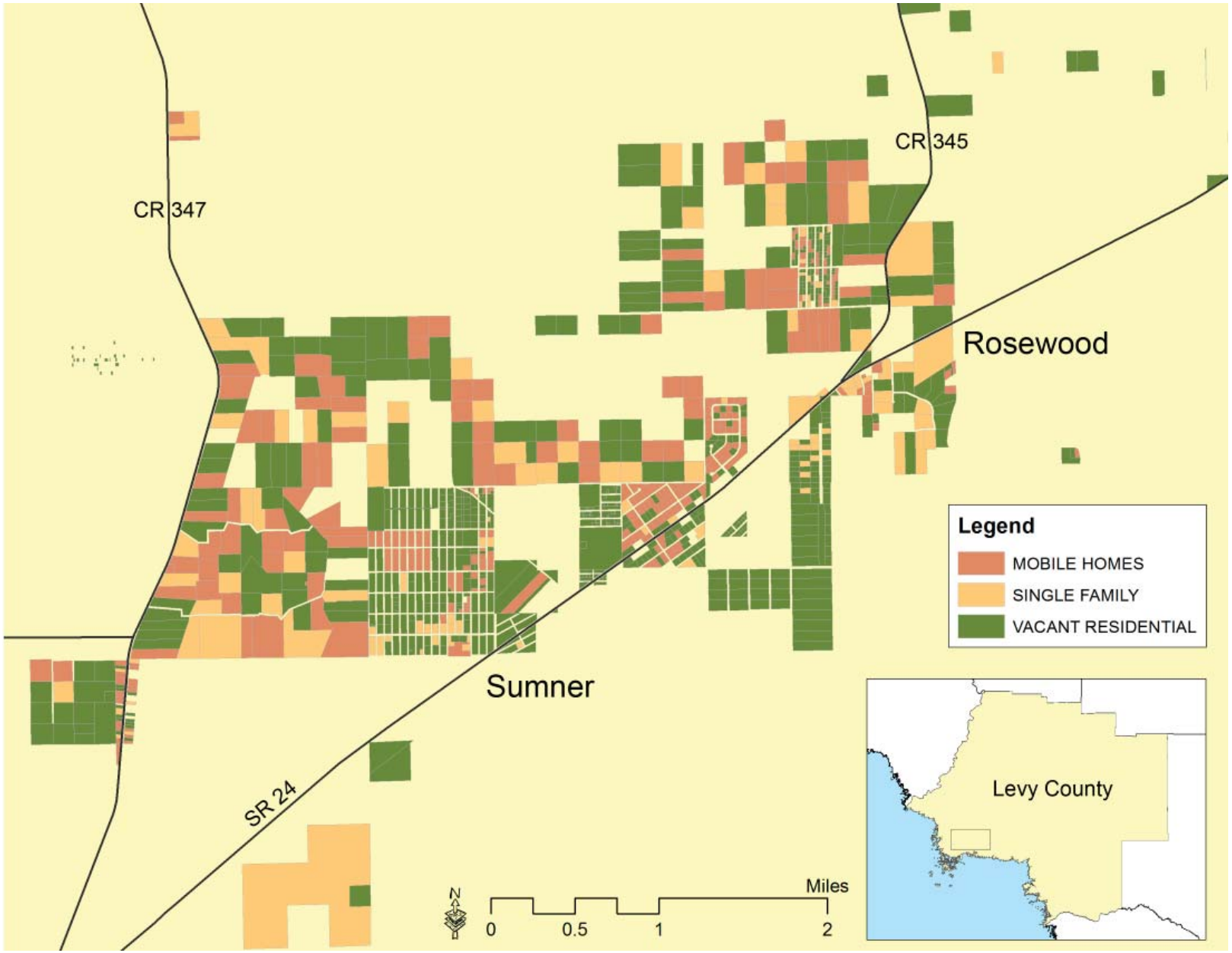
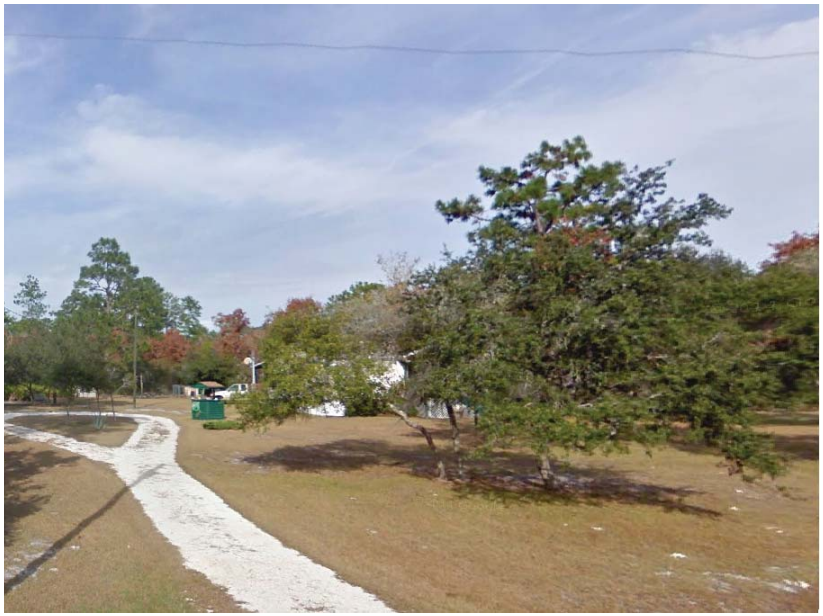


Figure 27: Sumner-Rosewood residential parcels

Cedar Key's land use is primarily residential, public, and semipublic, with much of the commercial and institutional uses located on the eastern side of island (see Figure 28). Half of the parcels zoned for residential use are vacant, and these are distributed throughout the city. The public and semipublic lands are used for parks, schools, and the airport, and they are held by the state, county and municipality. Most of the commercial uses are located along State Route 24 and in the downtown and city dock areas. A number of these businesses are restaurants, motels, real estate offices, and tourism-related retail.

Cedar Key's future land use plans provide for mixed use in the downtown area and more commercial uses in the south-central portion of the island and along State Route 24. The mixed use area is now primarily retail and office spaces, and vacant nonresidential uses. The desired commercial area in the south-central portion is currently a combination of residential and vacant residential parcels. As mentioned above, a number of commercial uses are located along State Route 24, and the City has identified additional parcels along this corridor for future commercial use.

In Sumner and Rosewood, residential, vacant residential, and agriculture are the primary land uses in the developed areas. A few retail, office, and industrial use parcels lie along State Route 24 and County Route 347. The communities are predominately surrounded by agricultural/forestry land uses. The areas to the south and southwest of Sumner are environmental conservation lands, with Waccasassa Bay Preserve State Park and Cedar Key Scrub State Preserve on the south and north sides of State Route 24, respectively. Future land use for this area has commercial uses located along State Route 24, with forestry/rural residential use surrounding the communities, and natural reservation to the south and southwest of Sumner.



Rosewood residence (https://www.google.com/maps, 2014)

Cedar Key's numerous prehistoric and historic resources are significant contributors to the local character that is valued by residents and visitors. In addition to a number of archaeological resources, which includes shell midden, burial mounds, and building remains, Cedar Key contains

Findings and Recommendations: Cedar Key - Rosewood

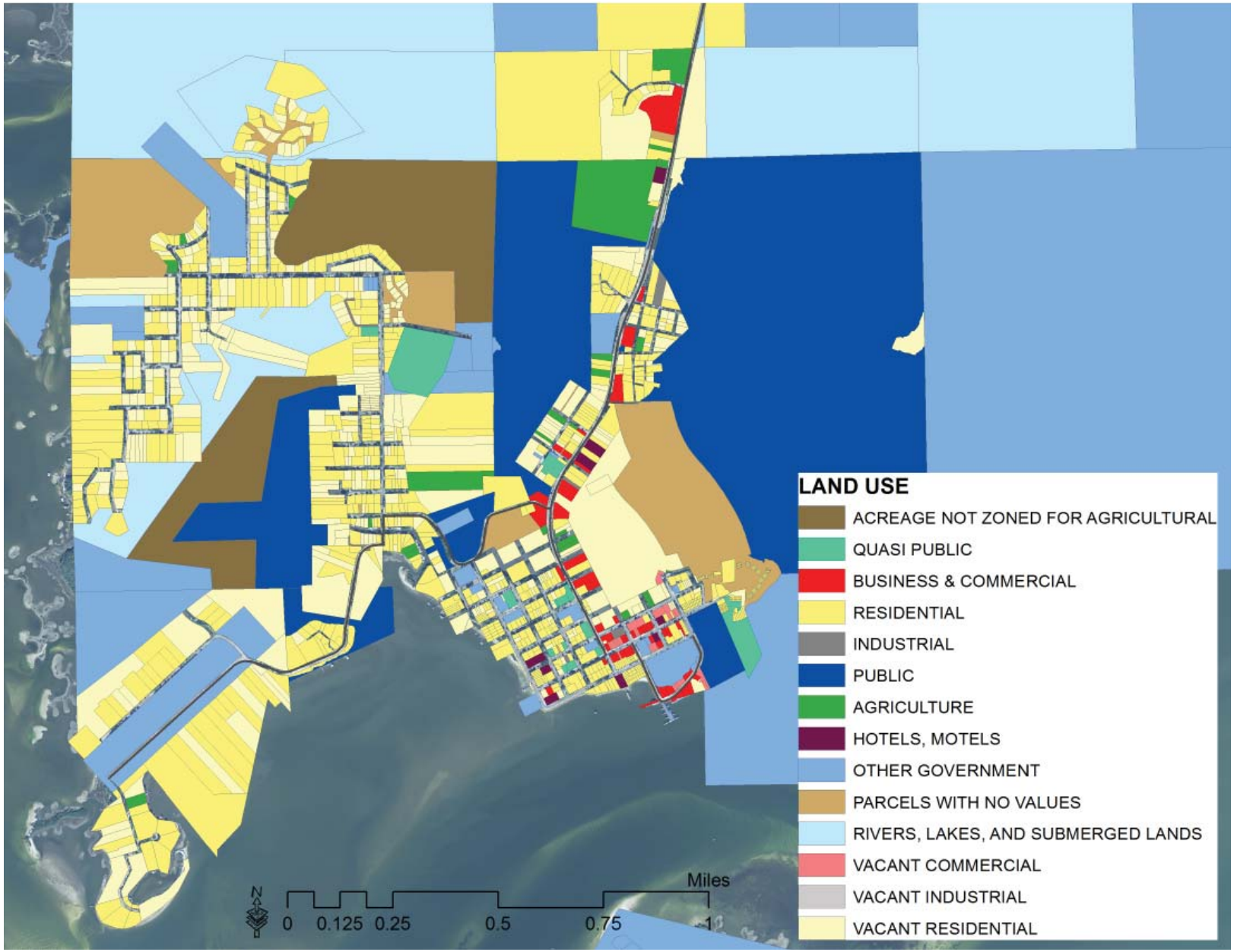
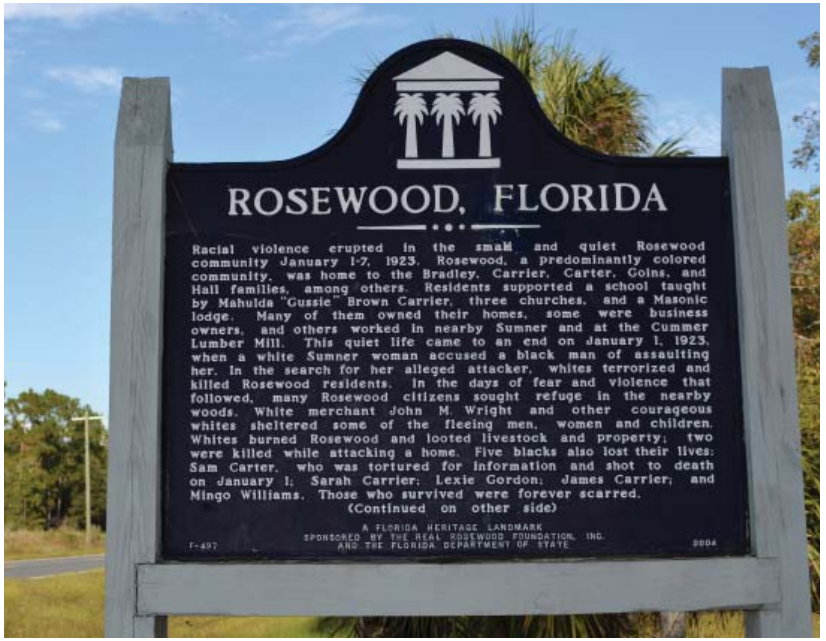


Figure 28: Cedar Key land use map

approximately 110 historic structures (see Figure 29). Nearly all of these historic structures are located near downtown Cedar Key and listed on the National Register of Historic Places as contributing elements of the Cedar Keys Historic and Archaeological District. Of particular significance is the Island Hotel, located downtown on 2nd Street. This tabby structure was built as a general store in 1859 and has survived storms, floods, and fires. The building is currently a well-known bed and breakfast individually listed on the National Register.

Rosewood has been recognized as a Florida Heritage Landmark to remember racially charged violence of 1923 that resulted in at least seven deaths, destroyed the town, and drove the African-American residents away. The only structure remaining from this time period is a private residence located on the south side of SR 24. The Florida Historical Marker is located just to the west of this property along SR 24. Rosewood's historic African American cemetery is also in the area. According to Gonzalez-Tennant (2012), "the handful of families currently living in the area where Rosewood once existed have little personal attachment to the history and events of 1923. Most have recently moved to the area and know nothing of the spatial layout of Rosewood in the 1920s" (p. 80).

Historic Island Hotel



Findings and Recommendations: Cedar Key - Rosewood

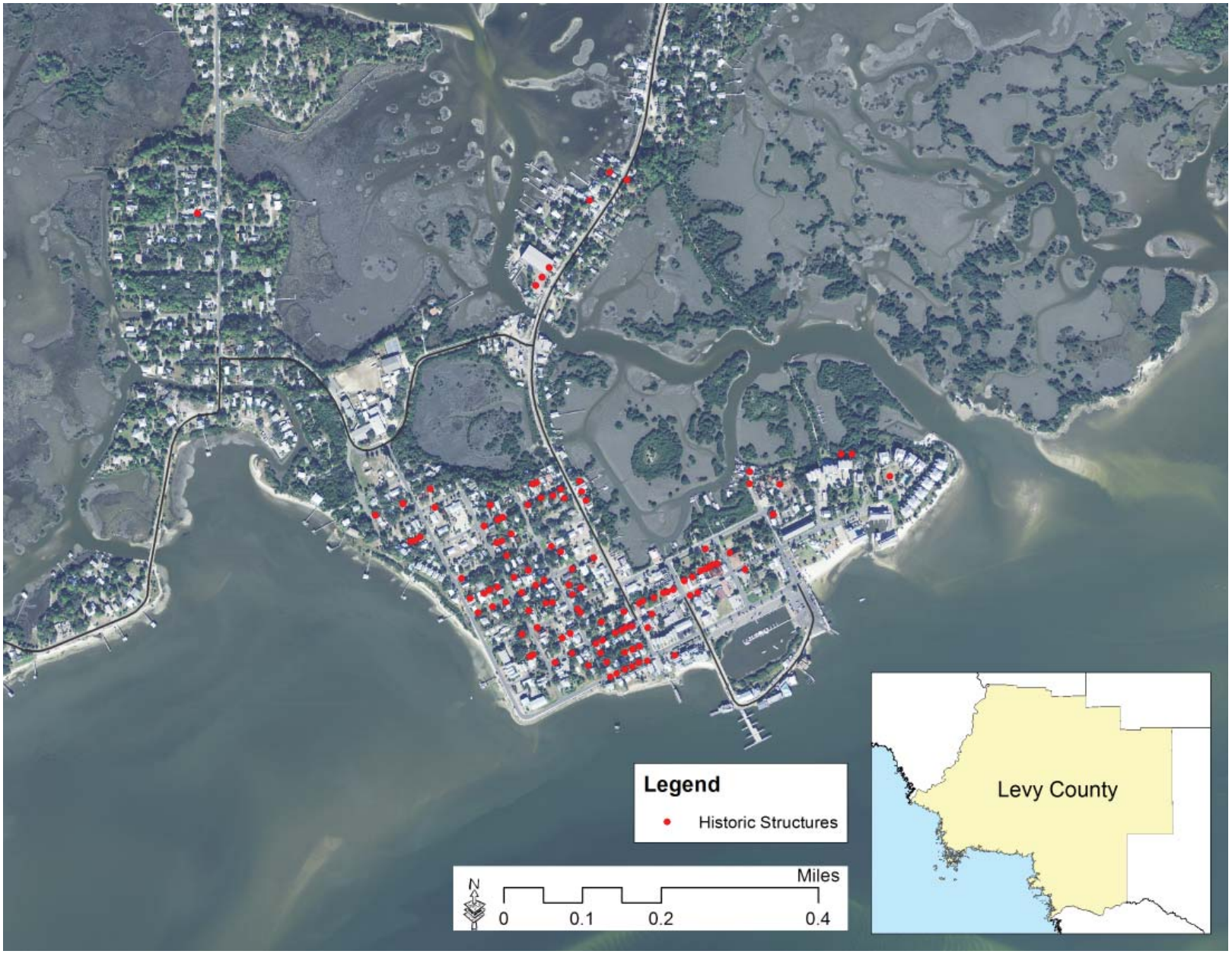


Figure 29: Cedar Key historic structures

Vulnerability to Sea Level Rise

A comprehensive analysis of the Cedar Key-Rosewood area's physical features, including elevation, ecological, storm surge, geologic, hydrologic, built, and economic/fiscal aspects, helps identify areas that may be vulnerable to sea level rise and other coastal changes.

Vulnerability Based on Elevation

Cedar Key is a hilly island, with several high points, and considerable low-lying areas (see Figure 30). Cedar Key contains some of the highest elevations in the Big Bend region. Hodgson Hill, with an elevation of 37 feet, is the highest point on the island. Areas with high elevations also occur to the west of downtown and near Cedar Key Cemetery. These areas have less exposure to sea level rise and other coastal hazards, but they could become isolated because most of Cedar's Key's roads, including the bridge to Cedar Key, lie below six feet in elevation (FEMA, 2012).

Figure 31 indicates the number of acres of dry land in Cedar Key (including the unincorporated areas) lying below specified elevations. About 42 acres (7%) of the dry land in Cedar Key lies below three feet elevation. "Tidally adjusting" for a three feet sea level rise scenario with an additional two feet of high tide means that all dry lands less than five feet in elevation, which is about 190 acres (31%) in Cedar Key, would regularly flood under this scenario. These lands are shown in Figure 32.

The lowest lying dry areas of Cedar Key, those lower than 5 feet in elevation, are located around much of the islands' perimeter and extend further inland in a few locations. The airport area, Sunset Point, and Rye Key all contain significant inland low-lying dry lands (see Figure 32). Portions of the downtown area, particularly near D Street, Cedar Cove, and the marina, are also low-lying. The low-lying areas also extend further inland on Way Key between Palmetto Drive and Indiana Avenue.

Slight elevation rise at cemetery

Areas located on higher elevations could become isolated unless alternative transportation methods are implemented. Currently, State Route 24 is the only road to the islands, and it is low-lying in a number of places including

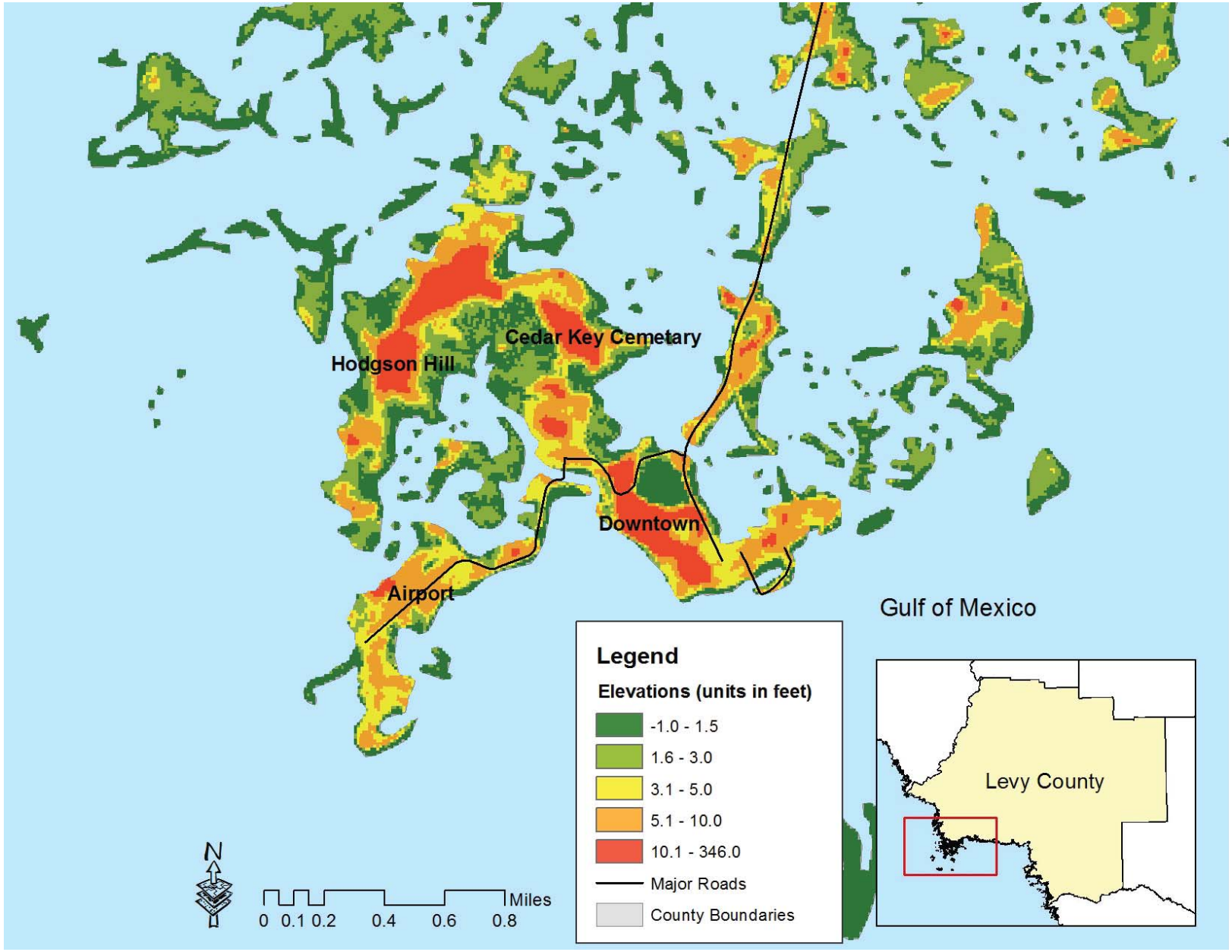


Figure 30: Cedar Key topography

Sunset Point and the downtown. On the islands, Airport Road, Gulf Boulevard, G Street, Hodges Avenue, and Hodgson Avenue each have low-lying areas. Since Cedar Key has a limited road network with only one access road and often only one through-road into an area, inundation of these roads could cut-off the islands from the mainland and severely limit vehicle mobility throughout the islands.

The 3 feet sea level rise scenario with tidal adjustment affects nearly 850 parcels in Cedar Key, which have a value of approximately $155 million. In some cases, an entire parcel may be inundated, and in other instances, only a portion of the parcel will be affected. These parcels contains about 325 single family homes, 90 condominium units, and 50 businesses. Additionally, 245 vacant residential parcels could also be affected, which limits areas for future development.

Located inland, Sumner and Rosewood are less vulnerable to sea level rise than Cedar Key. This area is relatively flat with elevations of approximately 5 to 20 feet (see Figure 33); however, areas south of State Route 24, in Waccasassa Bay Preserve State Park, are subject to tidal inundation under the 3 feet sea level rise scenario. State Route 24 may also be vulnerable under this scenario near Sumner and in the area where it intersects with County Route 347. Additionally, Sumner, and to a lesser extent, Rosewood, are still vulnerable to current storm surge levels (see below), and these will be exacerbated by sea level rise.

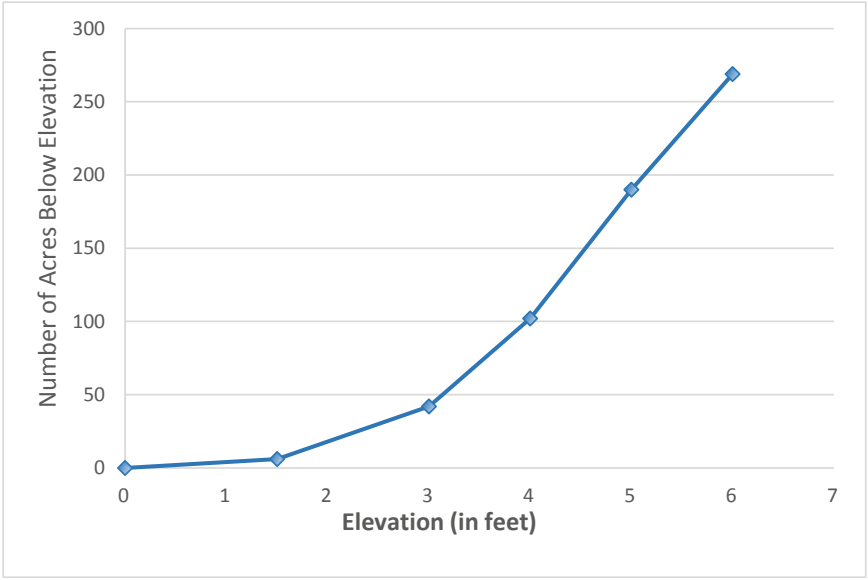


Figure 31: Total number of acres below various elevations in Cedar Key

Characteristic low elevations in Cedar Key

Findings and Recommendations: Cedar Key - Rosewood

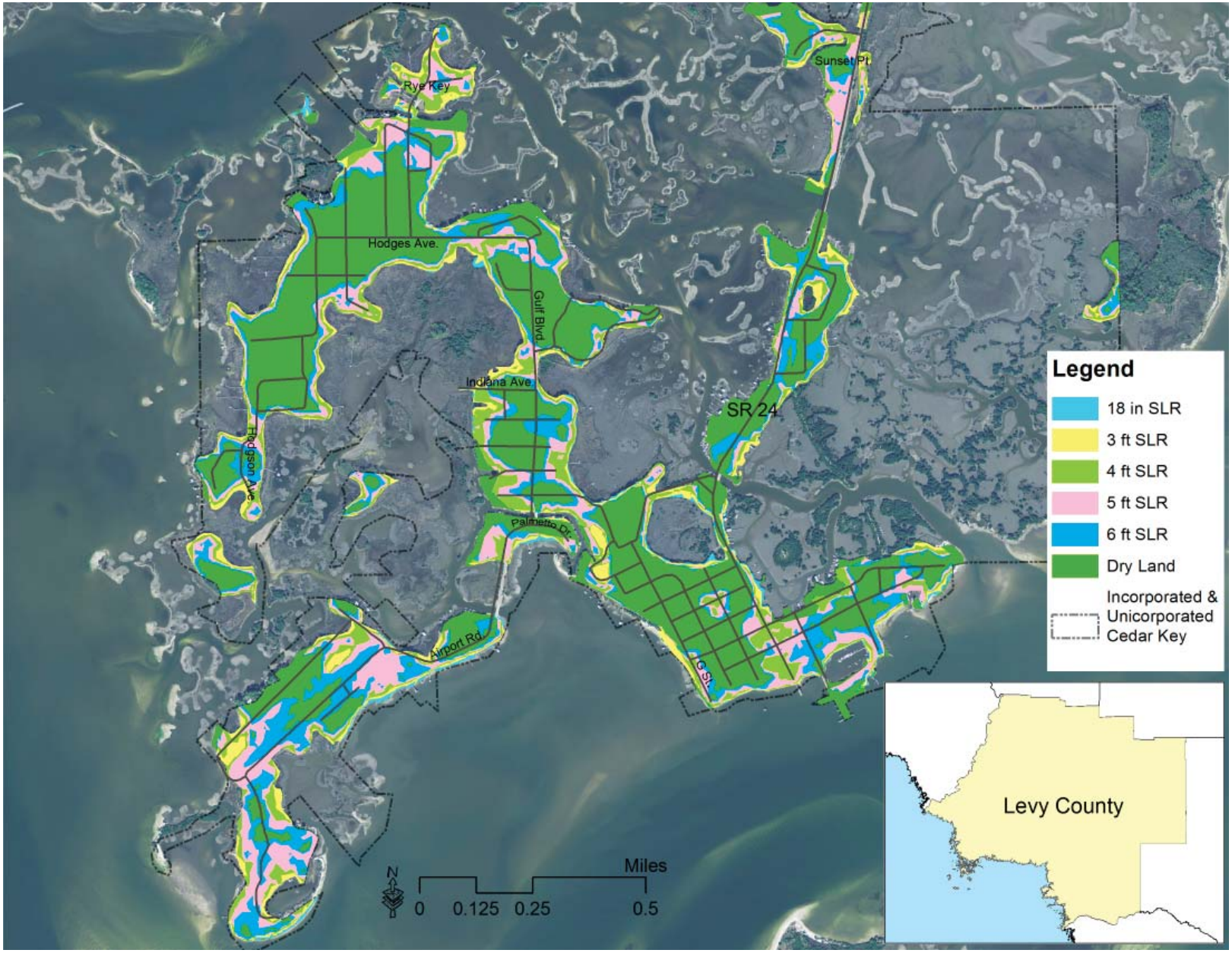


Figure 32: Cedar Key dry land lying below various elevations

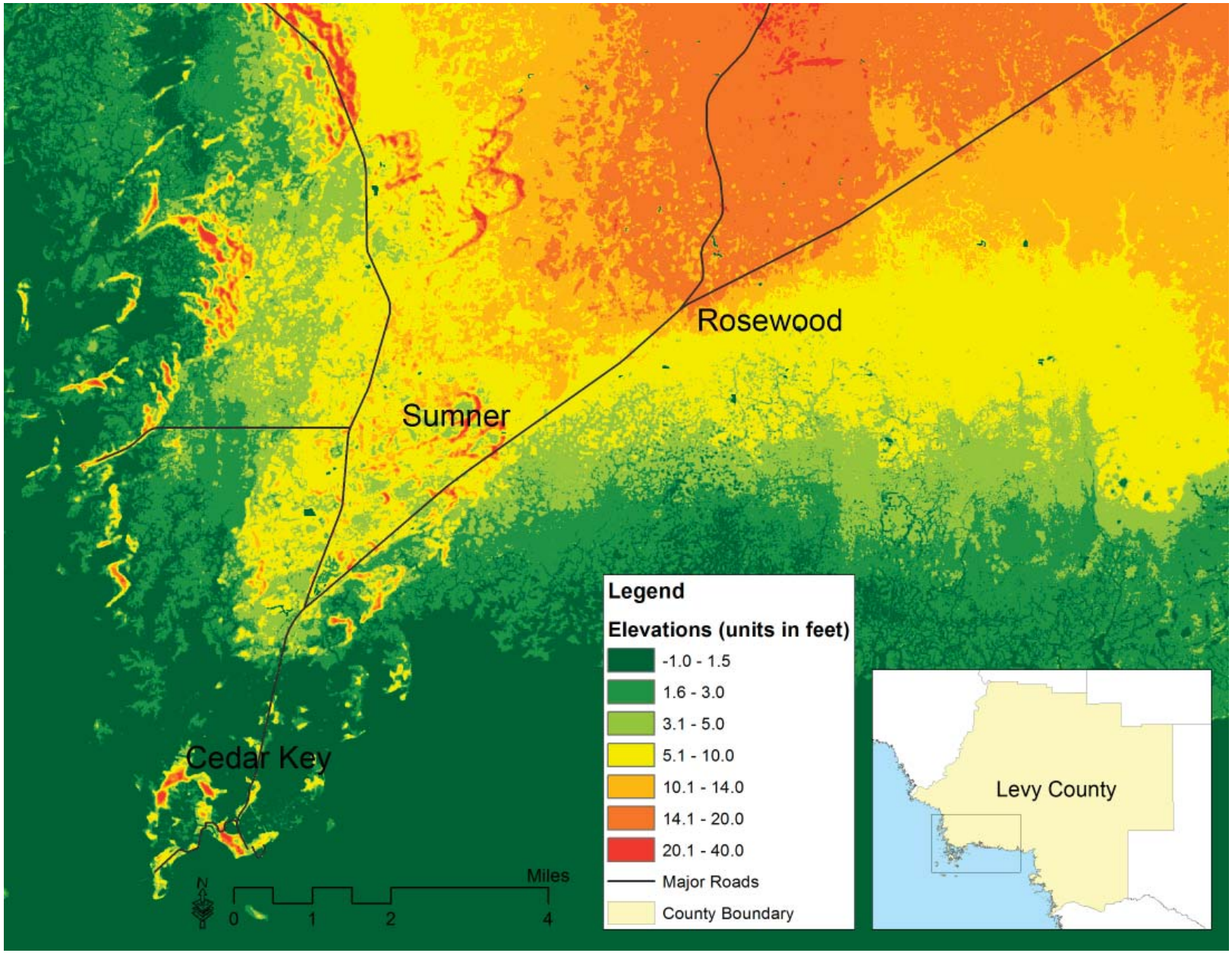


Figure 33: Cedar Key, Sumner and Rosewood elevation map

Vulnerability Based on Ecological Modeling (SLAMM)

The project team analyzed the Sea Level Affecting Marshes Model (SLAMM) data for the Lower Suwannee National Wildlife Refuge, Cedar Key National Wildlife Refuge, and the Waccasassa Bay areas, provided to the project by the Gulf of Mexico Alliance and The Nature Conservancy, respectively, for the Cedar Key-Rosewood area to assess the potential wetland and other ecological changes resulting from the 3 feet rise sea level rise by the year 2100 scenario. Impacts to coastal habitats predicted by SLAMM in and around Cedar Key are shown in Figures 34 and 35. Impacts to habitats are different than those seen further south around Yankeetown due to the cluster of islands that make up and surround Cedar Key and higher elevations along SR 24.

Between Cedar Key and the mainland SLAMM shows almost complete loss of the extensive tidal flats to open water. Because tidal flats are an important ecological food source, this would significantly impact birds, fish, and other wildlife. SLAMM suggests that a significant amount of dry land of Cedar Key under a three feet sea level rise scenario could become beach, marsh, and open water. Additionally, since tidal flats purify pollutants carried by stormwater runoff, this service would be lost, thus adversely affecting near-shore water quality.

Along the mainland, areas that are currently coastal forests (tidal swamps) are projected to convert to primarily saltmarsh with transitional saltmarsh expanding along the inland edge. Transitional saltmarsh refers to areas that are in the process of converting either to or from a traditional marsh habitat. These areas may receive tidal flooding, but in contrast to traditional salt marsh are characterized by more woody, broad-leaved, or deciduous vegetation. In general, the significant reduction in coastal forests will affect wildlife dependent on these unique habitats.

Cedar Key tidal flat

With respect to impacts in Cedar Key National Wildlife Refuge, Warren Pinnacle Consulting, Inc (2011b) states, "application of SLAMM to Cedar Keys NWR indicates the effects of SLR on this refuge will be severe. . . . In the 1 m SLR scenario, all wetlands are predicted to slowly

lose coverage to open water at an average rate of 5% every 25 years until 2050. After this date the loss rate is predicted to accelerate to 10% for the final 25 years of simulation" (p. 25). Their analyses predict major changes to coastal ecosystems and land cover as a result of sea level rise. These changes will almost certainly affect focal species and natural communities within the refuge requiring development of adaptation strategies and management plans in response.

Sumner is projected to see the most habitat change nearby to the south and southwest, with some change happening across SR 24.

When compared to the tidally adjusted bathtub model, SLAMM shows that many of the areas newly inundated by sea level rise become wetlands, rather than open water (as might be suggested by the simple bathtub model).

Honeymoon Cottage, Cedar Key

Erosion along G street, Cedar Key

Vulnerability Based on Flood Zones, Storm Surge, and Erosion

The Cedar Key-Rosewood area is currently vulnerable to flooding from rain events and storm surges, with more than 80 percent of the residential parcels located within a special flood hazard area according to FEMA. In Cedar Key, as shown in Figure 36, approximately 750 residential properties and 60 commercial properties, having a market value of about $145 million and $17 million respectively, are located in FEMA "VE," "A," and "AE" flood zones (See Glossary). In the Sumner-Rosewood area, approximately 250 residential parcels, having a value of about $17 million, are located in these zones (see Figure 37). The remaining residential parcels are located in moderate flood hazard areas, which are the areas that lie between limits of the 100-year and 500-year flood zones.

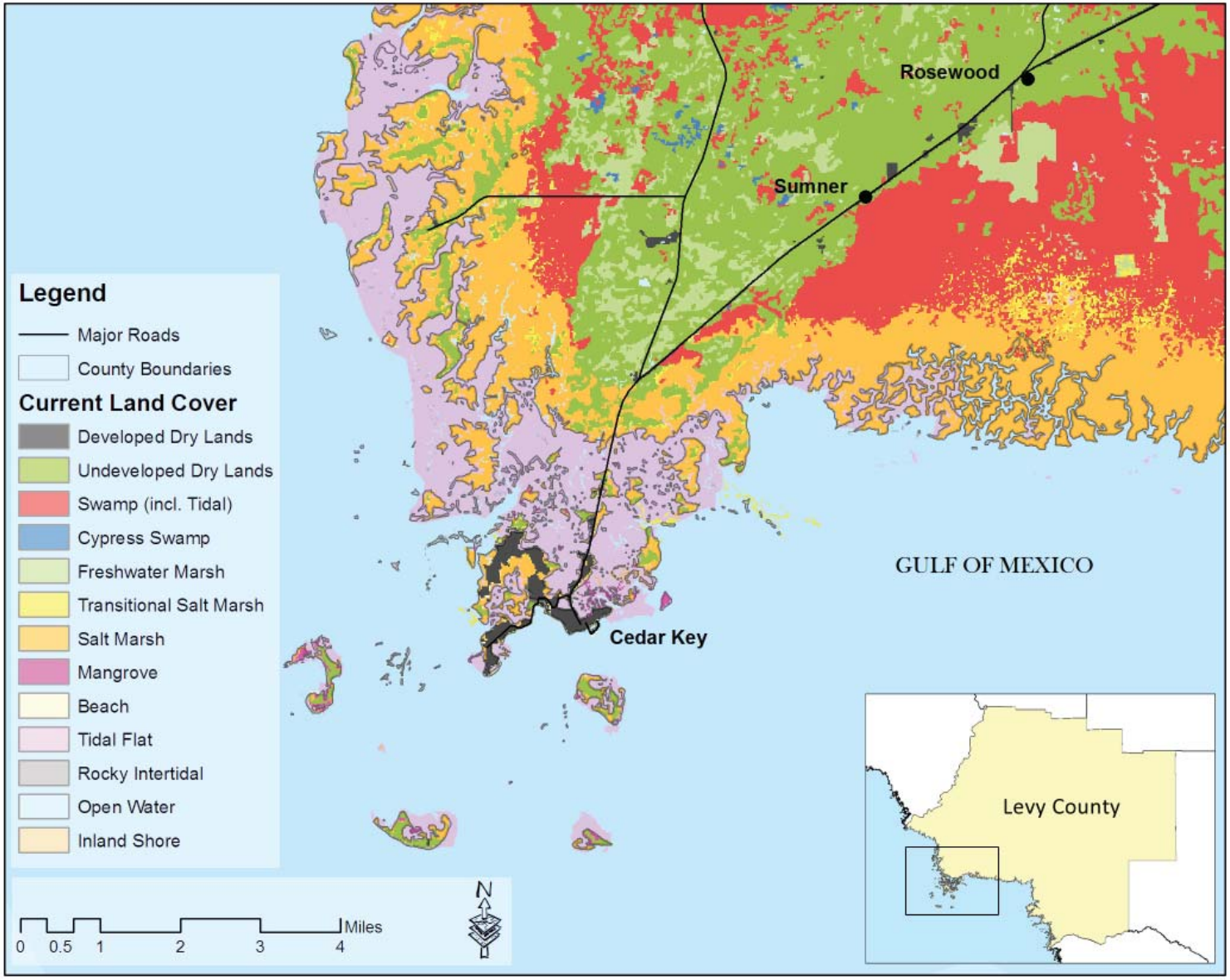


Figure 34: Current land cover in the area of Cedar Key, Rosewood, and Sumner (Warren Pinnacle Consulting, Inc. 2011b and Freeman, K. & Geselbracht, L. 2011)

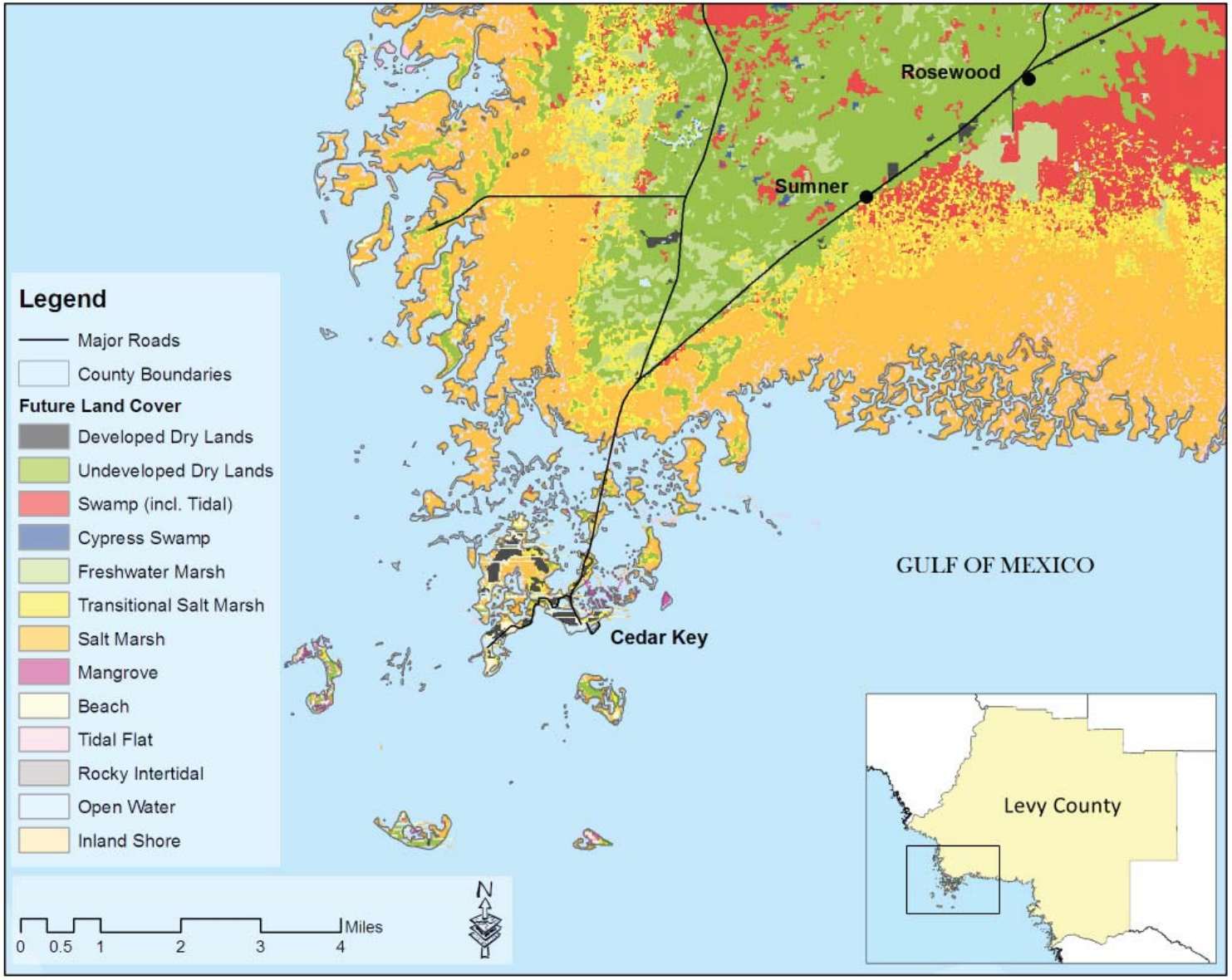


Figure 35: Projected land cover in the area of Cedar Key, Rosewood, and Sumner with 3 feet of sea level rise by the year 2100 (Warren Pinnacle Consulting, Inc. 2011b and Freeman, K. & Geselbracht, L. 2011)

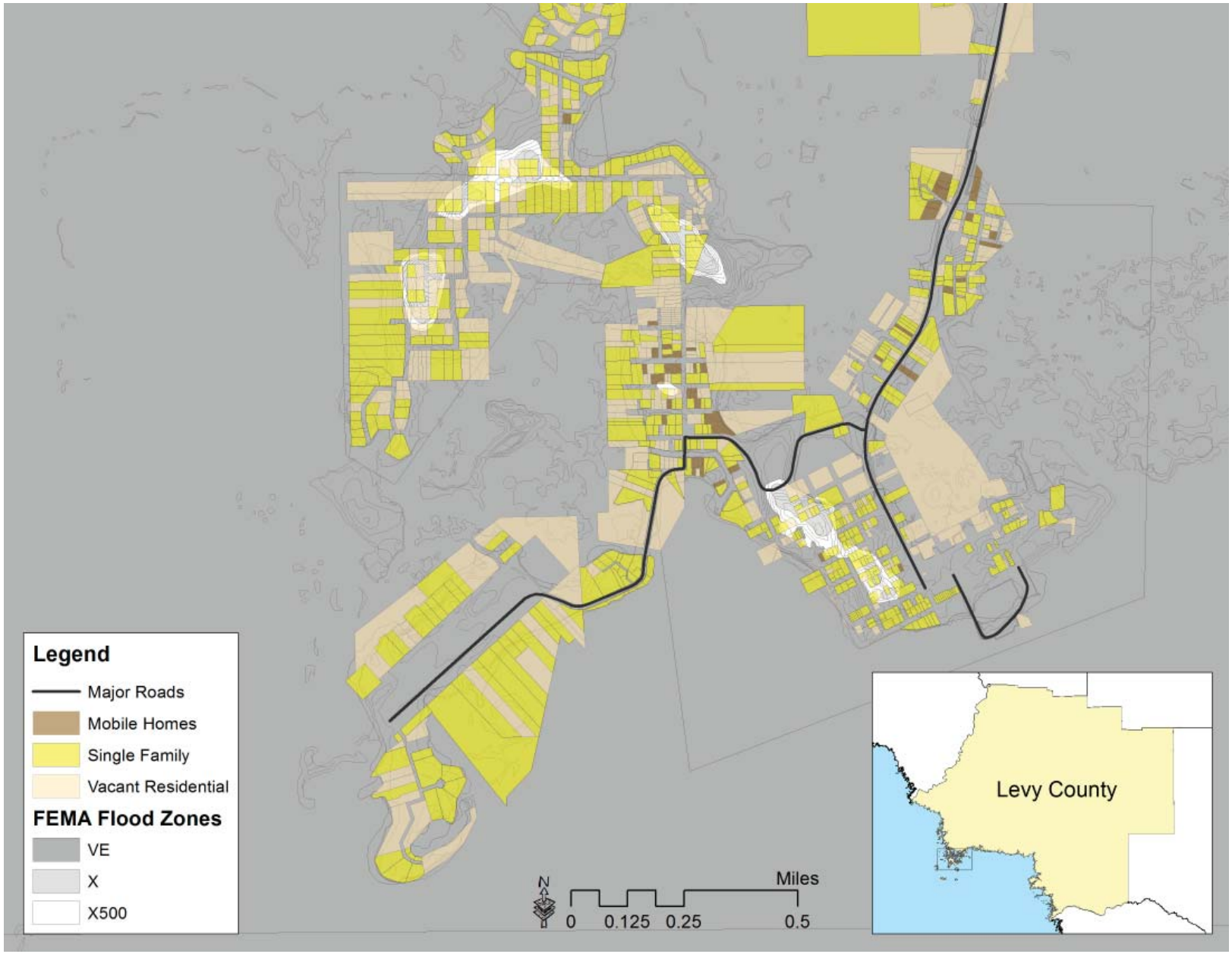


Figure 36: Cedar Key residential parcels and flood zones

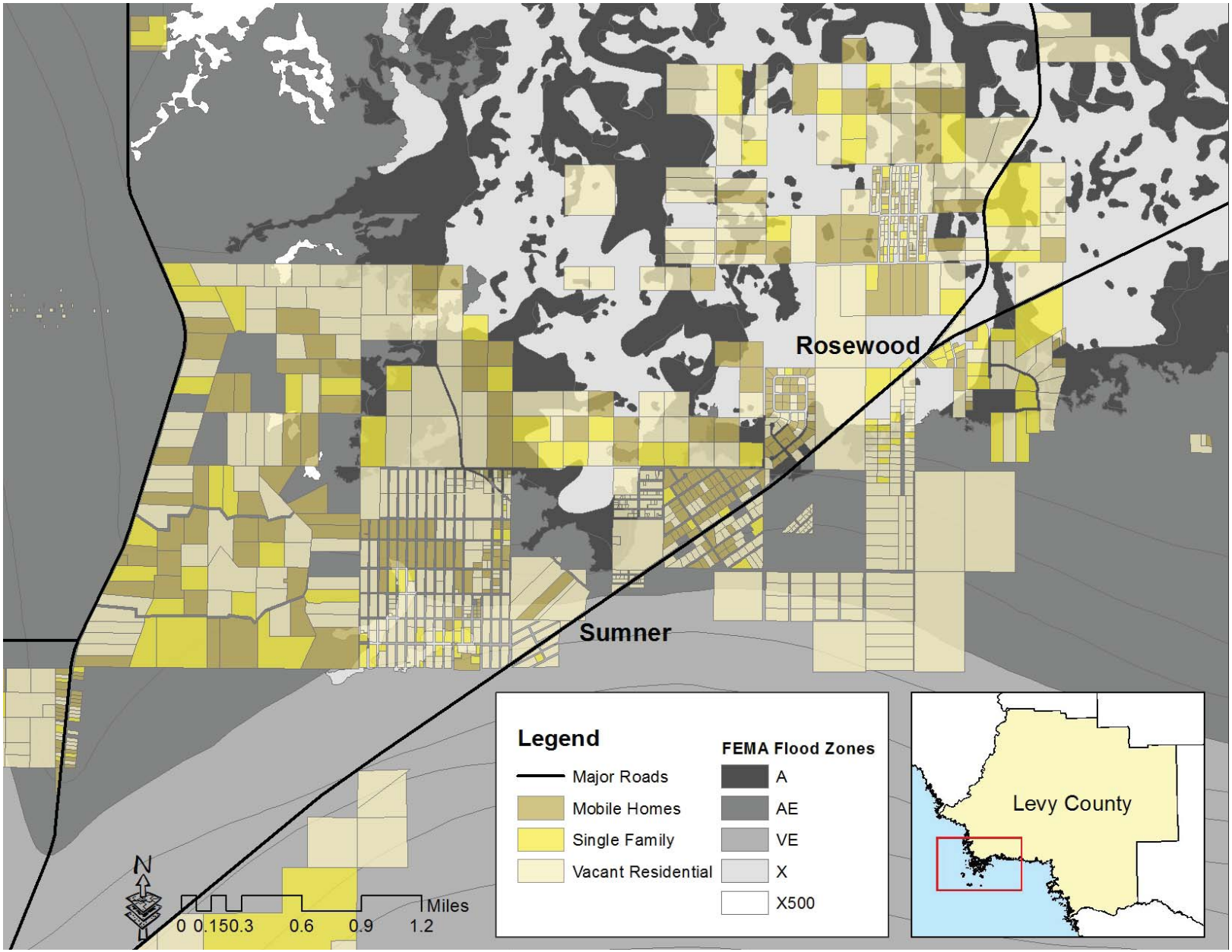


Figure 37: Sumner and Rosewood residential parcels and flood zones

Figure 38 shows modeled storm surge levels in the Cedar Key-Rosewood area for a 100-year storm event and current sea level. As sea level rises, low-lying lands, especially, those in the FEMA "VE" flood zone, may experience higher and more frequent storm surge flooding. On Cedar Key, due to the hilly topography, the parcels outside the special flood hazard area are usually located at higher elevations that are less likely to flood with an additional 3 feet of sea level rise, particularly those built in the Hodgson Hill area or on the hills located to the west of downtown (see Figure 36). In Sumner and Rosewood, a large number of the residential parcels that are currently in FEMA's moderate flood hazard area are at elevations that are only two to four feet higher than parcels in the special flood hazard areas (see Figure 37).

Sea level rise can exacerbate existing erosion and cause erosion in new places. Erosion is especially noticeable when it is rapid or threatens development, including roads, yards, and houses, or degrades cultural or natural features of value, such as beaches. Erosion is currently a concern at several locations on Cedar Key (see Figure 39). According to the Florida Department of Environmental Protection (FDEP, 2012), Cedar Key has one-half mile of "critically eroded beach" that is "threatening development interests and the public roads" (p. 61). This section is along 1st and G Streets to the southwest of downtown, and it extends along Joe Rains Beach at the west end of 8th Street.

At Joe Rains Beach, Cedar Key residents are proposing a living shoreline restoration project using salt marsh and oyster reefs, in combination with an existing seawall, to stabilize the area. Other possibly eroding areas on Cedar Key, as seen in aerial photographs, are along Airport Road and at Piney Point south of the airport. The FDEP report (2012) also stated that neighboring Seahorse Key (home to the Cedar Keys lighthouse and the University of Florida's Seahorse Key Marine Laboratory) has "noncritical" erosion along 1.2 miles of beach, and Atsena Otie Key has 0.2 mile of critical erosion threatening gravesites and a Seminole holding area.

Rip rap protection on 1st street, Cedar Key

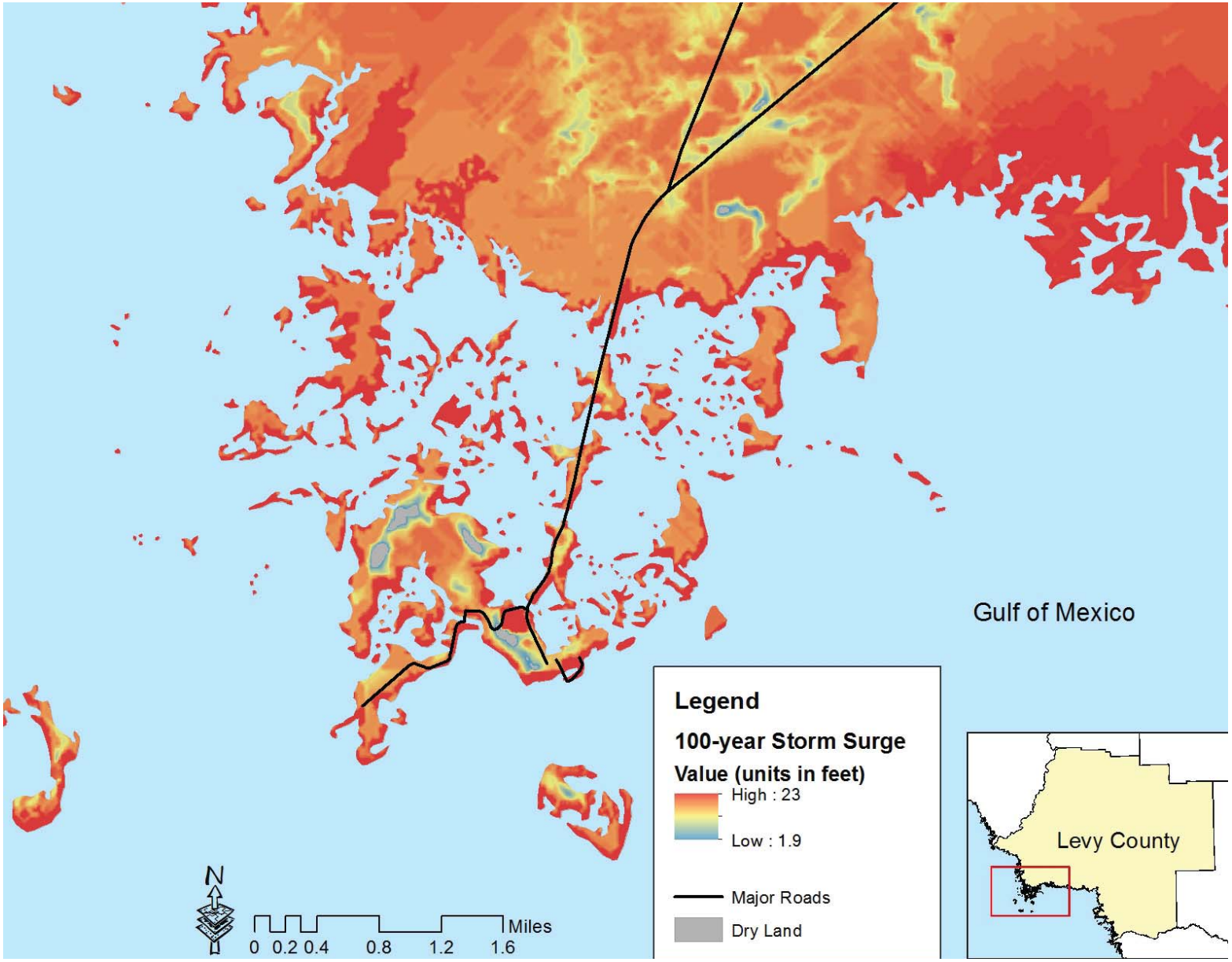


Figure 38: Cedar Key 100 year storm surge

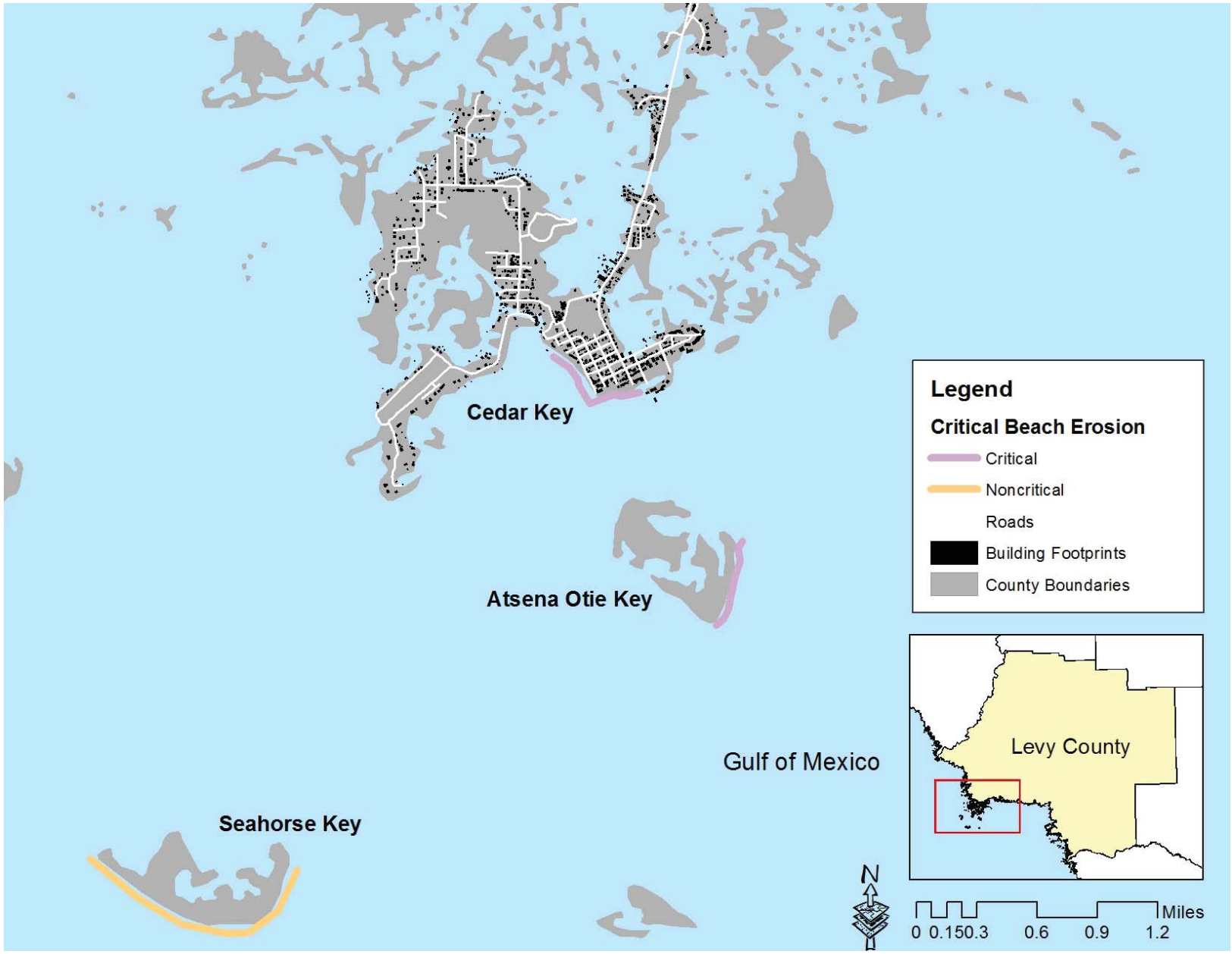


Figure 39: Cedar Key critical beach erosion

Vulnerability of Structures and Building Stock

The ways in which buildings are constructed affect their vulnerability to sea level rise and coastal change. In 1985 the City of Cedar Key adopted an ordinance requiring compliance with FEMA's building regulations. Nearly 500 of the approximately 800 structures in the town were built prior to 1985. Since these buildings do not necessarily meet the stricter building codes, such as the requirement to be elevated, they may be more vulnerable to future hazards. However, many of these buildings have weathered past storms, and a detailed analysis of the area's buildings and their exposure to hazards (such as location) should be conducted to determine overall vulnerability.

Traditional Cedar Key homes

The aging of the building stock in Cedar Key may provide opportunities for future adaptation. A particular building may reach the end of its physical life around the same time that flooding or erosion in its location becomes a concern. In Cedar Key, 64% of buildings were constructed before 1990 and will require significant renovations or need to be replaced in the not too distant future (see Figure 40). This provides an opportunity for these structures to be updated or relocated to become better adapted for changing conditions. Historic buildings, many of which are located in downtown and at higher elevations, may have a longer lifespan than mid-century structures, because of their methods and materials of construction.

Modern elevated homes

Construction type of the area's structures is another critical consideration for adaptation planning because certain types of construction are more resilient or easier to adapt. For instance, elevated structures may be more resilient; however, utilities and physical access will be vulnerable to sea level rise. Wood frame structures on piers are easier to relocate or elevate, while structures with masonry construction or slab-on-grade construction are more difficult to move or elevate.

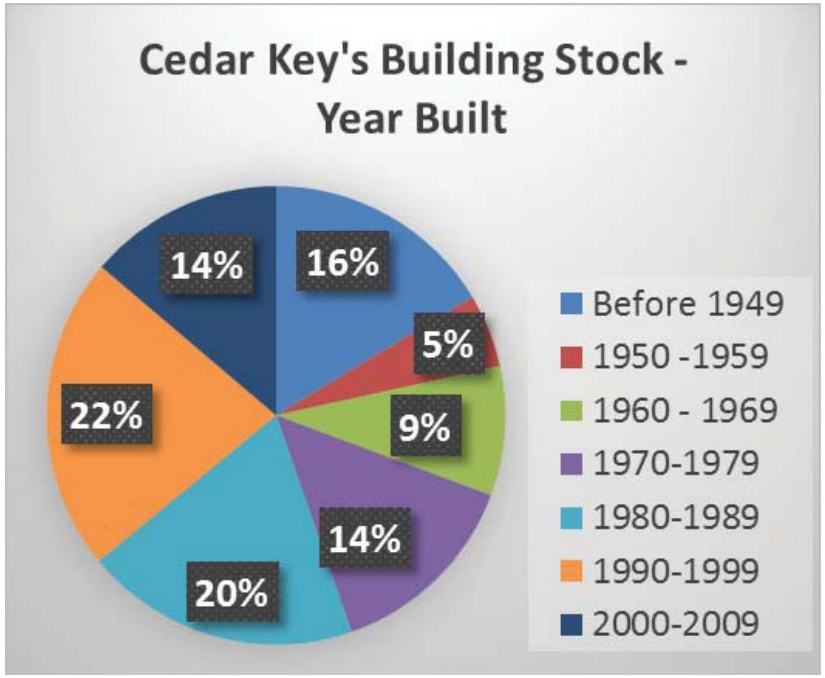


Figure 40: Percentage of Cedar Key's building stock by year built

Vulnerability Based on Geology, Hydrology, and Water Infrastructure

The proximity to Gulf waters, the porous nature of the limestone substrate, and the shallow depth to water table (the Floridan aquifer), create several concerns for the Cedar Key-Rosewood area relative to future sea level rise and storm events. Sea level rise has the potential to push the unconfined aquifer upward causing an increase in flooding and subsurface inundation of pipes, tanks, and septic systems. Sea level rise can also raise water levels that block the gravity flow of stormwater drainage systems, thus leading to decreased ability to remove rainwater during storms.

One of the most serious concerns is that the porous substrate may allow saltwater intrusion into freshwater supplies as sea level rises, and this issue could be more pronounced during droughts, as well as if additional demands are placed on water supplies by coastal development and inland agriculture. Overall, these changes affect a broad range of infrastructure operation and maintenance, with pronounced impacts on water management and quality, affecting residents and businesses dependent on these services and resources.

The Cedar Key Water and Sewer District is the main provider of potable water and wastewater services to the Cedar Key area. The District has two water supply wells between Cedar Key and Sumner, a water treatment facility at the intersection of County Route 347 and State Route 24, and a wastewater treatment facility within city limits on the corner of 3rd Street and C Street.

In the summer of 2012, Cedar Key's water supply experienced saltwater intrusion due to a multi-year drought, and a reverse osmosis water filtration device was installed as an emergency measure to provide safe drinking water. The City of Cedar Key and the Cedar Key Water and Sewer District are in the process of building a new well and water treatment facility, in the same locations, because better sites are not available. Although the drought has ended and the saltwater intrusion episode has passed, the new water treatment facility is being

designed to be able to process a wide range of groundwater quality, including high salinity levels. It is unclear what impacts sea level rise and coastal change will have on salinity levels at the wellfield, so it is important that the facility have flexibility. The facility is also being designed to be elevated outside the 100-year floodplain. Future sea level rise may increase the inland extent of the 100-year floodplain, so depending on the design life of the facility and the rate of sea level rise, the facility may fall within the new 100 year floodplain. Regarding the impact of future development, the City of Cedar Key's comprehensive plan requires coordination with Levy County to limit growth in the immediate aquifer recharge area of the City's water supply. The Cedar Key Water and Sewer District's wastewater treatment facility is located downtown in a low-lying area near the water's edge, making it vulnerable to both potential sea level rise and storm surge.

Water and Sewer Utility

In Sumner and Rosewood, residents and businesses maintain individual water supply wells and septic systems. The project team is not aware of saltwater intrusion in these wells or the impact that future sea level rise may have on the water supplies in these communities; however, the porous aquifer, proximity to the coast, and occurrence of saltwater intrusion in Cedar Key's nearby wellfield suggest that these issues be studied. Sea level rise may affect the water table level and hence septic system performance in some areas, but more research is needed before vulnerability can be assessed.

Fiscal and Economic Vulnerability

Examining the fiscal and economic impacts of coastal change and sea level rise are critical because of Cedar Key-Rosewood's reliance on coastal industries, tourism, and land/infrastructure investments in areas vulnerable to sea level rise and coastal change. While this would warrant a major study beyond the scope of this project, the project team has made a few observations along these lines. Sea level rise would affect the coastal ecosystem upon which the aquaculture, fisheries, and tourism industries depend. For example, increases in water depth and salinity impact oyster reefs and could require changes to clam farming practices. Coastal water quality and the health of the estuaries are also of paramount concern to these industries. Sea level rise would also impact the structures and infrastructure associated with tourism, especially those located on the coast. Tourism is also threatened by the deterioration of the area's character and the loss of cultural and historic resources that may result from storm surge.

Findings and Recommendations: Cedar Key - Rosewood

The economic impacts of coastal change may negatively impact the area's potential for growth, resulting in lower tax revenues, at the same time that the communities face additional costs associated with erosion, storm damage, and adaptation. As mentioned earlier, many parcels are located within FEMA's "V" Zone, which results in higher construction and insurance costs. Homeowners and potential homeowners have concerns about future insurance costs and may be discounting coastal areas.

Dock Street

Property sale posting

Community Input

Cedar Key-Rosewood area leaders, residents, and visitors provided input to this project via two Cedar Key City Council meetings, four public workshops, the summer youth program, project booths at two local festivals, the oral history interviews, and the artists workshop and exhibition. The input included information about coastal change, local values, ideas for adaptation to coastal change, and adaptive capacity (community ability to implement ideas and continue planning).

Community members said that they had observed many changes along the coast and Gulf waters due to what appear to be natural and human causes, which can occur acutely or chronically; and that the impacts can become apparent immediately or emerge over time. For example, cessation of channel dredging may be allowing natural erosion at Piney Point south of the Cedar Key airport, and the construction of a sea wall at the western end of 8th Street may have accelerated beach loss. In response to the project's presentations, community members acknowledged that sea level rise could be playing a role in these changes as well.

The community values centered on several interrelated themes: water, natural landscapes, economy, and community identity. These themes, and community members' specific suggestions for responses, provide direction for adaptation strategies and continued planning and engagement.

View from 8th St. of proposed living shoreline, Cedar Key

Water, broadly considered (in the Gulf, marshes, bayous, rivers, springs, and aquifer), plays many important roles in local daily life and shaping the natural landscapes, economy, and hence community identity, of the area. Water provides the communities with strengths and opportunities, but it also poses significant weaknesses and threats, such as the crisis of saltwater intrusion into drinking water supplies, which the Cedar Key Water and Sewer District experienced during the summer of 2012 (there were also reports of other wells in the area drawing salty water).

Water benefits the communities by providing the foundation of economic welfare, leisure activities, and natural amenities. Many long-time residents make their living through fishing or aquaculture, particularly the clam farming industry. The City of Cedar Key has made major wastewater and storm water infrastructure upgrades and has established land use regulations to enable the aquaculture industry to thrive. New residents and tourists are attracted to the area for its seafood, outdoor recreation activities, and natural beauty. Sport fishing and boating are popular activities. Island residents appreciate being near the water and catching glimpses of it down side streets during their everyday routines. It is thus important to community members to continue to protect water quality and flows, access to the water, and natural shorelines.

With these community concerns, there are multiple contributing threats, with sea level rise being one of them. These values should influence the design of sea level rise adaptation strategies; specific strategies offered by community members were possible adaptation of the Cedar Key wastewater treatment plant (currently located in a low-lying area), incorporation of "low impact development" (LID) principles for storm water management, use of innovative ecological engineering and living shorelines, modified water quality monitoring and rural infrastructure standards in Sumner and Rosewood (e.g., for wells and septic systems), and responsible watershed management and land use of the Suwannee and Waccasassa basins.

Community members had questions about the potential direct and indirect impacts of sea level rise on shellfish, such as oysters and clams, due to changing estuary salinities and water depths, degraded water quality, and ecological changes, and the potential inundation of onshore supporting facilities. University researchers are currently investigating oyster bar collapse, migration, and restoration. Community members' ideas for shellfish fisheries/aquaculture adaptation included proactively maintaining natural overland freshwater flows via land management (e.g., on timber lands), growing shellfish for water quality restoration, treating shellfish if they become mildly contaminated, changing the type of clams grown, and modifying the methods of harvesting clams.

Sea level rise may exacerbate other water-related concerns, including storm flooding, erosion, and saltwater intrusion. The complexities and dynamics of the natural and man-made systems make it difficult to predict future timing and locations of flooding, erosion, and saltwater intrusion; however, community leaders and residents are interested in incorporating extra measures into infrastruc-

ture design on a project-by-project basis to improve its robustness and resilience. For example, the Cedar Key Water and Sewer District recently designed a new water treatment facility to handle a wide range of aquifer water quality, and to be elevated higher for storm surge adjusted with sea level rise. Residents were also interested in innovative techniques to minimize erosion in vulnerable areas, such as "geotubes," which are large sand-filled fabric rolls.

New model homes -Cedar Key

Community members value the iconic Gulf "Big Bend," "Cedar Keys," and "Suwannee" natural landscapes and wildlife, as expressed in their words, art, and activities. They are aware of the changing natural landscape of the Cedar Key-Rosewood area, including the numerous topless palm trees adjacent to the salt marshes, which are indicative of sea level rise impacts. Community members also reported variability in mangroves over the past decades, and the establishment of the cold intolerant red mangrove, which may signal a warming climate. Residents emphasized their desire for more natural methods of shoreline stabilization, and strategies to allow the migration of habitats, such as marshes and mangroves, on private lands. Balancing natural processes and the maintenance of properties and human presence along the shore will require sophisticated and innovative designs, practices, and institutions.

Cedar Key community members expressed that the current flood risk was affecting property insurance rates, the patterns of new construction, and the local economy. One person said that very few houses had been built in the last five years because of the high cost of constructing to the standards of the newer building codes. Another resident commented that houses were raised so high that older residents have difficulty going up and down the stairs. This person also wondered whether past sea level rise had changed the zones where Cedar Key should allow new houses to be constructed. Another community member described the need to reimagine the kinds of buildings and economic activities in Cedar Key's historic downtown commercial district along 2nd Street in light of the constraints imposed by the flood risk. In Sumner and Rosewood, residents and business owners wanted to understand how flood risk might change with future sea level rise.

The economic, financial, and fiscal dimensions of coastal hazards and sea level rise impacts and adaptation were especially prominent in the minds of Cedar Key residents. They were concerned that individual property owners and their local governments would not be able to pay for the needed strategies. Residents thus recommended ongoing planning to include benefit-cost analyses, at individual and community levels, and for the short and long terms. Such studies should include modeling of the effects on local and regional economies. Residents also recommended that local information be provided to the market to send better price signals of risk, such as through "buyer beware" practices. More so than local planning and factors, community members expected future state and federal policies to have a strong bearing on the price of coastal development, and thus its extent. They also realistically questioned the fate of Cedar Key if it were struck by a devastating hurricane.

Community identity is what the Cedar Key residents said they valued most about their community and want to maintain amongst the change. Community identity is an emergent property of the people, economy, and landscapes of the Cedar Key-Rosewood area. Community identity can be divided into sense of place and sense of community. The strong sense of place comes not only from the water and landscapes, economies, and lifestyles, but also from the special, rich history, which is kept alive through historic remnants (such as buildings, railways, and Native American artifacts), storytellers (such as writers and museums), and long-time residents. The sense of community stems from the small town population, member diversity (especially across ages and income levels), shared experiences and services (e.g., the Cedar Key School), local leadership, organizations, caring citizens, and daily interactions (e.g., meeting on the street).

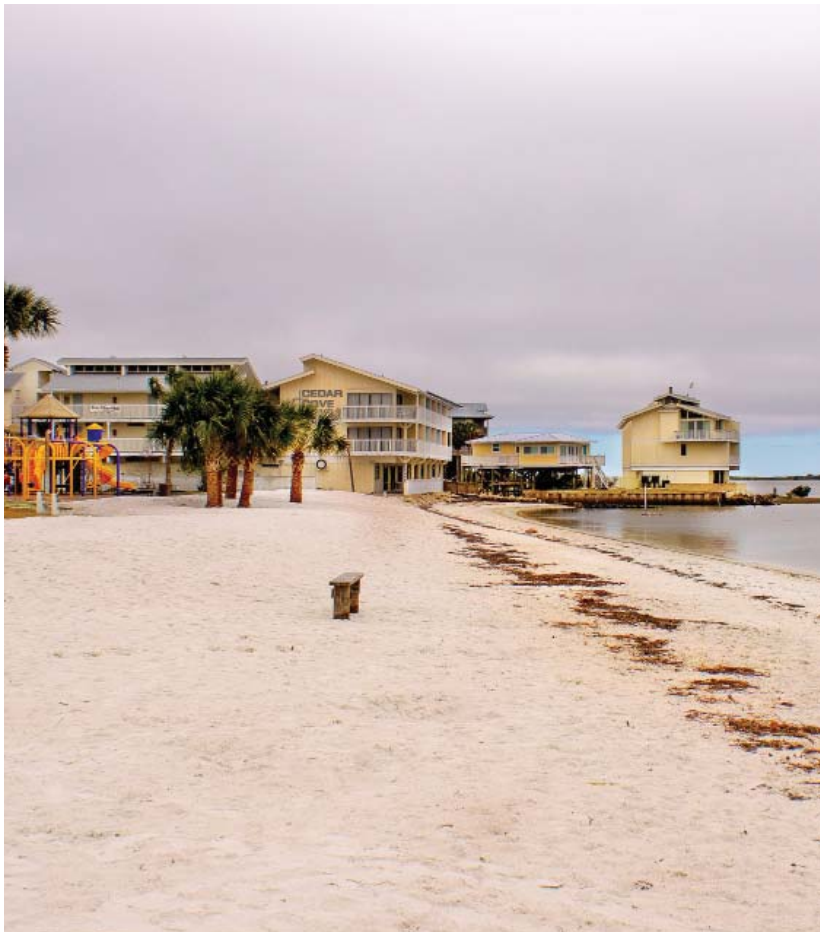
Cedar Key school

The community identity of Cedar Key has changed over time, and it is important to clarify which aspects are flexible and which are critical to maintain. Higher-end residential construction over the past few decades has driven up property values and taxes, and lower income community members, many of whom worked in the natural resources (such as commercial fishing or aquaculture) moved to the Sumner-Rosewood area or elsewhere. Cedar Key community members believed that this shift was a social and

cultural loss for the island. A similar, undesired shift in island character has occurred as newer residential construction has been raised on high stilts.

Through Cedar Key leadership, the town continues to reach out to the Sumner and Rosewood families by offering their children enrollment in the Cedar Key Summer Youth Program. Although these children live inland, they have a strong connection with the islands and coast, because they attend school in Cedar Key, they visit Cedar Key, and their parents work in the Gulf. The economically motivated migration to Sumner and Rosewood is an interesting case for comparison to the potential planned relocation or steering of future development away from vulnerable areas in Cedar Key. There are also persons who are active in the Cedar Key community but live outside Cedar Key-Rosewood (e.g., in the Fowler's Bluff community along the Suwannee River). For public workshop participants, planned relocation to less vulnerable areas was a viable long-term strategy, provided community identity and access to natural amenities could be maintained through thoughtful planning/design, economic, and social means.

Through the many changes and crises the people of the Cedar Key-Rosewood area have faced, including hurricanes, natural resource depletion, the net ban, the BP Gulf oil spill, saltwater intrusion, and large-scale economic and demographic trends, they have adapted. Following the BP Gulf oil spill, researchers sought to understand what makes communities like Cedar Key resilient. One feature is that they accept change while keeping the core of what matters, such as community. The children in the Cedar Key Summer Youth Program demonstrated this philosophy when they were asked to describe what happens to Cedar Key's public beach and park if it is inundated by future sea level rise. Their answer was to turn it into an underwater playground accessible by scuba.



Cedar Key City Park (Juan Castillo Jr.)

Adaptive Capacity

A community's long-term resilience, or "adaptive capacity," enables it to not only withstand but also adjust to coastal change. Adaptive capacity is necessary to conduct future planning, including the selection, design, and implementation of adaptation strategies. Information about the adaptive capacity of Cedar Key-Rosewood can be used to design adaptation strategies with greater local support and potential of being implemented. On the flip side, barriers to adaptation, constrained options, and lack of resources lower adaptive capacity.

Physical Adaptive Capacity

The resilience of some existing buildings in Cedar Key is of concern, because they do not meet FEMA hazard mitigation standards, and this has put the Community Rating System (CRS) out of reach. The current and future built environment in Cedar Key has the capacity to adapt to changing coastal conditions through the use of infill, redevelopment, structural adaptation, and living shoreline practices. As current structures age and need to be renovated or replaced, these structures can be better adapted to changing conditions. Some structures on Cedar Key, including older historic structures, are built on piers, and it is possible to raise them. Vacant residential parcels are available in higher elevation areas.

Infrastructure, including roads and water systems, will need to be adapted to changing conditions. Depending on when a given system was built, and the issues faced and budget available at the time, systems have varying levels of robustness. State Route 24, which is the only access road for Cedar Key, is vulnerable to sea level rise and storm surge. Many roads and bridges on the islands of Cedar Key are low-lying. Airport Road is the only access road for the airport and the people living to the west side of Daughtry Bayou. Near the downtown area, the road network is in a grid, thus alternative routes are available. The Cedar Key stormwater management system was modernized; however, the City has to carefully manage its small budget to pay regular maintenance of the system. The City is less vulnerable to water quality issues due to the centralized wastewater treatment plant,

Cedar Key street grid (https://google.com/maps, 2013)

but the plant's location in a low-lying area on the island raises questions about how the plant will function during a major storm or over the long-term with sea level rise. There are several locations suitable for living shorelines, and planning for a pilot project is underway.

The ability of Cedar Key's natural environment to adapt to coastal changes is limited by existing development. In Cedar Key, a number of structures and roads are built very close to the shore, particularly along G Street, Airport Road, and State Route 24. In other areas of Cedar Key, development occurs within a few hundred feet of the coast. Raised buildings, however, could provide a means for habitat migration and more natural, low-impact approaches to infrastructure and hazard mitigation.

The physical environment, both built and natural, in Sumner and Rosewood has more adaptive capacity than Cedar Key due to land availability. The lands to the west, north, and south of Sumner and Rosewood are intermixed with wetlands with the driest land being located between these two communities. Sumer and Rosewood have a number of parcels designated as FEMA's moderate flood hazard areas, which provides opportunity for infill development in less vulnerable areas than high hazard areas. A growing population, and possibly relocating Cedar Key residents and businesses, can move to this area, while maintaining a connection to the coast. The area around Sumner and Rosewood has two state parks that have limited development and provide space for habitats and species to retreat inland with sea level rise.

Legal and Political Adaptive Capacity

Cedar Key leaders are aware of the area's vulnerability to coastal hazards and sea level rise, as well as the necessity of protecting the natural resources, and a number of proactive local policies are in place. These policies focus on maintaining the working fishing village and providing for the use and enjoyment of natural and cultural resources, while protecting residents' health, safety, and welfare.

As an incorporated coastal town with a comprehensive plan and development regulations, Cedar Key has experience managing land use and project expenditures within coastal hazard areas. The City requires new construction and major renovations to meet FEMA design and construction standards within Coastal High Hazard Areas, which includes building above the base flood level in FEMA's "V" zones. On the other hand, community members commented that FEMA regulations limit innovation in building types, such as floating houses.

The City prohibits development seaward of the Coastal Construction Setback Line, which is defined as 50 feet landward of the Mean High Water Line. The Mean High Water Line is determined when the development is proposed and is therefore responsive to sea level rise. The Comprehensive Plan indicates that the City will only maintain, not expand, existing capacity and facilities within the coastal high hazards area, with the exception of projects that are or support water-dependent facilities.

Findings and Recommendations: Cedar Key - Rosewood

Cedar Key policies provide direction on preferred methods for protecting the shoreline. The comprehensive plan limits the use of vertical coastal armoring and allows its use only to protect existing endangered structures and beach restoration/preservation structures. Preference is given to maintaining the natural state, but the comprehensive plan supports the use of living shoreline practices. The City maintains the natural state by protecting the coastal vegetation and limiting the percentage of vegetation that can be removed in the area 500 feet landward of the Coastal Construction Setback Line.

Cedar Key's regulations favoring low density development may limit the ability to accommodate growth or relocation in less vulnerable areas. The Laws of Cedar Key provide for high density residential land use districts of 24 units per acre; however, low density residential with a maximum of five units per acre is prevalent. The regulations provide density bonuses for building low to moderate income housing, which are capped at 14 units per acre. Infill construction is limited to the same average density as the development abutting the property.

Within the context of water adaptive capacity, both the City and Sewer and Water District prioritize maintaining good water quality, access to clean drinking water, and water conservation. For example, the comprehensive plan requires new development to conform to available water supplies and treatment capacities, thus limiting issues of overdevelopment threatening the water supply (see Potable Water sub-element of the City of Cedar Key's Comprehensive Plan), and it promotes the use of low impact development (LID) practices for new development. The Cedar Key Land Development Code requires that new and replacement water supply and sanitary sewer systems shall be designed to minimize or eliminate infiltration of floodwaters into the system. Such policy measures can help improve the resilience of Cedar Key's water infrastructure to sea level rise.

The legal and political adaptive capacities of the unincorporated areas of Cedar Key, Sumner, and Rosewood are tied to the Levy County comprehensive plan and land use regulations. The concentrated, fairly isolated, and mixed residential and commercial development of these areas would make them suitable for a special area plan within the Levy County comprehensive planning framework. This could be a vehicle for gaining a better understanding of local conditions and community members' values and preferences in these areas, and to coordinate with the City of Cedar Key for adaptation planning. For more information about county policies, see the Levy County section of this report.

Technical, Financial and Civic Adaptive Capacity

Cedar Key's resilience is largely driven by civic adaptive capacities, combined with access to organizational, technical, financial, and training resources. Two examples illustrate these interrelated capacities. First, in the early 1990s, a housing development was proposed for Atsena Otie, which is the island that was occupied by the townspeople prior to the hurricane of 1896. In response, a local group, Florida's Nature Coast Conservancy, led a successful drive for public acquisition of the island. Second, in the late 1990s, when Cedar Key residents were reinventing their economy after the statewide gill net ban dramatically reduced commercial fishing, local citizens formed the Cedar Key Water Alliance to focus on water quality issues to enable the clam aquaculture industry. The group worked with elected officials and agency representatives to plan major improvements to the stormwater and wastewater treatment systems, including the replacement of all septic tanks in the community with connections to the centralized wastewater system, and the creation of water conservation policies; citizens also monitored the Gulf waters as part of a university-agency program, because they recognized the potential for regional sources of water pollution such as from the Suwannee River Basin (Colson & Sturmer, 2000).

Local residents' strengths come from community ties and sense of place, personal character, and "a willingness to adapt" (Colson & Sturmer, 2000, p. 477). Additionally, many residents have substantial educations and professional backgrounds, and they often have time to devote to community service. Furthermore, Cedar Key-Rosewood residents have close ties with the University of Florida extension and research, and state and federal natural resource agencies.

Challenges to civic adaptive capacity include new residents who may not understand coastal dynamics, such as how storms move sediments. In these cases, property owners quickly react to protect their land through hard armoring, which makes the problems worse elsewhere; whereas without action, the sediments may have returned. Also, newcomers may not be as attached to the community, and they may leave after hard times or not invest in proactive, long-term adaptation strategies.

Cedar Key's small budget limits its adaptive capacity, and residents are justifiably concerned about the costs of planning and implementing adaptation strategies. In fiscal year 2012, Cedar Key's tax revenues decreased due to decreasing property values, and the City experienced decreased federal grant revenue (Purvis Gray & Company, 2012). The City anticipates higher tax revenues for 2013-2014; however, this reflects a higher millage rate (City of Cedar Key, 2014).

The small City staff also limits adaptive capacity. The City has a manager, clerk, two part-time staff members, and a part-time building inspector. The City's laws describe the duties of the planning and development department, which is headed by an administrator, who primarily performs development review and code enforcement. Adaptation planning and implementation take additional time

that staff may not have available.

Less is known about the civic capacity of unincorporated Sumner and Rosewood, such as residents' sense of community or place, and how organized they are with regard to community issues. Churches and economic endeavors may bring people together. University of Florida researchers have studied the area's history, but there does not seem to be any attention on the current residents. Levy County is in the process of updating its comprehensive plan, which includes an inventory of existing geospatial data. However, this coastal change project determined that there is limited information available about rural issues in Levy County, particularly with regard to groundwater quality.

Recommendations for Adaptation

Graduate students in the Spring 2013 "Urban Design" course led by Dr. Joseli Macedo generated the following recommendations of adaptation strategies, as well as other improvements for the built environment, for the Cedar Key-Rosewood area. The students based their recommendations on two public workshops the class hosted in Cedar Key, the class' information booth at the Cedar Key arts festival, prior information and public input gathered by the project, the students' case studies of sea level rise adaptation in the United States, and an analysis of Cedar Key-Rosewood. The aspects analyzed included local information, patterns of the built environment (i.e., "urban form"), and low-lying areas vulnerable to sea level rise and coastal hazards. Each student made recommendations focused on a sub-area of Cedar Key and the Sumner-Rosewood area.

Students discuss recommendations in studio

The students' recommendations touched upon several approaches, many of which corresponded to the community input and aspects of adaptive capacity discussed above. Unless specified, the recommendations were mainly targeted to Cedar Key, although they may apply to any vulnerable area.

The students' most straightforward recommendations for adaptation to sea level rise were strategies associated with reducing vulnerability to coastal hazards. These "local mitigation" strategies consisted of elevating buildings, retrofitting critical buildings for storm "hardening," stabilizing shorelines, and controlling development in hazard prone areas.

Beyond traditional local mitigation strategies, the recommendations included ecological engineering of the shoreline, using "geotubes" (textile tubes filled with sand and covered to resemble dunes) and planted mangroves. The students described the functions of the mangroves to buffer storm surges, stabilize/build soils, and provide wildlife habitat.

To enhance stormwater management, a specific low-impact development practice - bioswales - was suggested. Bioswales replace ditches near impervious surfaces to allow rainwater to soak into the ground slowly, thus reducing street flooding and the amount of water running into the ocean. The ditch along First Street is one place that

could be converted into a bioswale.

The protection and migration of wildlife habitat and natural processes was also a goal for adaptation strategies. For important and migrating habitats, the students recommended the use of low-impact infrastructure, such as raised boardwalks rather than roads or sidewalks, and the managed retreat of structures. The dynamics of the natural environment in response to sea level rise, combined with local efforts to accommodate habitat migration and incorporate "green infrastructure," serve as the focus of an outdoor education center or exhibit for the public.

In addition to suggesting where new development should not go (vulnerable areas), the students recommended that land use policies and neighborhood designs in the safer areas be revised to accommodate higher densities and other amenities. New development (in-fill) and redevelopment are opportunities to incorporate the latest ideas in neighborhood design, such as beautification, street or path connectivity for walkability, mixed uses (residential, commercial, and parks) for conveniences, and affordable housing.

Perhaps the most innovative recommendation was the use of alternative transportation modes, particularly boats driven between existing docks, at times that roads are flooded. This recommendation is innovative, because it breaks free of the mindset that the solution to a flooded road is a more robust road. Adaptation strategies can be different and occasional.

In Sumner and Rosewood, the students recognized the unique rural character, which is different than Cedar Key. Given the constraints imposed by significant floodplains, wetlands, conservation lands, and water supply concerns, the students recommended that future development incorporate principles or "rural conservation design." Rural conservation design standards promote compact, mixed use village centers, buildings with little setback along primary streets, and residential clusters around the village center that are based on landscape characteristics to provide open space, ecological services, and rural character. This style of development would mainly occur on the north side of State Route 24.

The students' final workshop poster graphics are presented below (see Figures 41-45).

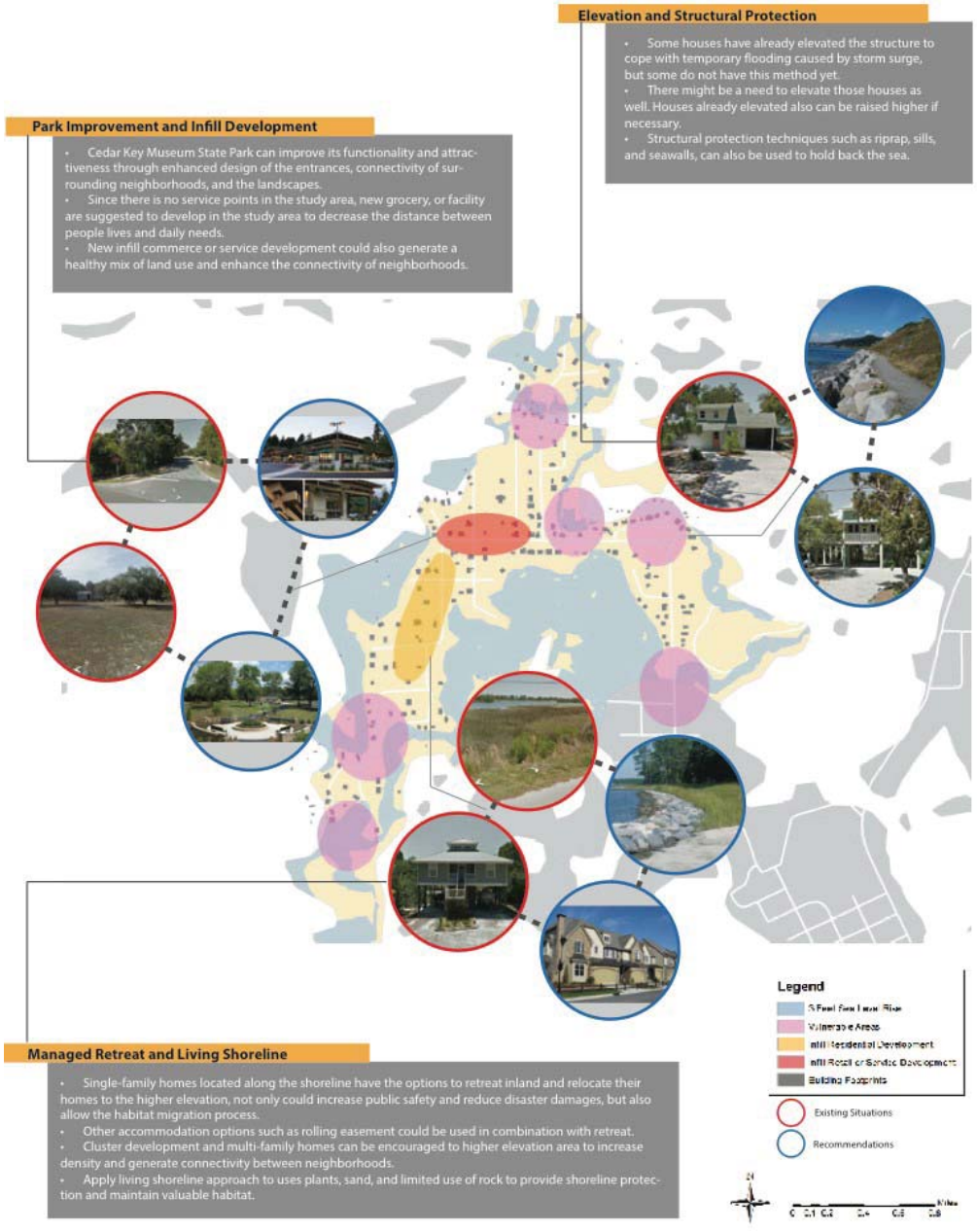


Figure 41: Recommendations for Northwestern Cedar Key by Rong Zeng

Findings and Recommendations: Cedar Key - Rosewood

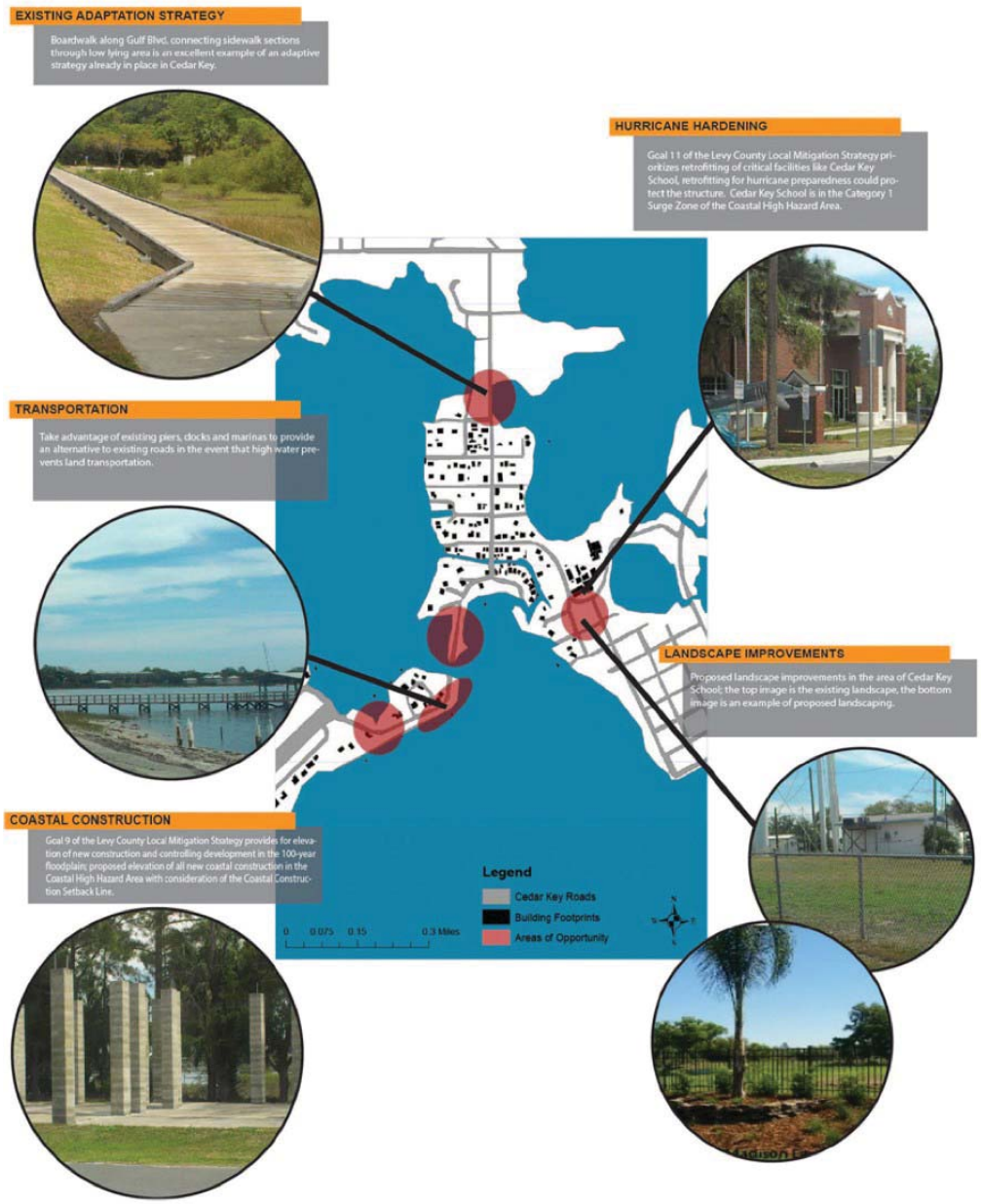
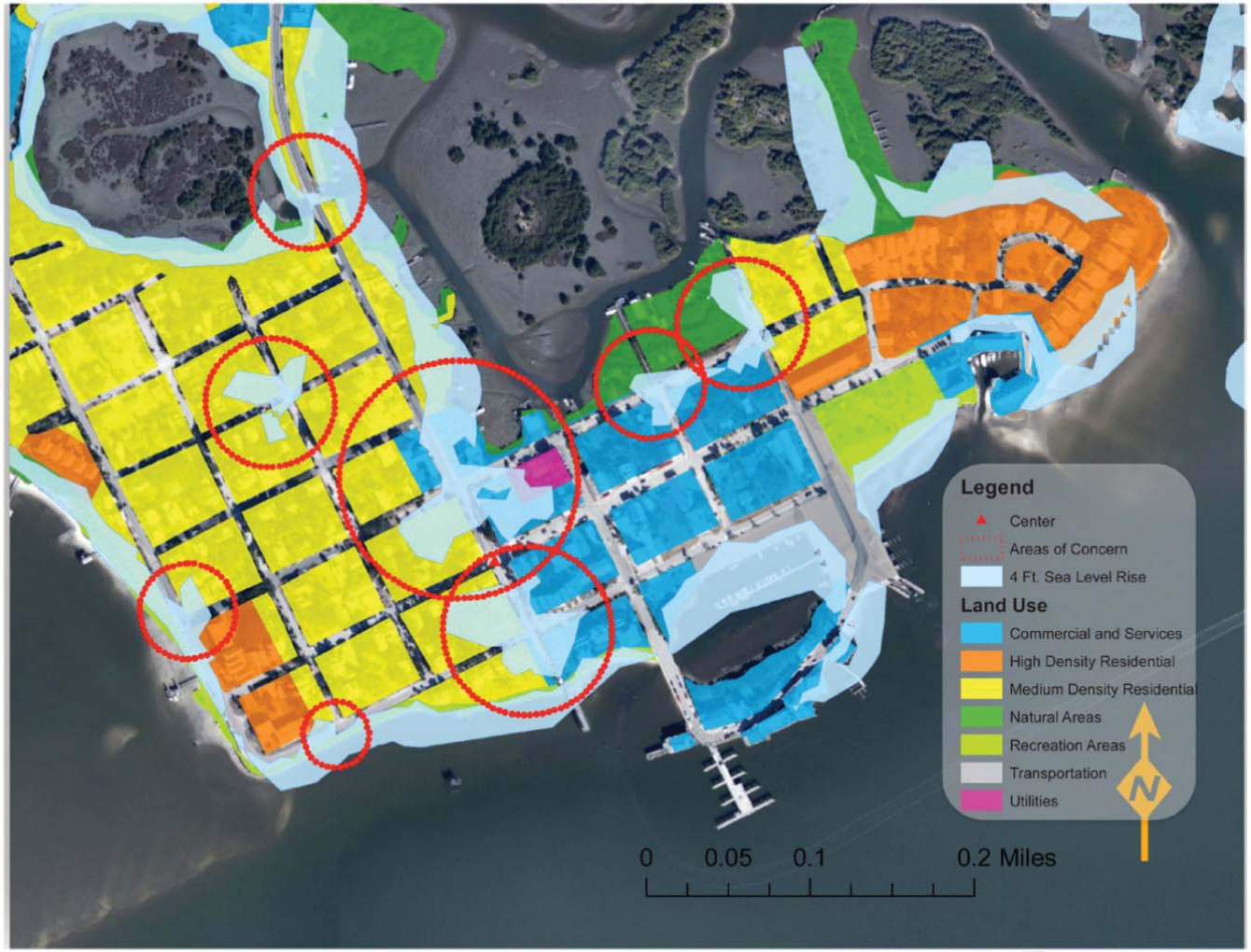


Figure 42: Recommendations for Central Cedar Key by Karlin Warketin

Figure 43: Recommendations for Eastern Cedar Key by Valerie Voight

Findings and Recommendations: Cedar Key - Rosewood



Adapting to Change

- The majority of water encroachment due to sea-levels rising happens in areas zoned for Commercial and Services
- Special attention should be made to:
  - SR 24 at 1st &3rd street intersections, and bridge before Whiddon Ave
  - Moving services like grocery store and utilities to higher elevations
  - Densify commercial district

Figure 44: Recommendations for Eastern Cedar Key by Mario Duron

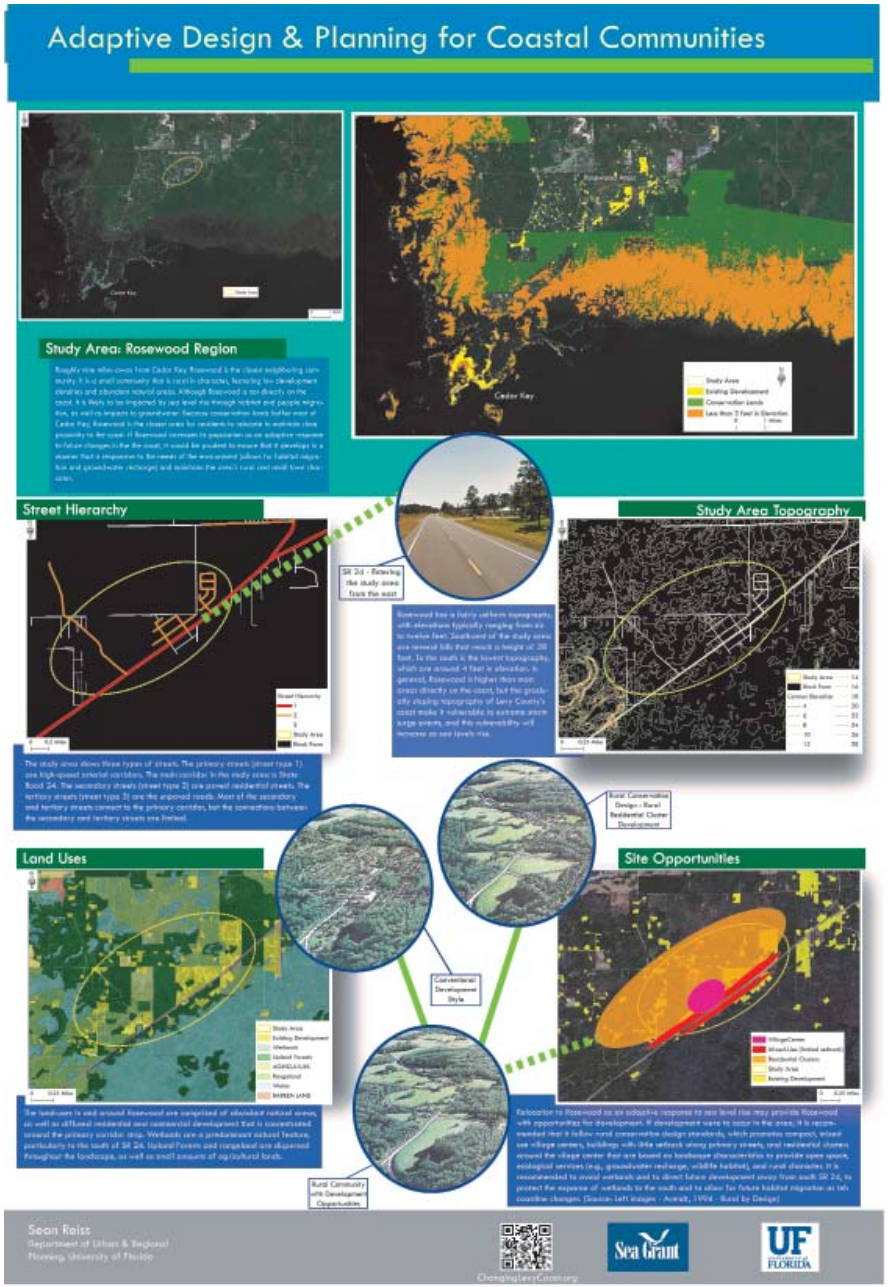


Figure 45: Recommendations for Sumner-Rosewood by Sean Reiss

Cedar Key - Rosewood Conclusion

Since the Cedar Key-Rosewood area is already experiencing coastal changes and is vulnerable to storm surge and sea level rise, the community needs to develop an integrated, holistic adaptation plan to reduce the risk to human health and property. Following the work begun by this project, future planning should continue to involve the public, local leaders, and experts. University and state resources can be leveraged to help with the expenses of planning and adaptation. Recently, Florida Sea Grant funded a new University of Florida project, Reimagining the Form of Rural Coastal Communities in Response to Sea Level Rise, which focuses on the creation and testing of a collaborative and integrated framework of sea level rise planning in the Cedar Key-Rosewood area. This provides the opportunity for the project team to build upon and extend the work begun during this project. Community members have demonstrated resiliency during past physical, economic, and social changes. By continuing to move forward in their planning efforts, they have the opportunity to serve as a model for the rest of the Gulf Coast and Florida.

A view of Cedar Key's wetlands


Welcome To
YANKEETOWN MARINA
& TACKLE SHOP
SAVE YANKEETOWN

Yankeetown - Inglis

This section examines the potential impacts of sea level rise within the communities of Yankeetown and Inglis, reports community input received, describes adaptive capacity in each town, and identifies potential strategies for adaptation.

Overview of Yankeetown and Inglis

Yankeetown and Inglis are adjacent small towns located along the Withlacoochee River in the southwestern corner of Levy County (see Figure 46). The Withlacoochee River is the dividing line between Levy County to the north, and Citrus County to the south. The portion of Levy County where Yankeetown and Inglis are situated is low lying and rural in nature, with extensive undeveloped coastal forests and wetlands. Upland areas surrounding the two towns are generally undeveloped and consist of conservation, timber, and some low density residential or commercial uses, and these lands have been designated as having high conservation priority and importance for ecological connectivity (Oetting, Hoctor, & Volk, 2014).

Yankeetown

Yankeetown has a population of about 500 people and an area of approximately 21 square miles. Of this, 7.6 square miles is land, and 13.4 square miles is water or wetlands (U.S. Census Bureau, 2010b). Situated with its southern edge along the Withlacoochee River and its western edge on the Gulf of Mexico, a large portion of the undeveloped lands within the town boundaries consist of wetlands and conservation areas. These include the Withlacoochee Gulf Preserve, a 413 acre coastal preserve owned by the town, and managed for educational and resource conservation uses (FWGP, 2010).

Izaak Walton Lodge

The developed portion of the town consists primarily of residential land uses, civic, and commercial uses, with the most densely populated area situated along the Withlachoochee River on the southwest corner of town. This area includes a number of historic structures, as well as civic buildings and commercial uses. Additionally, there are less densely developed upland areas in the

Findings and Recommendations: Yankeetown-Inglis

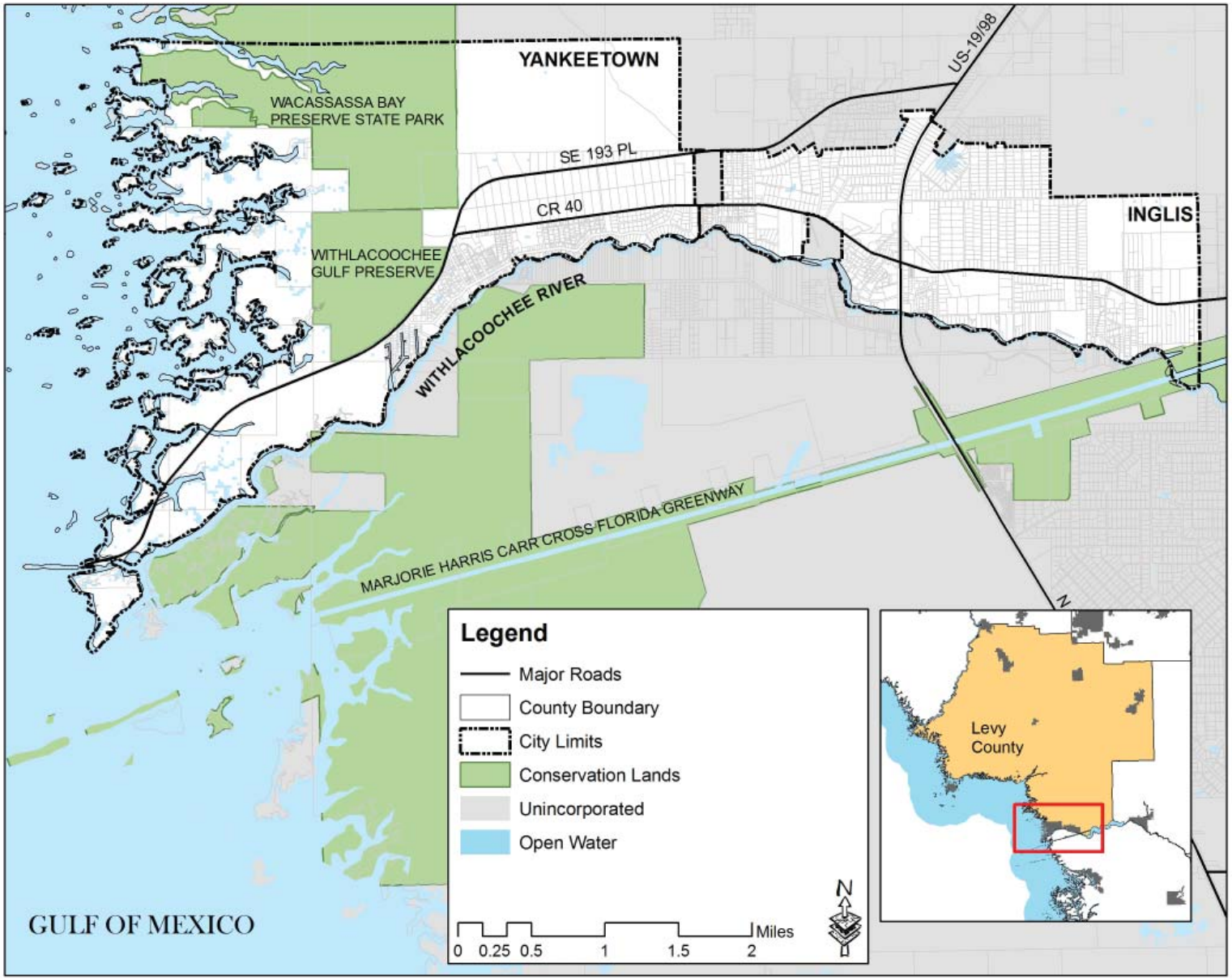


Figure 46: Towns of Yankeetown and Inglis

northeast portion of the town, which include additional residential and commercial uses, as well as public utilities. Primary access to the town are via County Route 40 and SE 193rd Place, both of which connect to US 98 running north-south. Construction, manufacturing, transportation, and entertainment/recreational jobs (such as ecotourism) are the primary types of employment for residents, (see Figure 47) though the area has a low per capita income and low earnings per job compared to the rest of the state. A large percentage of residents in Yankeetown are also seasonal or retired.

Inglis

Inglis lies directly to the east of Yankeetown, with its southern edge bordering the Withlacoochee River. The town covers approximately 3.67 square miles. It has a population of approximately 1300, primarily employed in education/healthcare, entertainment/recreation, and construction industries. (see Figure 47).

Primary access to Inglis is via US 98 and County Route 40. These roads are the main low density commercial corridors running through town, with US 98 creating a major division between the eastern and western portions of Inglis. Surrounding these corridors are primarily low density residential, strip commercial development, and vacant residential or commercial land uses. The Cross Florida Barge Canal and Cross Florida Greenway lie directly to the south and cut through the southeastern portion of the town. In general, Inglis is at a higher elevation than Yankeetown. Undeveloped upland areas are generally dry, including mixed hardwoods and coniferous ecosystems, and hydric habitats directly along the Withlacoochee River.

Historic home in Inglis

Inglis-Yankeetown Municipal Service District

Yankeetown and Inglis both also have unincorporated lands adjacent to the city limits that are included in the Inglis-Yankeetown Municipal Service District (see Figure 48). These areas are intended for future town expansion, with infrastructure and services provided or encouraged to support development (Levy, 2011a). In addition to areas within the Municipal Service District where development is encouraged, tourism and retirement interests are

creating the potential for increased development in flood-plain areas near the water due to sports and recreation (FEMA, 2012a).

Both Yankeetown and Inglis are important rural communities in Levy County, with significant assets and cultural, historic, and natural resources, which need to be considered in the face of future sea level rise. An understanding of vulnerability, adaptive capacity, and options for adaptation is necessary so that planners can proactively move forward to address the impacts from future coastal change in these communities.

Industry by Occupation for the Civilian Employed Population 16 Years of Age and Over					
	Inglis			Yankeetown	
Total Employed Population	405			211	
Agriculture, Forestry, Fishing/Hunting, and Mining	8	2%		9	4%
Construction	44	11%		47	22%
Manufacturing	23	6%		29	14%
Retail Trade	42	10%		18	9%
Transportation, Warehousing, and Utilities	43	11%		23	11%
Information	9	2%		0	0
Finance and Insurance, Real Estate	30	7%		16	8%
Professional, Scientific, and Management	28	7%		12	6%
Education, Health Care and Social Assistance	53	13%		17	8%
Arts, Entertainment, Recreation, and Food Services	46	11%		26	12%
Public Administration	35	9%		6	3%
Other Services	44	11%		8	3%
			Source: US Census Bureau, 2007-2011 American Community Survey		

Figure 47: Employment statistics for Yankeetown and Inglis

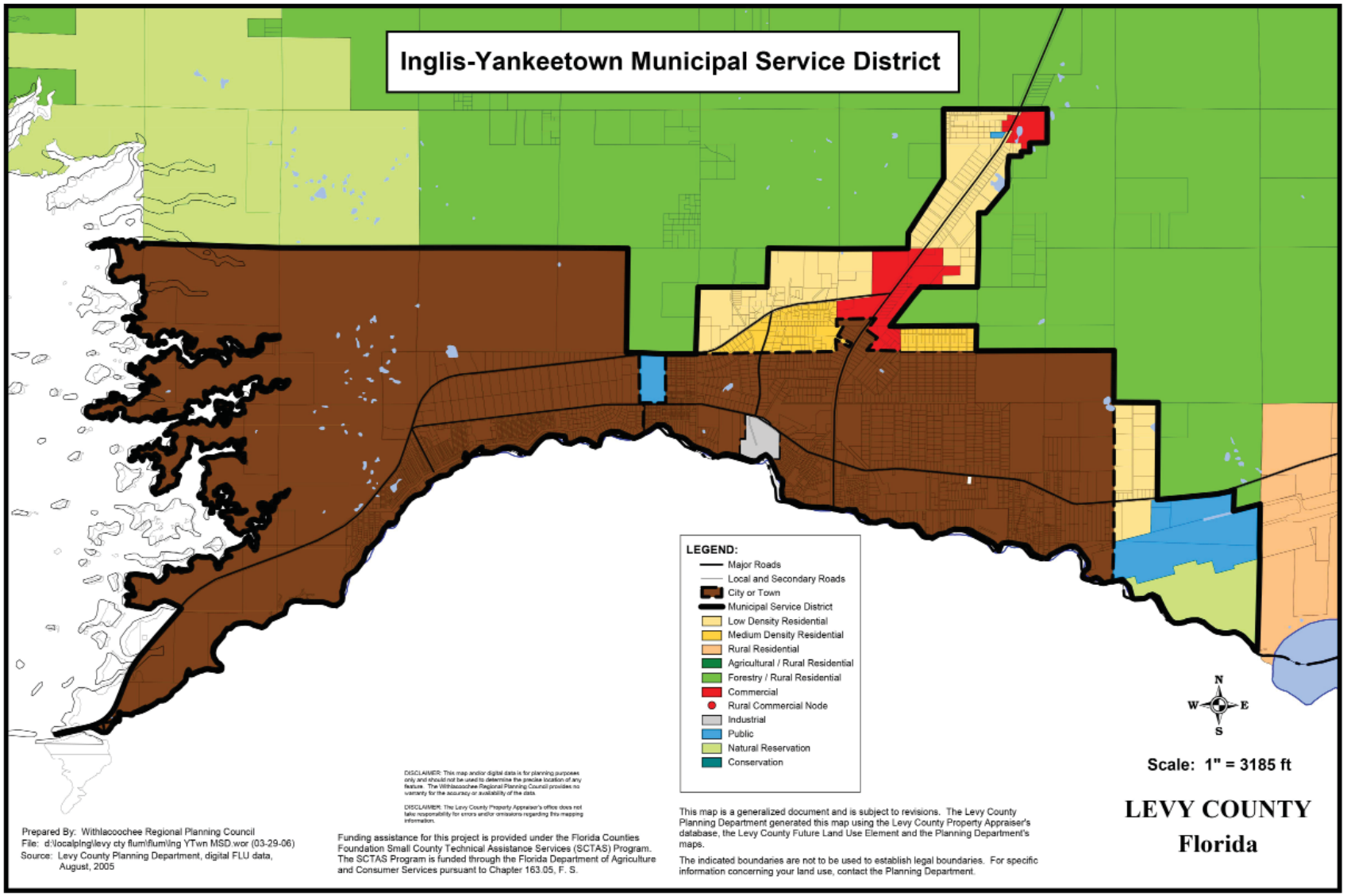


Figure 48: Inglis-Yankeetown Municipal District (http://www.levycounty.org/Planning/map-inglisyankeetown-msd.pdf)

Vulnerability to Sea Level Rise

Understandings of the elevation, ecology, storm surge, and geology/hydrology of Yankeetown and Inglis are critical for identifying potential future vulnerabilities and impacts from sea level rise and coastal change. The following sections summarize vulnerability based on these various components. Yankeetown and Inglis are analyzed separately, as each have unique characteristics and vulnerabilities.

Vulnerability Based on Elevation

A map showing elevations in Yankeetown and Inglis is shown in Figure 49. The areas closest to the Gulf are especially low lying (darkest green in the figure), and these are the locations where future impacts from sea level rise will likely be the most immediate and dramatic. The coastal landscape has a fairly rapid elevation gain to the east of Inglis, thus providing a location relatively close to the coast that has less exposure to sea level rise and other coastal hazards. However, the majority of Yankeetown and Inglis are low-lying and the region in general is characterized by a shallow coastal gradient. This means that the impacts of sea level rise will be felt farther inland than they might otherwise.

As discussed earlier in this report, the potential impacts from a 3 foot sea level rise scenario were assessed within Yankeetown and Inglis. Based on current sea level rise projections, these areas are the most likely to be impacted by land cover change and flooding by 2100, although other impacts such as erosion, saltwater intrusion, and greater vulnerability from storm surge will affect additional upland areas. It is also important to note that additional areas beyond the 3 foot elevation line will be impacted during high tides, possibly affecting areas beyond a 5 foot elevation.

The majority of the acreage below a 3 feet elevation falls within Yankeetown and is undeveloped or in conservation. This indicates that perhaps the greatest impacts from sea level rise will, at least initially, be to the coastal natural habitats adjacent to Yankeetown. In addition, the elevation model indicates that the historic core of Yankeetown will be highly impacted. The developed areas of Inglis are less vulnerable to inundation, but the coastal areas in both towns that lie along the Withlacoochee River are likely to be impacted.

Vulnerability Based on Ecological Modeling (SLAMM)

Sea Level Affecting Marshes (SLAMM) data, given to the project by The Nature Conservancy, were used in Yankeetown and Inglis to further quantify the impacts and potential changes to land cover resulting from a 3 feet rise in sea levels by the year 2100. In contrast to a simple bathtub inundation model, SLAMM provides a nuanced picture of natural area changes in areas with shallow coastal gradients and extensive marsh or other coastal habitats. In particular, SLAMM is able to identify areas affected by a given amount of sea level rise that are likely

to convert to marsh or another coastal habitat type.

In the Yankeetown-Inglis area, SLAMM predicts extensive conversion of upland areas to wetlands, and a smaller amount of upland conversion to open water. We expect that these new wetlands will be less suitable for new or existing development. In Figure 50, the projected new wetlands are shown in light green, with existing wetlands represented in the darker green. Most of the impacts projected by SLAMM will occur in the low-lying historic portions of Yankeetown, similar to the impacts indicated by the bathtub model. However, rather than assuming this will be continuously inundated, SLAMM indicates that these areas could gradually become more wet, flood prone, or flooded entirely, with shifts from dry uplands to wetlands. This is a major planning issue for Yankeetown, since the areas projected to be impacted currently are not only those most densely populated, but also include the most culturally and institutionally significant portions of the town. For Inglis, the impacts will occur along the Withlacoochee River.

Vulnerability Based on Flood Zones and Storm Surge

Much of Yankeetown and Inglis are already vulnerable to flooding from rain events, abnormal tides, and storm surges. Of these, flooding from tidal events typically associated with tropical storms, depressions, or strong and sustained southwesterly winds is currently the most dangerous (FEMA, 2012a). With small exceptions, the entire Town of Yankeetown lies within the 100-year floodplain. Low lying areas with elevations less than 5 feet already experience frequent tidal flooding (FEMA, 2012a). The locations of FEMA "V" and "A" flood zones within the two towns is shown in Figure 51.

Figure 52 shows areas modeled to be inundated by a 100 year storm surge in Yankeetown and Inglis at current sea level. Storm surge inundation will intrude farther inland as sea levels rise. However, even at current sea level, it is clear that all of Yankeetown and much of Inglis are highly at risk from a 100 year surge. As part of the report on the 2012 Discovery Project, the Federal Emergency Management Agency (2012) states that in Yankeetown, storm surge problems are "exacerbated by the lack of adequate outfall and drainage infrastructure. Low-lying areas become filled with water as a result of abnormal tides or because of heavy rainfalls. Once filled, they are unable to drain and they must rely on evaporation and slow percolation for relief. In such situations, septic tanks become inoperable and the mosquito population increases dramatically" (p. 27). An additional concern is the vulnerability of transportation corridors providing access to the communities. There are two primary roads providing access to Inglis and Yankeetown: CR 40 and US 98. If these roads are made inaccessible by a storm, provision of emergency support to the communities would be extremely difficult. Generally, the existence of unpaved residential streets is a risk for both Yankeetown and Inglis, in that they make evacuation more difficult in the case of a storm (Levy, 2011b).

In addition to problems associated with the built environment, coastal habitats along the Gulf Coast adjacent to

Findings and Recommendations: Yankeetown-Inglis

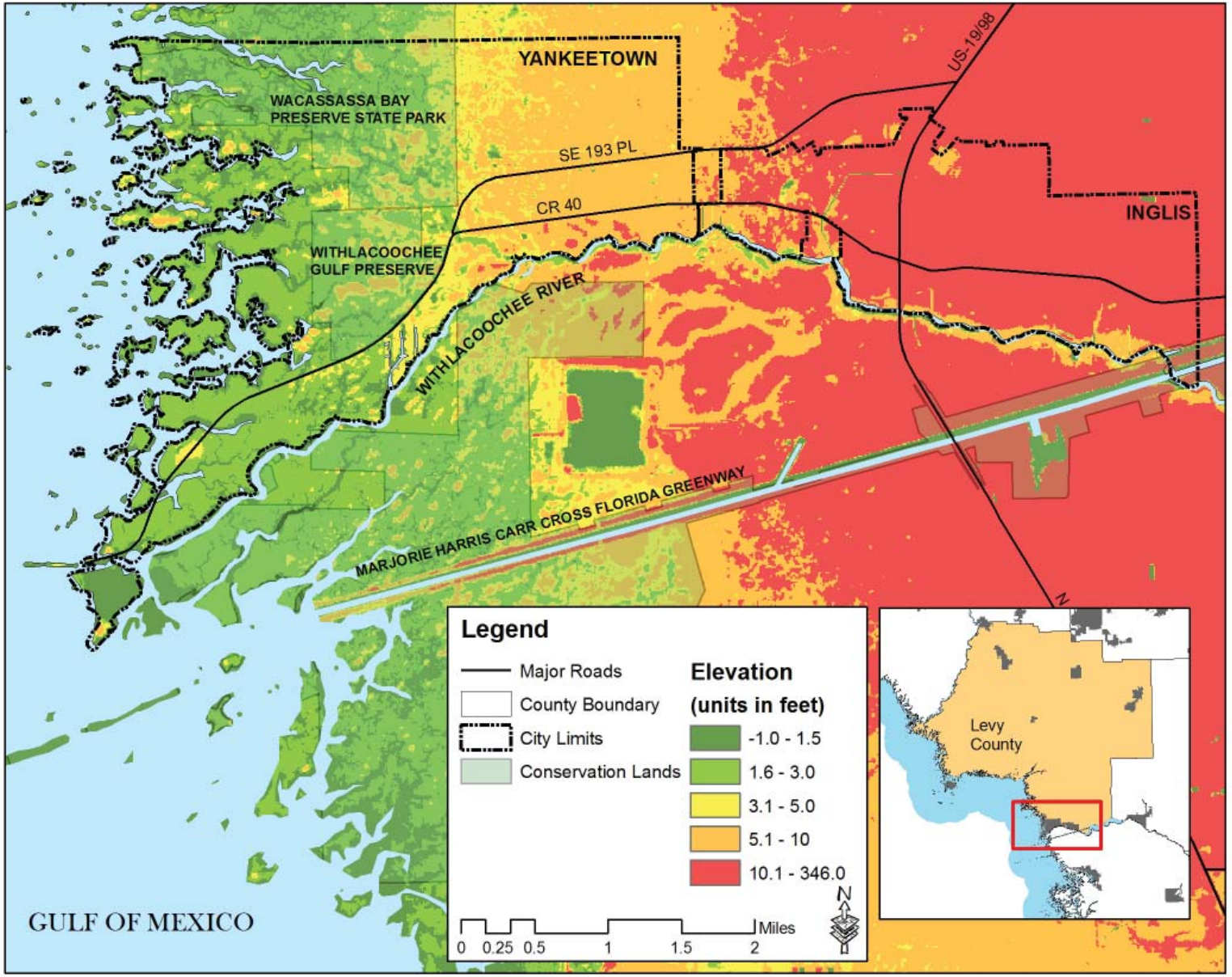


Figure 49: Elevation map of Yankeetown and Inglis

Yankeetown are likely to be impacted by increased flooding and storm surges, with dramatic changes resulting from storm events. Coastal ecosystems provide important services, which include buffering and reducing the impacts from storm surge, winds, and flooding (Arkema et al., 2013). Depending on the degree of degradation and conversion to open water, the capacity of these ecosystems to protect Yankeetown and Inglis from storms and storm surge may be greatly reduced, further increasing storm surge impacts.

Vulnerability Based on Geology and Hydrology

The porous nature of the limestone substrate around Yankeetown and Inglis leads to several specific concerns, particularly regarding flooding, sewage treatment, and water supply.

Sea level rise has the potential to push the unconfined, surficial aquifer up through the ground causing an increase in flooding. The Yankeetown-Inglis area septic systems are already highly constrained by poor soil suitability and a high water table. Increased flooding and higher water tables resulting from sea level rise could cause more frequent failures in existing onsite sewage treatment systems, resulting in impacts to ground and surface water quality.

Saltwater intrusion into the freshwater aquifer, including during storm events, is an additional change that is likely to impact public water supply and domestic wells, particularly as sea levels rise. Wells closer to the coast are much more susceptible to these impacts than wells farther inland (see Figure 53). Yankeetown's water supply appears to be the most vulnerable to these changes, and there may come a day when the town is unable to provide the public drinking water from wells within the municipality as a result of saltwater intrusion.

Fiscal and Economic Vulnerability

In general, concerns related to economic vulnerability in Yankeetown and Inglis echo those described for Levy County and Cedar Key-Rosewood, and town staff are well aware of many of these vulnerabilities. These towns face direct costs resulting from sea level rise impacts to the built environment (such erosion/corrosion of infrastructure and flooding/repair of structures), particularly in low-lying areas of Yankeetown. Costs may also result from projects aiming to restore and increase the resiliency of coastal ecosystems. In addition to direct costs associated with adaptation and mitigation of the impacts from coastal change, future changes to insurance policies at the state and national levels may have a more immediate financial impact on residents due to higher premiums and possibly reduced property values. Additional costs are likely to result from planning projects and consultants retained by the towns to conduct planning work related to coastal change.

Finally, in addition to expenses related to adaptation and mitigation, if Yankeetown and Inglis follow the two-pronged approach of adaptation and redevelopment recommended in the following sections, costs will result

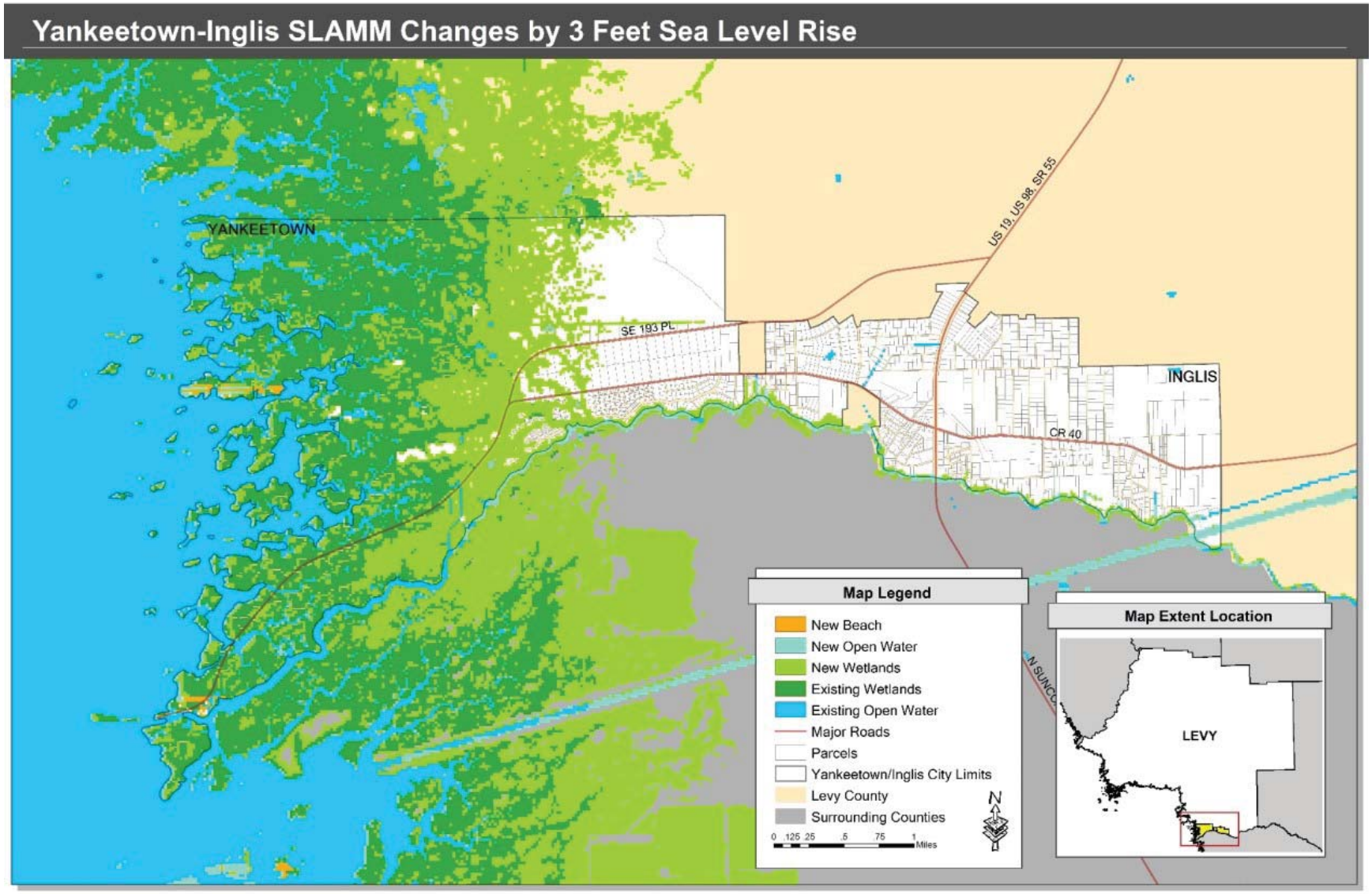


Figure 50: Projected land cover change in Yankeetown and Inglis with 3 feet of sea level rise (Warren Pinnacle Consulting, Inc. 2011a and Freeman, K. & Geselbracht, L. 2011)

from redevelopment and infill in upland areas, although these costs can yield economic benefits of community revitalization. Many of the costs listed above may be met with assistance from outside sources such as state/federal mitigation grants or developer financing. Additional internal financing options may also be possible, such as tax increment financing.

Coastal change will also impact the livelihoods of residents in Yankeetown and Inglis, particularly those supported by water dependent industries. Examples include ecotourism operations, and general reductions in economic activity within the towns when residents move away from hazardous and flood prone areas. Town planners need to consider the potential changes in the viability of current industries and sources of employment, identify possible sources of grants or financial assistance to mitigate these impacts, create a plan for economic development to help retain current residents in safer areas, and identify alternative income sources for those residents in industries likely to be impacted. The recommendations for identifying financial and technical resources provided earlier for Levy County can be referenced for more information.

Findings and Recommendations: Yankeetown-Inglis

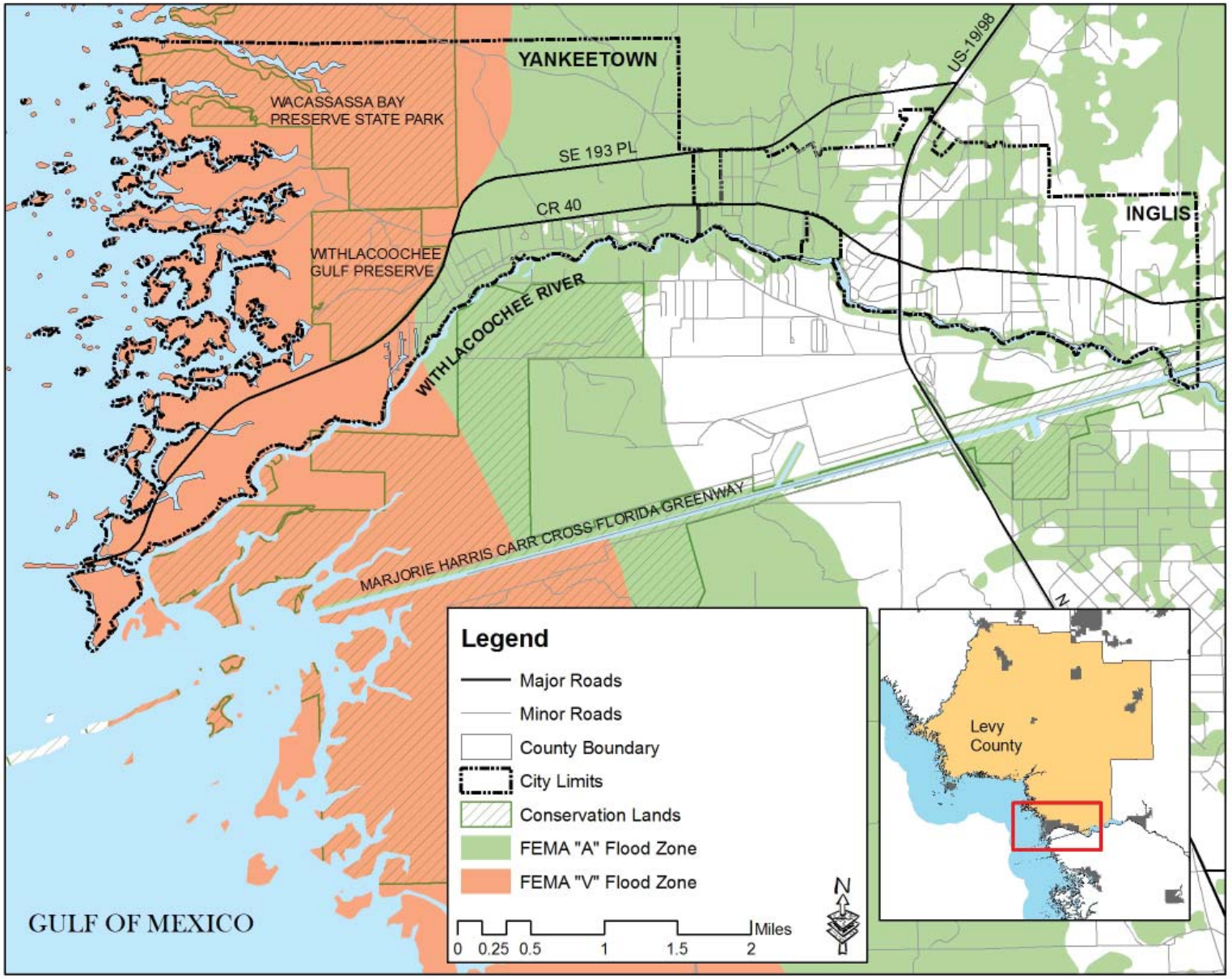


Figure 51: Locations of current flood zones within Yankeetown and Inglis

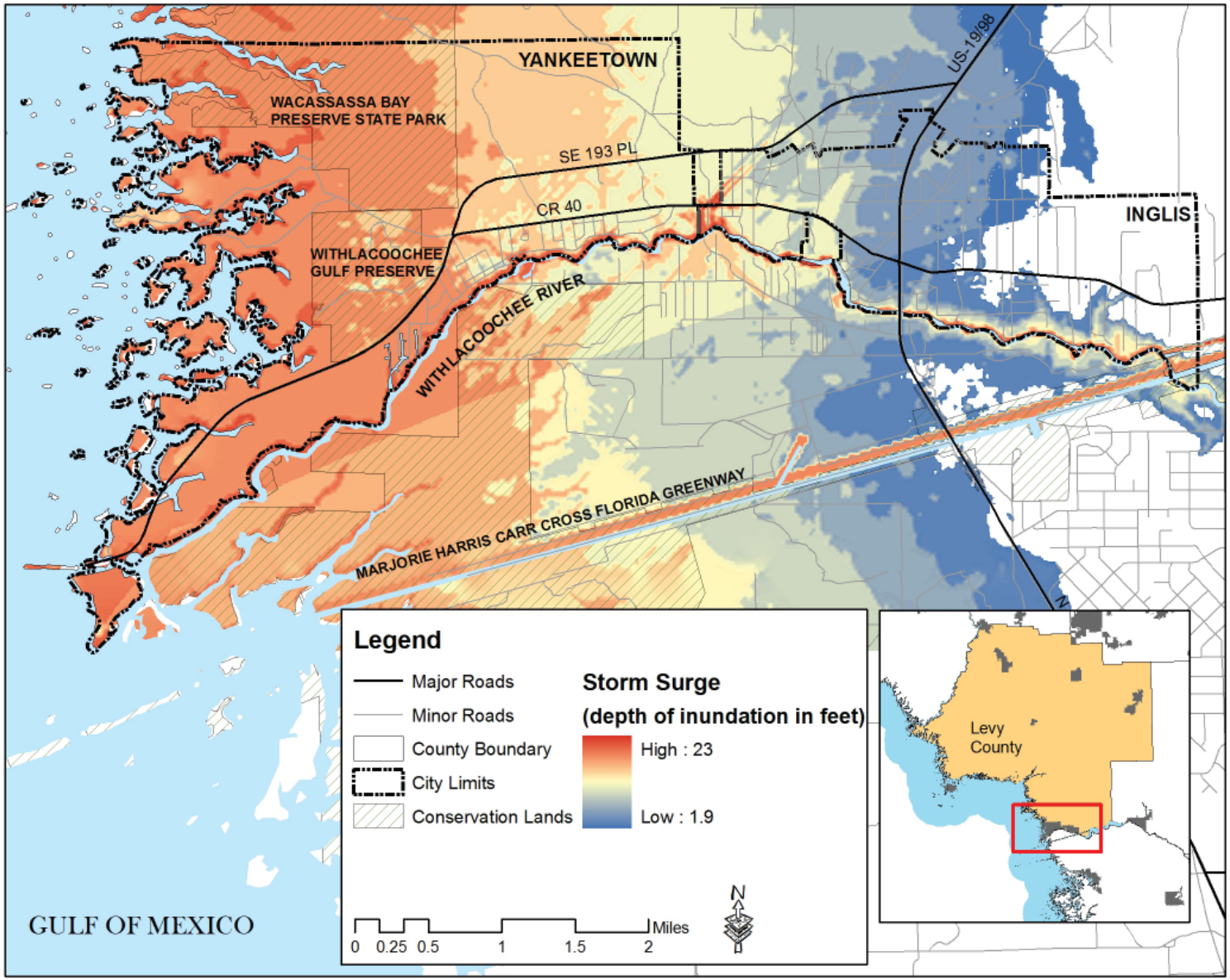


Figure 52: 100 year storm surge inundation map for Yankeetown and Inglis (The sharp line south of the Withlacoochee River is due to anomalies in the data and modeling process)

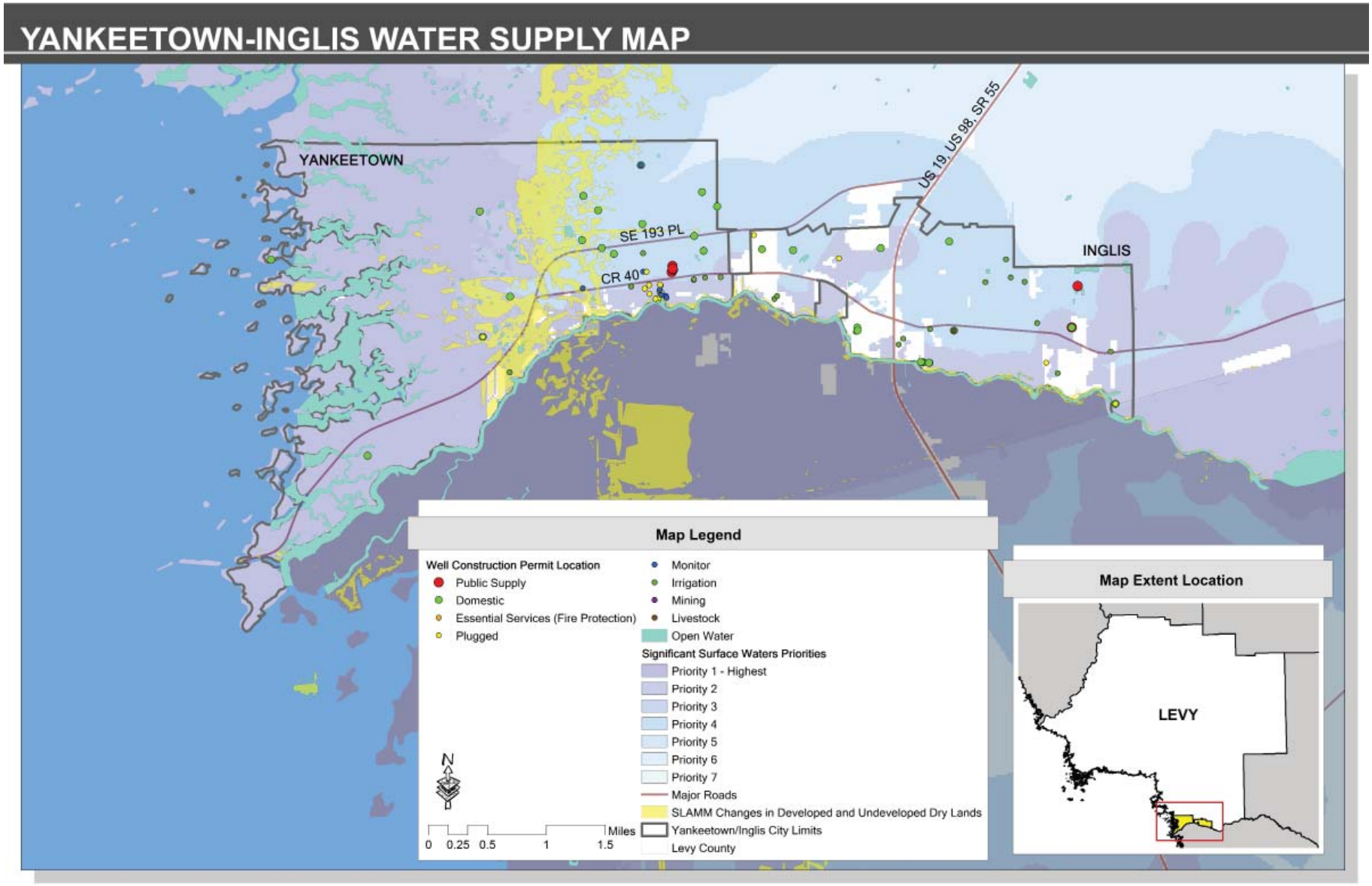


Figure 53: Wells in the Yankeetown-Inglis area

Community Input

As part of our work in Yankeetown and Inglis, we conducted a variety of outreach and community engagement activities, which are described in the Methods section. Input received in the course of these activities is summarized here.

Town planners and officials in Yankeetown and Inglis are very engaged and concerned about the issues related to future sea level rise. Participant input echoed that of residents in other portions of the county, but Yankeetown participants in particular were distinguished by their knowledge of planning issues, and immediate interest in sea level rise.

At the broadest level, participants were concerned about the future of their towns (especially Yankeetown), and their ability to persist in the face of coastal change. Both the natural areas and residential/civic core of Yankeetown are particularly impacted by coastal change, and some town officials expressed doubt that the town could continue to exist in the long run. The natural resources and rural character are very important to the people of Yankeetown and Inglis, and there is concern that both will be degraded as a result of coastal change, thus affecting residents and visitors.

Beyond these broad considerations, participants were concerned about several specific impacts. Saltwater intrusion and its potential impacts on water quality and supply, in particular impacts on wells, septic systems, and the Withlacoochee River, was a high priority issue. As adaptation strategies, citizens were interested in the possibility of man-made marshes being created to filter community wastewater and the use of composting toilets.

Residents expressed concern about how to manage abandoned structures. When asked about potentially adopting some of the recommendations provided later in this report, participants were concerned about finding the funding to facilitate adaptation planning, and several were resigned about ultimately having to relocate in response to the physical and economic impacts of coastal change.

Participants were interested in how policies in the local Comprehensive Plan, Land Development Code and Zoning Code could be changed to address sea level rise issues. People agreed that assistance from state and local agencies for addressing coastal change and sea level rise adaptation planning in small towns and rural areas was needed. Finally, changes to coastal flood insurance (principally the 2012 Biggert-Waters Act) were a major concern, as several residents were already seeing increases in their flood insurance premiums, or were concerned about impacts to their property values. Although some participants, including commissioners, expressed disagreement regarding the causes and future projections of sea level rise, there was general consensus about the flood risk and the need to address insurance rates.

Adaptive Capacity

Adaptive capacity can be considered from a variety of facets, but there are at least three categories relating to the overall ability of Yankeetown and Inglis to adapt to coastal change. These include adaptive capacity of the physical environment; legal and political capacity; and technical and financial capacity.

Physical Adaptive Capacity

Adaptive capacity of the physical environment can be considered in terms of natural and human systems. Natural systems have evolved to adapt to environmental changes, with varying degrees of ability. Some systems are much more vulnerable and sensitive to environmental changes than others. The same is doubtless true in the areas including Yankeetown and Inglis, and will vary depending on the rate of sea level rise and human responses. One of the best ways to enhance the adaptive capacity of natural systems is to maintain and enhance their current health and resiliency, while providing space for future upland retreat (Hoctor et al., 2014).

In Yankeetown and Inglis, there are a variety of risks to the current health of coastal ecosystems including those from septic failures and upstream impacts to water quality and quantity. Community members are generally aware of these risks and are reducing them as possible. In addition Yankeetown is creating policies to protect current natural areas, discourage future development in these areas (such as via transfer of development rights zones), and assist in their adaptation to coastal change. There is minimal upland development that is preventing habitat and species migration, though there are road corridors that provide potential barriers.

The Withlacoochee River

There are various strengths that increase the ability in these communities to adapt and increase the resiliency of their infrastructure and built environment. One of these is the availability of upland open space for infill and redevelopment, though in Yankeetown this space is limited within the town limits. Additionally, there is a relatively small amount of centralized infrastructure currently in place, including paved roads and sewer systems. This

means that if constructed, these systems can be built to higher standards more resistant to coastal change, and judiciously located to reduce risk. The adaptive capacity in terms of structures and residents will vary throughout the communities, but elevated wood frame structures are likely to be more easily relocated (albeit with difficulty and cost). Due to the historic nature of Yankeetown there are a number of wood frame structures which may be relocated, though a cost-benefit analysis is needed on a case-by-case basis.

Legal and Political Adaptive Capacity

Town planners and staff in Yankeetown and Inglis are well aware of and concerned about the issues related to future coastal change and sea level rise, including vulnerabilities and potential impacts to the natural and built environments in both towns. In general, the legal and political adaptive capacity, especially in Yankeetown, is high due to the proactive policies already in place and the existence of concerned planners, politicians, and stakeholders.

Local planners in Yankeetown have already been proactive in efforts to protect the coastal natural resources that lie within the town boundaries. Yankeetown has an extensive comprehensive plan and land development code that is driven by the goal of maintaining the existing character and qualities of life in Yankeetown. Yankeetown's comprehensive plan features the town's natural surroundings and its unique small town charm and character as points of pride. The comprehensive plan clearly outlines a vision and policies for the town that are designed to maintain its character as a low density coastal village. The plan highlights the town's limited capacity to handle higher intensity development because of its lack of a central sewer system and central wastewater treatment facility. The Coastal High Hazard Area (CHHA) encompasses most of the town, thus limiting public expenditures and siting of public facilities in the municipal limits. Yankeetown's Code of Ordinances also contains provisions for flood damage protection. The ordinance establishes the town's administration of floodplain management, provisions for flood hazard reduction, and specific standards for construction within Special Flood Hazard Areas (SFHAs) (FEMA, 2012a).

Findings and Recommendations: Yankeetown-Inglis

Yankeetown has limited development in its coastal areas, except those along the river farther inland. Most of the existing developed areas are located in the central and eastern portions of the municipality in close proximity to the river. Yankeetown has established a Transfer of Development Rights (TDR) program that allows transfer of development rights along the coast and in conservation areas to the area between State Routes 40 and 40A (see Figure 54). Development in these areas is permitted at a maximum of one dwelling unit per two acres. This program has the opportunity to be expanded to include "sending" areas that are vulnerable to coastal change impacts, like the area defined as Adaptation Area One in Figure 57 in the recommendations portion of this report.

The town also requires that all new subdivisions, planned unit developments, and commercial uses in all districts utilize low impact development practices, which will be helpful in mitigating stormwater runoff problems that may be exacerbated by coastal change. Yankeetown also requires all new development to utilize performance based septic systems, designed to treat wastewater to a certain standard of nutrient and pollutant removal. This will assist in maintaining water quality relative to new development, but does not help address existing systems that are failing or vulnerable to future coastal change.

The policies restricting residential dwelling units per acre in Yankeetown aim for a low density development pattern. The maximum allowed residential densities in the areas with existing development is two units per acre, but all lawfully established parcels are entitled to one dwelling unit regardless of parcel size. Density increases greater than 4 or more units an acre are illegal in Yankeetown without a central sewer system.

This low density development framework in Yankeetown could become problematic in light of coastal change. Adaptation strategies may call for spatial shifts that marginally increase residential densities in the town, such as through cluster and infill development. Yankeetown needs policies that are more flexible to accommodate redevelopment in areas suitable for relocation, a greater variety of housing types (e.g., not just single family detached housing) to accommodate redevelopment, and the option to employ alternative wastewater and sewage systems, such as cluster or advanced treatment technology systems, to facilitate redevelopment in suitable areas. Thoughtfully designed redevelopment can accommodate relatively small increases in density that allow for adaptation, while preserving the quality of life the people of Yankeetown desire. Yankeetown's Future Land Use Map is shown in Figure 55 including areas designated for future low density residential development. Some of these upland areas might be important areas for at least marginally higher development densities as sea levels rise and residents are compelled to relocate further from the coast.

Additionally, Yankeetown's proposed Natural Resource Adaptation Action Area (NRAAA) is a great step towards addressing adaptation to coastal change. The proposed NRAAA includes the Resource Protection (RP) area and Residential Environmentally Sensitive (RES) area as

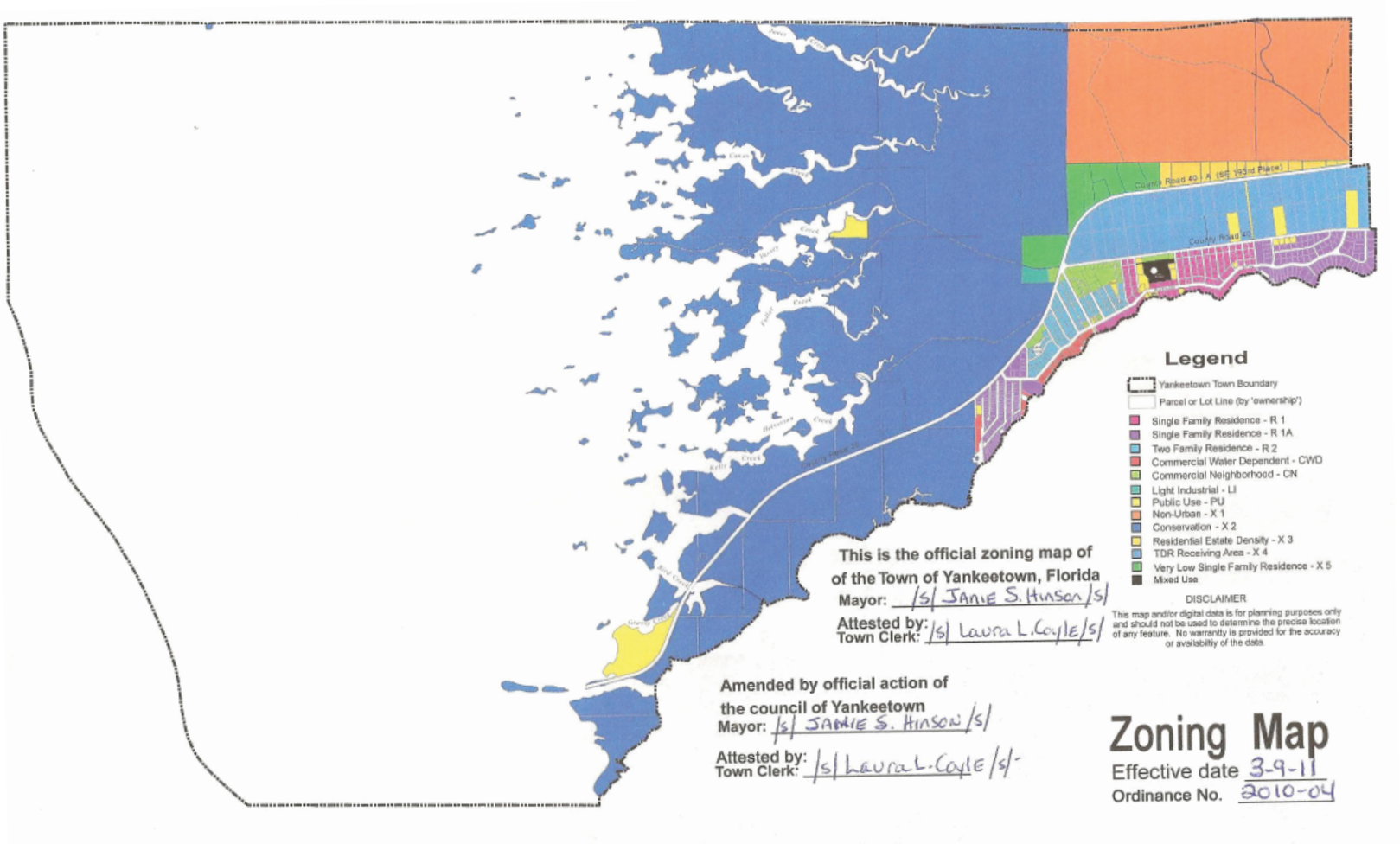


Figure 54: Yankeetown zoning map (http://www.yankeetownfl.govoffice2.com/vertical/sites/%7BE9D8B3C9-8B09-4342-8F48-B60BABFAF7FD%7D/uploads/Chapter_21_-_Zoning_Map_-_all_of_YT_-_Mar_9_2011_-_Ord_2010-04.jpg)

Findings and Recommendations: Yankeetown-Inglis

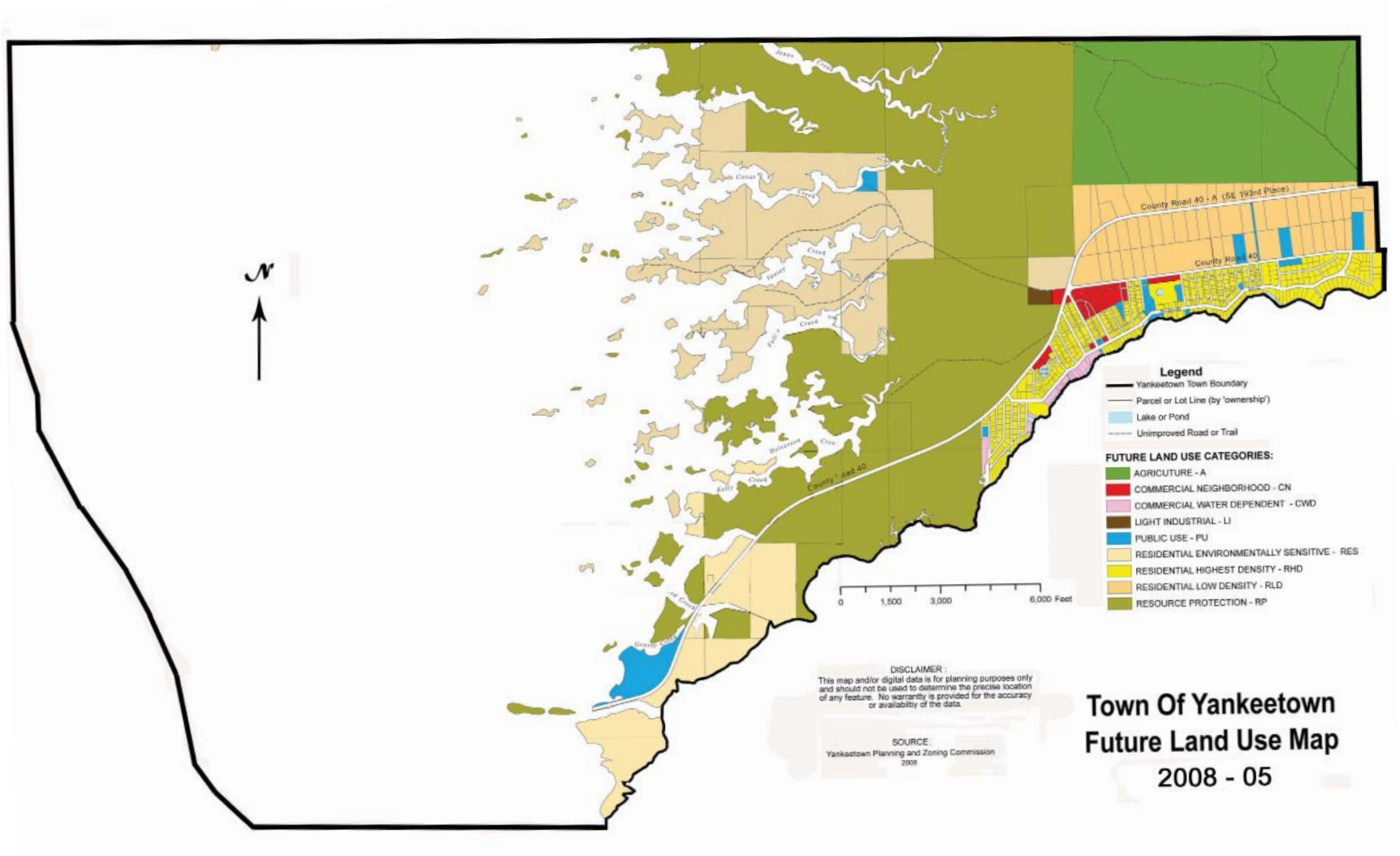


Figure 55: Yankeetown future land use map (http://www.yankeetownfl.govoffice2.com/vertical/sites/%7BE9D8B3C9-8B09-4342-8F48-B60BABFAF7FD%7D/uploads/Future_Land_Use_Map-Signed_-5-14-12__Approved_7-3-12_by_DEO(1).jpg)

designated on the future land use map (see Figure 55). Many of the goals, objectives, and policies mentioned in the proposed NRAAA have applications that could be employed in the areas of existing development that are not within the proposed boundaries, such as those dealing with structural adaptation. The NRAAA can both inform and compliment an adaptation action area and/or adaptation strategies within the areas of existing development.

Natural resources provide many public amenities

Yankeetown has begun to address the issues of sea level rise and other coastal changes, with this project and their proposed NRAAA. Additionally they are part of the FEMA Community Rating System (CRS) program, which has so far allowed them to maximize potential reductions in flood insurance rates. This involvement will help reduce the impacts of future changes to insurance policies, which are otherwise likely to compound the economic impacts from coastal change. Their existing plans and policies seek to maintain the current character and qualities of life in the town and contain many progressive planning practices that could be modified to address coastal change (e.g., the TDR program).

The Town of Inglis has also developed policies that provide a foundation for addressing coastal change. The Code of Ordinances includes Flood Damage Prevention articles that describe the foundation for establishing areas of special flood hazard, development permit requirements, permit procedures, and establish standards for buildings and development within Special Flood Hazard Areas (SFHAs) defined by FEMA (FEMA, 2012a). These include basic requirements to ensure that new development does not increase base flood elevations, and to identify flood zones, flood ways, and base flood elevations.

Additional ordinances are included that address development activities within protected or environmentally sensitive zones, such as requiring the maintenance of natural drainage patterns, minimizing use of fill, and prohibiting dredging and filling of wetlands. It is likely that these ordinances, though currently helpful in minimizing environmental impacts and flood damage, would need to be reviewed and revised to address future coastal change with additional specificity and consideration of flooding and drainage.

Based on the surveys conducted with town staff during the FEMA Discovery project, it appears that Inglis has several potential weaknesses that could inhibit their adaptive capacity and resiliency (FEMA, 2012b). These include minimal experience with flood disasters and recovery, a low perception of the town's ability to implement mitigation actions, lack of an NFIP compliant floodplain ordinance, lack of coordination between the town's comprehensive plan and hazard mitigation plan, lack of special consideration for coastal areas in the comprehensive plan, and lack of a coastal zone management plan. The feasibility and necessity of correcting these various weaknesses would need to be assessed.

Technical, Financial, and Civic Adaptive Capacity

Town commissions and staff in Yankeetown and Inglis are proficient and knowledgeable regarding planning and policy options that are generally important to their rural communities, as well as those relevant to adaptation to sea level rise. This makes them better equipped than many communities with regards to planning for coastal change. In addition, there are numerous civic, religious, and public interest organizations active in the region that assist in protecting and advocating for community resources, such as the Friends of the Withlacoochee Gulf Preserve, the Withlacoochee Gulf Area Chamber of Commerce, the Inglis-Yankeetown Lion's Club, and the Withlacoochee Area Residents group. Organizations such as these are important stakeholder groups who can provide input, support, and political pressure when it comes to making adaptation planning a priority, both generally and for certain resource types.

The primary hindrance in terms of technical and financial capacity for both Yankeetown and Inglis is the limited number of staff, and limited financial means available to implement capital improvements and conduct planning work. The attention of staff and available financial resources are already spread between the many planning issues that need to be addressed by the towns. For these reasons, outside staff and financial support are very important for both communities .

Recommendations for Adaptation

As a means of addressing the coastal changes that are projected to occur in Yankeetown and Inglis, and in order to stabilize the economy, attain fiscal responsibility, protect life and property, and maintain quality of life, we propose a planning framework of six geographically defined Adaptation Areas (AA's), within which various adaptation strategies may be implemented (see Figure 56). The AA's represent different neighborhoods with unique characteristics, needs, and roles in adaptation.

A description of each of AA is included in the following pages, along with specific recommendations for adaptation to coastal change. At their crux, these recommendations are based on essentially two components.

First, in areas that are most vulnerable to the direct impacts of sea level rise during this century, especially AA-1 but also AA-2 along the Withlacoochee River and parts of AA-4, we recommend that future decisions about development and infrastructure take a long-term perspective, aim to reduce risk through accommodation and relocation/decommissioning strategies, and avoid protection measures that would encourage additional development and prohibit ecosystem migration. We recognize that funding and staff resources in small towns are limited, therefore we suggest that coastal change be considered in the usual timeframe for decision making as issues, needs, and opportunities arise, rather than as a separate agenda. Town officials and staff could adopt policies to facilitate the incorporation of coastal change information into decision making for vulnerable areas, such as through the post-disaster redevelopment plan, the capital improvements plan, and the construction permit program. Additionally, a moderate revision of Yankeetown's Transfer of Development Rights (TDR) program can designate the new sending area as everything at risk from coastal change, and the new receiving area as upland areas less at risk of change (AA-3 and portions of AA-2).

Second, relocation and redirection of future development should be combined with a careful approach towards redevelopment and economic stimulus within the upland receiving areas (especially AA-3, AA-5, and AA-6). We propose this begin with targeted improvements and infrastructure to support redirected development. Redevelopment may take the form of gradual relocation of civic buildings from AA-1 into upland areas, particularly along the CR 40 corridor, such as with a corridor plan. Done properly, relocation of civic buildings can be used to redirect other private development, and revitalize the upland portions of the town. Similar actions may be taken in Inglis, combined with a holistic plan for economic revitalization.

Finally, we note that this is a preliminary study. The scope and timeframe for this project did not permit us to develop solutions and plans for all the issues that need to be addressed. In the Conclusions section we have included recommendations for future studies and work.

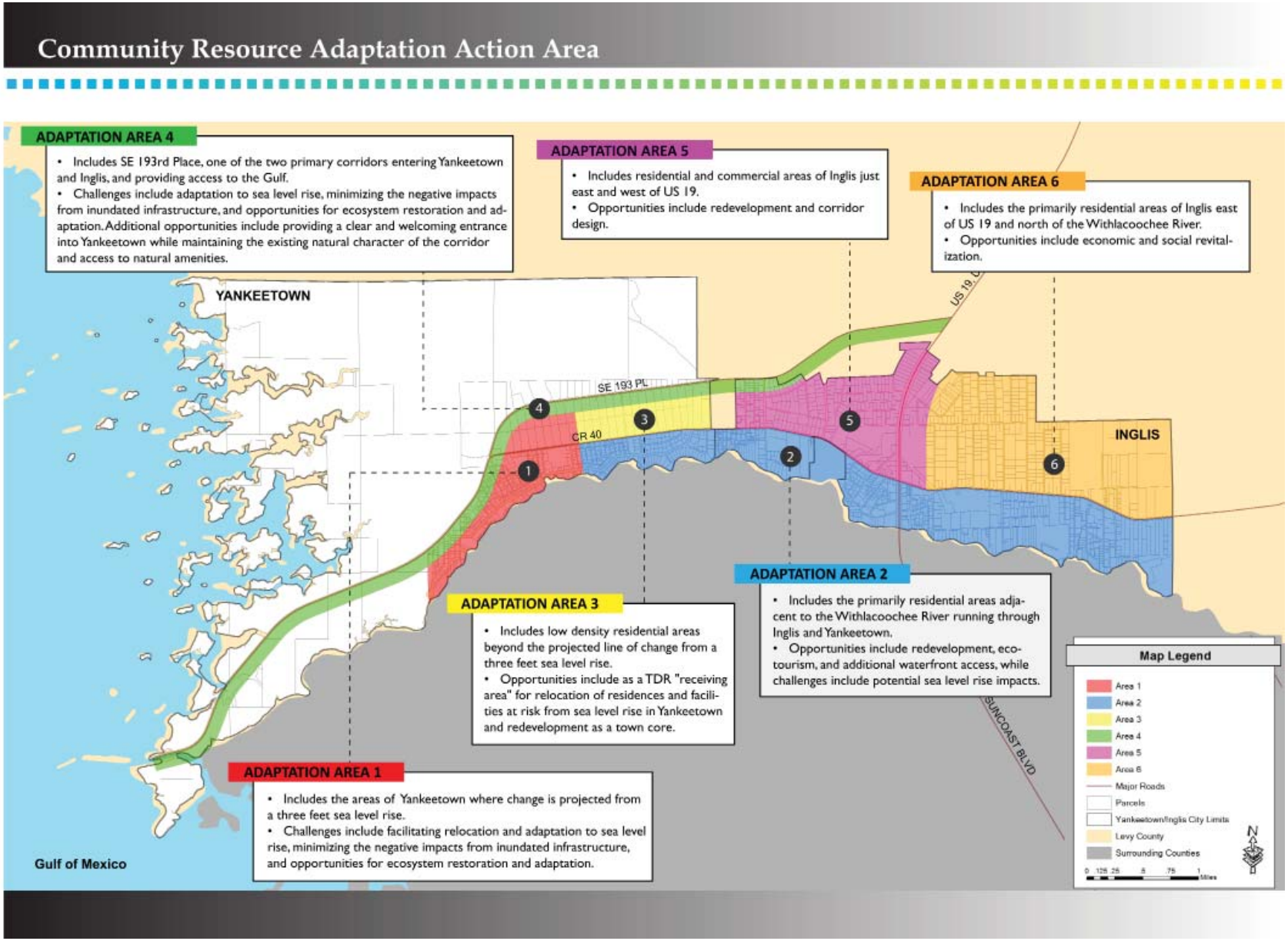


Figure 56: Proposed Adaptation Areas

Adaptation Area One

Adaptation Area One (AA-1) includes the western areas of Yankeetown where change is projected from three feet of sea level rise (see Figure 57). The boundary extends east to 54th Street, north to the CR 40A corridor (SE 193 PL), and west to the canal adjacent to the western side of Palm Drive. The Withlacoochee River is the southern boundary. AA-1 is the important current "heart" of Yankeetown, where community and cultural buildings (e.g., Town Hall and the Izaak Walton Lodge), many of the town's residences, and the annual seafood festival are located.

Challenges here include coastal hazards, increasingly flooded infrastructure and buildings, saltwater intrusion into drinking water supplies, and possibly declining property values. Opportunities exist for maintaining some activities in this important "heart" of the town, while gradually relocating or redirecting development to other parts of the town, and ecosystem conservation, restoration, and migration. Additional challenges include identifying policies that avoid the risk of a "takings" claim of private property rights (see Glossary).

Recommendations for Adaptation Area One include the following:

1) AA-1 should be designated a Transfer of Development Rights (TDR) sending area to redirect new development. The existing TDR sending areas closer to the Gulf may be incorporated into one enlarged TDR sending area.

2) The Town of Yankeetown could lead the way by developing a plan to gradually relocate civic buildings and infrastructure, as opportunities arise, into AA-2 and AA-3 and along CR 40, and by reducing investment in new infrastructure in AA-1.

3) At the same time, incentives should be developed to encourage relocation of existing private development into the receiving areas.

4) Additionally, a financing and phasing plan should be developed to assist in transitioning and ultimately removing existing civic buildings and infrastructure, including utility and septic systems, to accommodate and minimize potential risks from future sea level rise.

5) Activities that are important for this area and deemed compatible with coastal change should be designed or redeveloped with accommodation strategies.

6) Finally, a plan should be developed to assist in ecosystem adaptation within this area, as well as along the Gulf coast to facilitate habitat migration. Such a plan would explore where habitat corridors could be established at the block level and prioritize areas for adaptation.

Figure 57: Adaptation Area One

Adaptation Area Two

Adaptation Area Two (AA-2) includes the primarily residential neighborhoods adjacent to the Withlacoochee River running through Inglis and Yankeetown, where change is projected from three feet of sea level rise (see Figure 58). Its eastern border is the Inglis city limit, its western border is the edge of AA-1, and its northern border is CR 40, which is the main access to this area. The Withlacoochee River links the two towns and provides a high quality of life for adjacent property owners, town residents, and visitors.

Challenges include coastal hazards and sea level rise impacts along the river's shoreline and to adjacent development and natural communities. Existing infrastructure in this area may have limited capacity to handle sea level rise, rising water tables, or increased development density. Opportunities include accommodation strategies for existing waterfront development, including provision of additional public access to the waterfront, and clustered redevelopment on higher ground but still in AA-2 to maintain the communities' important relationship with the river.

Recommendations for Adaptation Area Two include the following:

1) Where sea level rise impacts along the Withlacoochee River are significant, relocation should be encouraged. If this is the case, building infrastructure (such as foundations and septic systems) may need be removed to minimize potential hazards. Yankeetown and Inglis should develop a plan for publicly or privately financing long term infrastructure removal, as well as providing incentives for relocation of endangered structures and shoreline restoration with the goal of enabling natural shoreline stabilization or if possible retreat.

2) Where impacts along the river are minimal to moderate, living shorelines and infrastructure updates (e.g., well relocation, dock refurbishment) could accommodate coastal change. Redevelopment of the waterfront could enhance public amenities for economic development and quality of life in areas of lower hazard. A redevelopment plan could include design for public waterfront access for existing and new opportunities.

3) An infrastructure investment and management plan should be developed for the entire AA-2 to maintain vibrant downtowns in Yankeetown and Inglis. Redevelopment towards CR 40 could include the creation of an attractive, pedestrian friendly streetscape, which is attractive to residents and visitors. Suitable areas in AA-2 should be considered for addition as TDR receiving areas for relocated uses in AA-1.

4) Guidelines should be established for new development in AA-2 that includes the following considerations (in addition to those just mentioned).

- Encouragement of water dependent and related uses through zoning changes that incentivize such uses.

- Requiring development design standards in-keeping with the existing historic and small town character of Yankeetown and Inglis.

- Requiring development that uses low impact development techniques.

Figure 58: Adaptation Area Two

Figures 59, 60, and 61 illustrate lot design and layout options for shoreline redevelopment and adaptation along the Withlacoochee. The lot layout options here are most applicable for new development but may apply to existing development as well. Figure 59 illustrates an option whereby buildings on piers may be relocated upland on narrow lots as sea levels rise. Figure 60 shows a "cluster development" design (see Glossary) which allows for preservation of larger natural undeveloped areas (which may help shoreline ecosystems adapt to sea level rise), provision of ecosystem services (such as more land for onsite stormwater drainage), and opportunities for visual and physical public access.

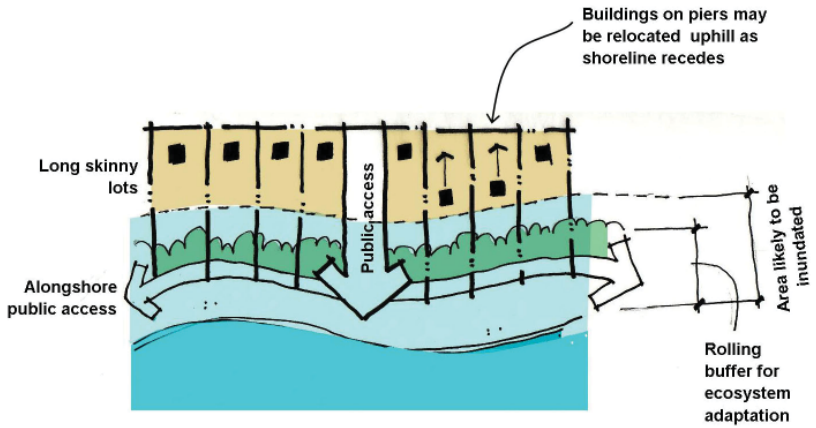


Figure 59: Shoreline development and adaptation options for small or newly platted parcels

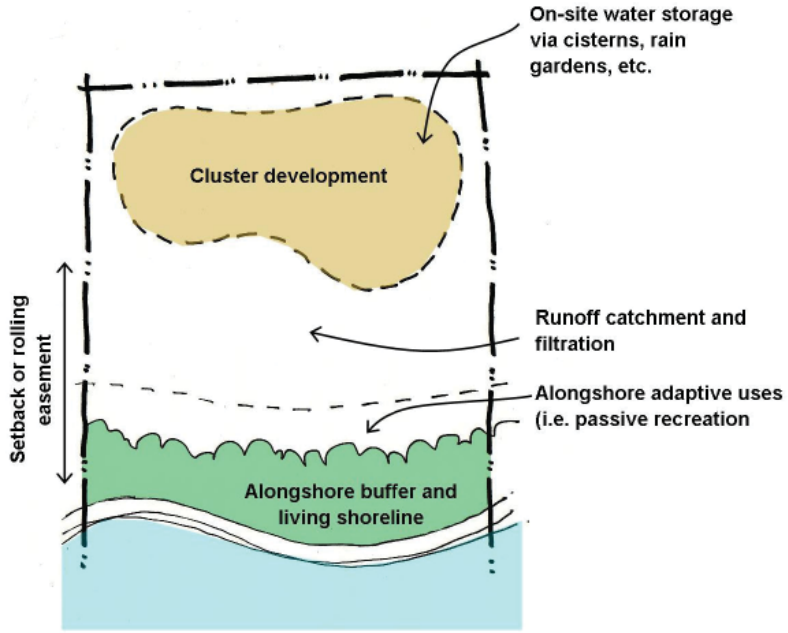


Figure 60: Shoreline development and adaptation options for large parcels or planned unit developments

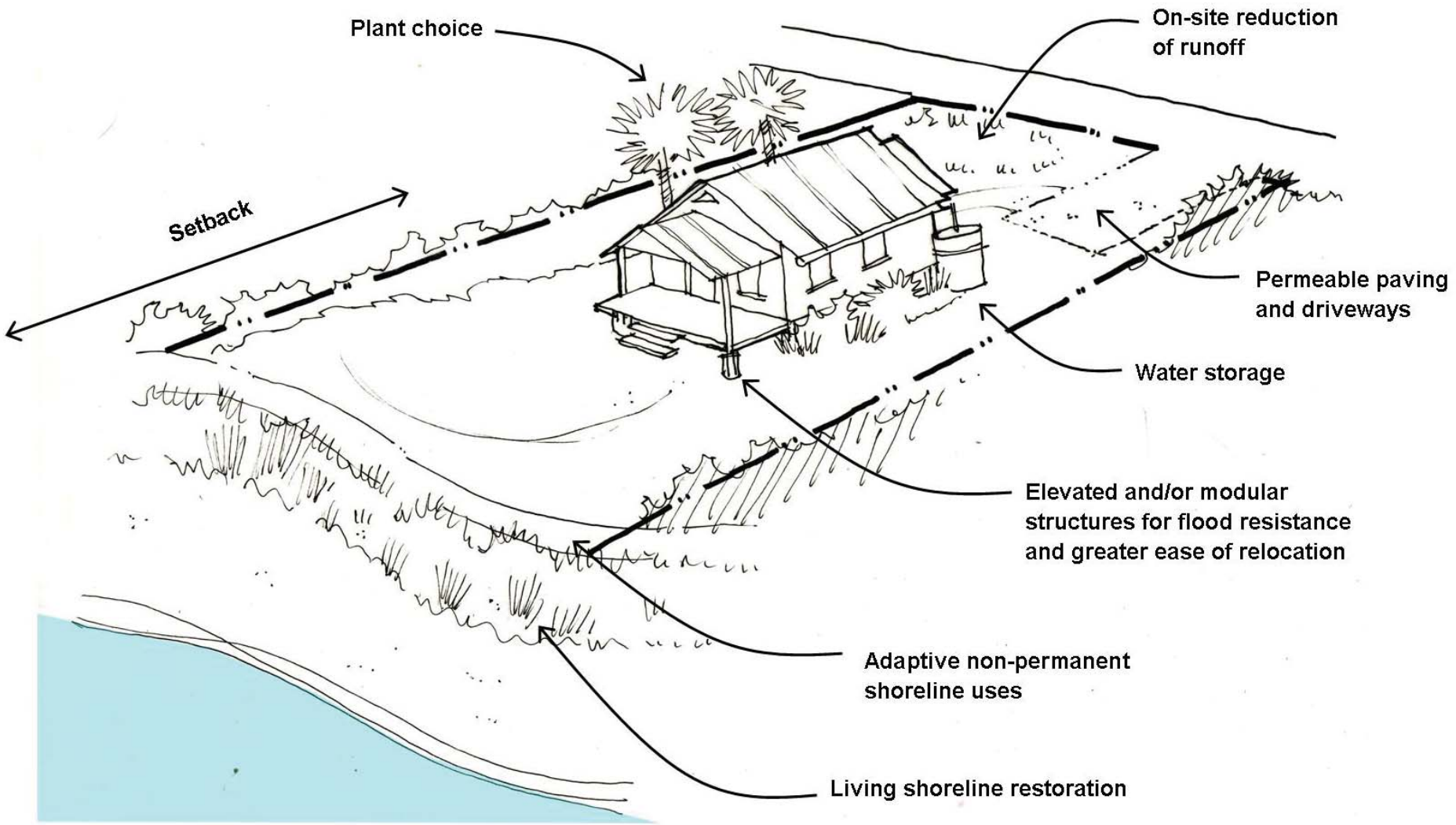


Figure 61: Example of Riverfront Site Design for Adaptation Area Two
This image illustrates the use of low impact design principles at an individual parcel scale. These are not only good design principles to use today to maintain healthy shorelines and water bodies, but also can be used to address future sea level rise impacts.

Adaptation Area Three

Adaptation Area Three (AA-3) includes the low-density residential areas beyond the projected line of change from three feet rise in sea level (see Figure 62). This area is bounded by CR 40 to the south, CR 40A to the north, and the Yankeetown city limits to the east. Opportunities here include revitalization and moderate redevelopment, particularly along the CR 40 corridor, as well as the potential for AA-3 to serve as a TDR "receiving area" for relocation of residences and facilities at risk from sea level rise in Yankeetown. Challenges in this area include maintaining Yankeetown's natural aesthetic and small town character while accommodating infill and redevelopment. Additionally, existing infrastructure does not support increased development intensity and soil and environmental factors highly constrain decentralized wastewater and sewage systems.

Recommendations for Adaptation Area Three include the following:

1) AA-3 should be designated a TDR receiving area for development at risk from coastal change. It may also be a focus for new infill and redevelopment of the town core outside of the vulnerable area beginning with institutional buildings as a catalyst for new investment.

2) Minimum lot size requirements in AA-3 should be reduced or eliminated to allow for additional density.

3) Zoning codes should be revised to allow for multi-use development within certain portions of AA-3, particularly along CR 40. Residential zoning may remain appropriate elsewhere in AA-3.

4) Targeted infrastructure improvements should be considered, addressing potential impacts from coastal change. This may require a specific study and recommendations by infrastructure experts and planners.

5) AA-3 is within/adjacent to the proposed Natural Resource Adaptation Action Area. Therefore low impact development (LID) principles should be used, in conjunction with conservation design principles, such as provision of buffers adjacent to conservation areas.

6) Physical and visual connections are encouraged to the multi-use trail proposed along CR 40A and orientation of development towards CR 40.

Figure 62: Adaptation Area Three

The area along CR 40 has the potential to become a new town core, once uses in the existing historic core of Yankeetown are relocated or less inhabitable because of coastal changes. Design guidelines should guide the development along the corridor from the start, with relocation of civic buildings as a catalyst for new private development.

Figure 63 is an example of a streetscape that is similar to CR 40. Note the low density character and placement of buildings and the pedestrian scale of the street (including sidewalks, native street trees, on-street parking, and 1-2-story buildings close to the roadway).

Figure 64 represents a style of residential development which may be suitable for AA-3, but is also developed at a higher density, which in AA-3 might be necessary due to the limited land available.

Figure 64: Medium density homes

Figure 63: Low density streetscape
(https://www.google.com/maps, 2013)

Existing conditions on CR 40
(https://www.google.com/maps, 2013)

Adaptation Area Four

Adaptation Area Four (AA-4) includes the southern portion of the SE 193rd Place right of way, which is one of the two primary corridors entering Yankeetown and Inglis (see Figure 65). The proposed area begins at the intersection of CR 40A and US 98 and continues until it ends at the Gulf.

Challenges here include providing a clear and welcoming entrance into Yankeetown, while maintaining the existing natural character of the corridor. Opportunities include the same: to create a clear and welcoming entrance to Yankeetown, helping draw new visitors to support the ecotourism opportunities that Yankeetown and Inglis offer. CR 40A is an important corridor connecting Yankeetown and Inglis from east to west and to the Gulf, therefore pedestrian access along this corridor, and good design of the entrance into the community is important.

Recommendations for Adaptation Area Four include the following, coordinated as need be with Levy County:

1) Construct new signage at the intersection of CR 40A and US 98 which clearly identifies it as an entrance to Yankeetown and Inglis. This should be of a design in keeping with the natural and rural character of the two communities.

2) Space permitting, create a multi-use trail, which can be used by bikers and pedestrians within the CR 40A right of way. This should include additional wayfinding signage and lighting.

3) Connections should be created from this trail into the cores of Yankeetown and Inglis to encourage connectivity and use. The trail should provide connections to natural areas, and be designed to accommodate coastal change.

4) Maintain to the greatest extent possible all existing non-invasive/exotic vegetation along the corridor, particularly shade trees, with the goal of maintaining the natural and rural character of the corridor.

Figure 65: Adaptation Area Four

Figures 66 to 69 show examples of signage and roadway design. Note the elevated pathway, which could extend the multi-use trail in areas inundated by sea level rise to allow pedestrian access to the Gulf. Temporary, elevated, relocateable, or replaceable designs should be considered in areas at risk from coastal change.

Figure 66: Elevated trail example (MacDonald, S., n.d.)

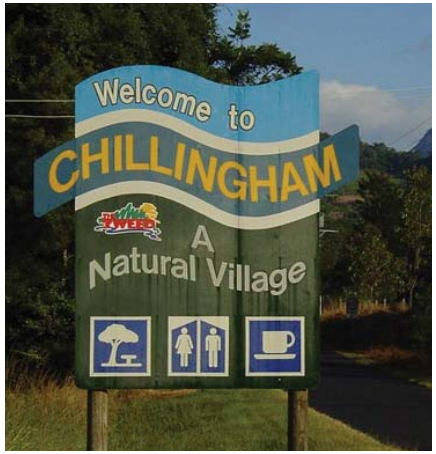


Figure 68: Signage examples
(City of Midland, MI, n.d.)
(Walter, F. B., 2006)

Figure 67: Existing conditions at intersection of US98 and CR40A
(https://www.google.com/maps, 2013)

Figure 69: Roadway example
(Wisconsin Department of Transportation, 2011)

Adaptation Area Five

Adaptation Area Five (AA-5) includes the western portion of Inglis that is not at direct risk from sea level rise impacts (see Figure 70). The southern border runs south to CR 40, east to include US 19, and north and south to the city limits.

Challenges and opportunities include corridor design for CR 40, economic development potential as a result from coastal change, and guidance for potential infill within the Adaptation Area to accommodate future growth.

Existing conditions along US 19 (https://www.google.com/maps, 2013)

Recommendations for Adaptation Area Five include the following:

1) A "Corridor Design Plan" is needed for CR 40 and US 19 where it runs through the area. Ideally, the character of CR 40 as it is redeveloped in Inglis may be differentiated from the streetscape where it runs through Yankeetown. Pedestrian crossing and connectivity across US 19 must be addressed.

2) AA-5 needs a redevelopment plan to address social, economic, and infrastructure revitalization.

3) Physical and visual connections should be made to AA-2, which lead pedestrian and vehicular visitors to the waterfront, and AA-4, which lead pedestrian and vehicular visitors into the center of town. These may include signage or pedestrian right of ways for example, which connect to pedestrian paths leading into town.

4) Consider application to the Florida Main Street program as a means of receiving technical support for redevelopment needs.

5) Consider encouraging a range of alternative housing types and mixed uses (see Figure 71).

We see revitalization of AA-5 as a primary need, which can occur as part of the process of careful adaptation planning to coastal change. AA-5 can build off of existing assets, identity, and community values (possibly identified through a visioning process) to create a plan for redevelopment in this area.

Figure 70: Adaptation Area Five

Existing structure/asset AA-5

Example of vibrant commercial area
(National Trust for Historic Preservation, n.d.)

Figure 71: Multiple housing types (Better! Cities and Towns, 2012)

Adaptation Area Six

Adaptation Area Six (AA-6) includes the primarily residential areas of Inglis east of US 19 and north of the Withlacoochee River (see Figure 72).

Existing conditions (www.maps.google.com, 2013)

Challenges and opportunities here include corridor design for CR 40, and economic and social revitalization combined with redevelopment within the AA-6 as a whole.

Recommendations for Adaptation Area Six include the following:

1) We recommend that the City of Inglis develop a redevelopment plan for this area, addressing social and economic redevelopment as well as infrastructure. This may be similar to the plans traditionally developed for Community Redevelopment Areas, but the area need not officially be designated/approved as such.

2) Redevelopment should consider both the CR 40 corridor as well as the inner neighborhoods. A Corridor Design Plan is recommended.

3) Redevelopment within the neighborhoods and vacant parcels of AA-6 could consider using a more cohesive approach to neighborhood design. For example development of pocket neighborhoods (image at right) and pocket parks can be a way of encouraging interaction between neighbors and community spirit. This doesn't necessarily apply to existing development, but could apply to new infill development within AA-6, and relates to the concept of cluster development (see Glossary).

4) Equally or more important than physical design, we see the building of community and youth connections within AA-6 and Inglis in general as something critically important. This could be accomplished via community and youth programs in existing facilities, but ideally would involve visioning to identify needs that are currently not accommodated (such as a skate park or community center) and development of a funding plan.

Figure 72: Adaptation Area Six

Findings and Recommendations: Yankeetown-Inglis

CR40 (US Dept. of Transportation)

Pocket neighbourhoods (Ross Chapin Architects, 2013)

A focus on a community's youth (King County Housing Authority, n.d.)

Yankeetown - Inglis Conclusion

We believe that proactive, incremental adaptation to coastal change is possible in Yankeetown and Inglis. Adaptation will not be easy, particularly in the areas at risk of direct impact by sea level rise in the coming decades (especially Adaptation Area One), but if begun now and carefully planned with a combination of hazard mitigation, economic revitalization, and design strategies, the future for Yankeetown and Inglis can be positive. We have identified several concepts and approaches that are important in all the Adaptation Areas:

- Coordinate relocation, redevelopment, and restoration to ensure economic and social vitality, physical and visual waterfront access, and continued water dependent and water related uses.

- Increase functional connections between natural and built areas, Yankeetown and Inglis, and with surrounding Levy County and Citrus County, including for transportation (land and water), economic, social, and environmental aspects.

- Target investment, disinvestment, and a broad range of policies including incentives, disincentives, and regulations.

- Leverage resources through partnerships with federal, state, regional, and county governments, universities, and the private/non-profit sector.

In addition, we've identified several recommendations for follow-up work and studies. Some of these have been mentioned previously, but are summarized again here:

- A Relocation Plan that addresses incentives for development relocation from vulnerable areas in AA-2 and AA-1, as well as a financing plan for relocation of abandoned infrastructure.

- An Infrastructure Plan to address potential impacts from coastal change and adaptation of septic, sewer, and other utilities. This should relate to the relocation plan and include a procedure for amending and adapting the plan as coastal conditions change.

- Design guidelines for all Adaptation Areas, so new or relocated development is in keeping with the desired community character of Yankeetown and Inglis. These may also include "performance guidelines" to ensure that new development is compatible with local goals and needs (infrastructure, desired public amenities, economic benefits). Low Impact Development (LID) practices should be required or at minimum incentivized in all areas, as they directly affect the health of coastal ecosystems.

- Separate Corridor Plans for US 19 and CR 40 where they run through Yankeetown and Inglis, to attract redevelopment, enhance design, and increase the economic potential of these corridors.

- A Post-disaster Redevelopment Plan to facilitate relocation and accommodation strategies in areas subject to

coastal change, as well as redevelopment in less vulnerable areas.

A combination of methods will be necessary to address the two pronged approach of adaptation and revitalization that we've outlined. Community visioning should be the first step to 1) continue to educate the community on coastal change issues, 2) identify a process for moving forward, and 3) to build community buy-in and support. A good outcome from this would be goals and objectives for both the adaptation and revitalization prongs.

Next, city staff may introduce and determine public preference for tools that can be used to meet community goals and objectives. It is likely that these tools will begin with comprehensive plan amendments, and may be followed by land development code and zoning changes. More specific plans and tools may be important as outlined elsewhere in this section.

It will be important to coordinate policies for the six Adaptation Areas presented here with those in the proposed Natural Resource Adaptation Action Area. A second "Community" Adaptation Action Area could be designated, provided that planning for this area is well coordinated with other areas as we've recommend in this report.

Financing is an issue for both development of plans and their implementation (such as infrastructure updates). City staff should immediately begin researching funding options. This may include contacting state or county staff, university, or private consultants to carefully develop a list of prioritized funding options. A starting point for technical assistance and funding information is the Florida Department of Economic Opportunity (DEO) Office of Community Resiliency.

All possible state and federal funding options should be explored, as well as local options such as tax increment financing (TIF) and utility improvement taxes. In particular, designation of an official Community Redevelopment Area (CRA) should be researched for both feasibility and benefit. The TIF which can be used by CRAs is potentially a valuable tool that could be applied to the two pronged approach that has been outlined. Adaptation to coastal change must be a careful and deliberate process, which includes community and governmental partners. Yankeetown and Inglis have the planning and community capacity to be successful and possibly even thrive as coastal changes occur.

Conclusion

Planning for Coastal Change in Levy County was a university-based project that initiated public dialog and planning for sea level rise in Levy County, Florida, and its coastal communities of Cedar Key, Sumner, and Rosewood, and Yankeetown and Inglis. The project assessed local vulnerability to sea level rise, identified potential adaptation strategies, and helped build the governance capacity of citizens, governments, and organizations to address the issue. This report documents the project's activities, findings, and recommendations, and it is intended to serve as an information resource for ongoing and future planning initiatives in Levy County. Planning topics in which sea level rise impacts and adaptation strategies have relevance are wide-ranging and interrelated, and they include land use and community design, infrastructure, hazards, environmental quality and public health, economic development, and social and fiscal matters. The report is also illustrative of planning for sea level rise in small town and rural areas, particularly in the Big Bend region of Florida's Gulf Coast.

Levy County's coastline runs about 80 miles, and the total population in areas vulnerable to storm surge is less than 5,000 people. The county is part of an ecologically significant region (the Big Bend), and it contains the mouths of three rivers. Outdoor recreation, including boating, fishing, and hunting are popular, and natural resource productivity is high, particularly in clam aquaculture and timber. The coastal communities have close relationships with the environment, and these relationships along with social forces and export trade have shaped the local economies and customs over time. Cedar Key is a unique small island community with many historic buildings and a thriving arts scene. Sumner and Rosewood are historically significant, and many of the current residents are clam farmers. The towns of Yankeetown and Inglis are located along the beautiful Withlacoochee River. A very long time ago, the natural resources of the area supported Native American cultures over thousands of years, and archaeological sites abound. Levy County's coastal communities, waters, conservation lands, and rural lands thus have many assets of local, regional, state, national, and international significance.

Sea level rise along the Levy County coast, as recorded by the NOAA tide gauge in Cedar Key, increased over the past 100 years about 7 inches. Scientific projections, such as those used by the US Army Corps of Engineers, show the future sea levels in Levy County in the year 2100 to be about 1.5 to 5 feet higher. This project considered the entire range of sea level rise projections to assess vulnerability. The report and adaptation strategies focus on the mid-range scenario of 3 feet of sea level rise by the year 2100. With a tidal range of about +/- 2 feet, that means that coastal land less than 5 feet elevation could be regularly flooded under this scenario.

Levy County has been and will continue to be impacted by sea level rise due to its low elevation and karst geol-

Conclusion

ogy, and potentially worsening reductions in freshwater flows. Currently observed impacts for which sea level rise is a possible contributor include Cedar Key's erosion in several locations near roads and houses, and Yankeetown's occasional flooding and aquifer saltwater intrusion. Scientific studies have verified that sea level rise is a major cause of Waccasassa Bay's considerable loss of coastal forests. Additionally, many coastal property owners have had financial hardships due to recent state and national policy changes affecting flood insurance. Sea level rise impacts that may occur by the year 2100 include the following: in Yankeetown more frequent flooding in the historic residential neighborhoods and downtown; the slight widening of the Withlacoochee River; in Cedar Key flooding in low-lying areas such as parts of downtown, and almost complete loss of the regionally significant tidal flats surrounding the island; and dramatic diminution of habitat diversity in the ecological preserves of the Lower Suwannee and Cedar Keys National Wildlife Refuges, the Waccasassa Bay Preserve State Park, and Yankeetown's Withlacoochee Gulf Preserve. Levy County's flat, wet landscape will also likely result in storm surges reaching farther inland to affect state highways and rural communities.

Adaptation to the anticipated sea level rise changes by Levy County and its coastal communities and conservation lands will necessarily occur in numerous ways, at different scales, at different times, and by different individuals and groups. Based on the information gathered, including local commission and public input, the project team recommended distinct sets of coordinated adaptation strategies for the following areas: across the Levy County coast, Cedar Key-Rosewood, and Yankeetown-Inglis. The types of strategies were wide ranging, including innovative site- and neighborhood-level designs, land use policies, and integrated economic development. Furthermore, the report provided supporting resources and continued planning and outreach approaches. The recommendations require further vetting and prioritization, followed by funding, detailed design, implementation, and monitoring of the selected strategies. As new information becomes available and conditions change, perhaps as a result of unexpected events unrelated to sea level rise, the strategies should be revisited.

Fortunately, Levy County lands, communities, and groups possess diverse resources that can help them adapt to sea level rise. Coastal communities have always had to adapt to changes, and Levy County's history has many instances of resilience and civic strength. Residents expressed commitment to community and place, including social compassion, and concern for the environment and local economy. Residents were knowledgeable and active in local affairs, as well as decision making at larger scales. Long-time residents recognized the need for continuous community building and place-based education, especially as new residents move in. With regard to the public's response to the sea level rise information presented by this project, many people accepted it and supported adaptation planning; for those individuals who disagreed with the science, they still acknowledged that

coastal change was occurring and that community planning had a role in guiding adaptation.

By the end of the project, Levy County institutions were using the sea level rise information. For example, the Cedar Key Water and Sewer District incorporated project information into the design of a new water treatment facility, and several local jurisdictions were considering adding sea level rise adaptation language and strategies to their comprehensive plans. Most importantly for the Cedar Key-Rosewood area, Florida Sea Grant funded the project team to conduct a second sea level rise planning project beginning in summer 2014. The new project will leverage the first project and work collaboratively with local and regional experts to further develop, integrate, and prioritize adaptation strategies for the Cedar Key-Rosewood area. The project team looks forward to continuing to serve Levy County and its coastal communities.

Glossary

Bathtub Model: A simple model showing areas inundated by sea level rise based on digital elevation data. If the model uses a scenario of three feet of sea level rise, it is assumed that anything hydrologically connected to the coastline that is less than three feet in elevation will be flooded. It provides an estimate of the areas that may be impacted by changes in sea level. Additional adjustments may be made to the basic version of this model to also account for tidal variation.

Cluster Development: Cluster development is a land use planning strategy where new development is "clustered" within a particular portion of the site at a higher density, and other portions of the site are left undeveloped. In contrast with traditional site planning strategies, cluster development may have a smaller footprint and can be used to preserve significant open space or natural features on a site.

Coastal Change: Any physical change to the shoreline including processes such as erosion, coastal landslip, permanent inundation, and coastal accretion. Coastlines are naturally dynamic and change physically, chemically, and biologically from scales ranging from very local to global. Human activity influences coastal change further by modifying and disrupting coastal environments and the natural processes of change. In this report, "coastal change" generally refers to any change experienced along the coastline associated with changing sea levels, storm surge, saltwater intrusion, or erosion/accretion patterns.

Digital Elevation Model (DEM): A digital model or 3D representation of a topographical information created from elevation data. A DEM can be represented as a raster (grid-like) surface where each square in the grid represents a different elevation, or as a vector-based triangular irregular network (TIN), which portrays a 3D surface. DEM models are commonly created using data collected using remote sensing techniques, but they may also be created from land surveying. In this project, raster DEMs were used to create bathtub models to estimate the amount of land inundated by future sea level rise, and as an input into the SLAMM model described elsewhere.

FEMA Flood Hazard Zones A, AE, and VE: Flood hazard zone "A" refers to areas inundated by flooding from a 100 year storm, for which no base flood elevations have been determined. Zone "AE" refers to areas inundated by flooding from a 100 year storm, where base flood elevations *have* been determined. Zone VE refers to areas inundated by flooding from a 100 year storm, and also at risk from wave action, where base flood elevations have been determined.

Geographic Information System (GIS): A computer system designed to capture, store, manipulate, analyze, manage, and present all types of geographic data. The data can then be used to better visualize an area or issue by overlaying the data on aerial maps allowing people to make informed decisions.

Glossary

Living Shoreline: A shoreline stabilization technique and management practice that provides erosion control benefits; protects, restores, or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. bio-logs, oyster reefs, etc).

Low Impact Development (LID): The U.S. EPA defines LID as an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features to create functional and appealing site drainage systems that treat stormwater as a resource rather than a waste product. LID encourages water management in a way that reduces the impact of built areas on the non-built environment and promotes the natural movement of water within an ecosystem or watershed.

Participatory Planning: A method of planning that includes the whole community in the decision making process. Participatory planning focuses on engaging stakeholders affected by potential future lands use plans, gathering input, and to the degree possible developing consensus as part of the planning process. All groups, marginalized and majority, participate in the planning process.

Rolling Easement: A rolling easement is a legal and policy tool that can be used to enable natural shoreline retreat in response to sea level rise and limit endangerment to human development. In Florida, lands below the mean high water mark are technically sovereign submerged lands. As sea levels rise, this policy is enforced and at the same time coastal protection is prohibited. Since shorelines are no longer protected, the mean high water line will migrate landward in response to sea level rise. With the exception of coastal protection measures, property owners are allowed to use coastal lowlands as they choose, but a legal mechanism is set up to ensure that the land is abandoned as it is inundated. To the authors' knowledge, this policy has not been used in Florida; however, there are precedents for its use in other states.

Sea Level Affecting Marshes Model (SLAMM): SLAMM is a software tool that can be used to simulate the potential changes in shorelines and coastal natural communities under various scenarios of sea level rise. In contrast to a model that assumes that all land below a certain elevation is inundated by sea level rise (commonly referred to as a "bathtub model"), SLAMM simulates dynamic wetland and shoreline processes as well.

Taking: The term "taking" is related to the Fifth Amendment of the United States Constitution, which states that, "No person shall be . . . deprived of life, liberty, or property, without due process, of law; nor shall private property

be taken for public use, without just compensation." A taking can occur both if property is physically taken without just compensation, or even when an undue burden is placed on a property owner, such as through regulation, that unjustly limits the use or value of their property. Qualified legal assistance and/or additional technical assistance should be consulted prior to implementing any land regulation that limits use or could be considered a taking as a precaution to avoid litigation.

Tax Increment Financing: Tax increment financing is a useful funding mechanism that may be used in combination with a Community Redevelopment Agency to fund redevelopment, blight eradication, and infrastructure improvements. When a redevelopment area is designated, the current assessed values of properties within the area are assigned as the base year value. Tax increment revenue is generated by increases in tax revenues as property values increase within the area. The tax increment is the difference between the base value and any additional tax based on an increase in property values at the end of the year. The CRA can use this money for redevelopment activities, but usually the tax increment from each redevelopment area must be used within that same area.

Water Dependent Use: Water-dependent uses are land uses for which water access is essential and which could not exist without water access. (Lee County Comprehensive Plan) Examples could include fishing piers, boat ramps, or marinas. The need to create specific space for water related and dependent uses has come as a rising population has flocked to waterfront areas throughout Florida, causing land values to rise and pushing-out businesses that depend on proximity to waterways in order to transact business.

Water Related Use: Activities which are not directly dependent upon access to a water body, but which provide goods and services that are directly associated with water-dependent or waterway uses. (Citrus County Comprehensive Plan) Examples of water-related businesses include kayak/canoe shops, bait and tackle shops, maritime history museums, and others.

Works Cited

Arkema, K. K., Guannel, G., Verutes, G., Wood, S. A., Guerry, A., Ruckelshaus, M., Kareiva, P., Lacayo, M., & Silver, J. M. (2013, July 14). Coastal habitats shield people and property from sea-level rise and storms. *Nature Climate Change 3*, 913-918. doi:10.1038/NCLIMATE1944

City of Cedar Key (2014). City of Cedar Key final budget 2013-2014.

Colson, S. & Sturmer, L.N. (2000). One shining moment known as clamelot: the Cedar Key story. J*ournal of Shellfish Research 19(1)*:477-480. Retrieved from http://shellfish.ifas.ufl.edu/PDFs/Publications/One%20Shining%20Moment%20Known%20as%20Clamelot.pdf

Eastern Research Group, Inc. (2013, June). What will adaptation cost? An economic framework for coastal community infrastructure. Retrieved from http://seagrant.noaa.gov/Portals/0/Documents/what_we_do/climate/NOAA_What_Will_Adaptation_Cost_Report.pdf

Florida Department of Environmental Protection (FDEP), Engineering, Hydrology, and Geology Program, Division of Water Resource Management. (2012). *Critically eroded beaches in Florida*. Retrieved from http://www.dep.state.fl.us/beaches/publications/pdf/CriticalErosion-Report.pdf

Federal Emergency Management Agency (FEMA). (2012a, July 13). *Discovery report* (Task Order HSFE04-11-J-0101 for Levy County, Florida). Retrieved from http://www.southeastcoastalmaps.com/PublicDocs/Discovery%20Report_Levy%20County_July%202012.pdf

Federal Emergency Management Agency (FEMA). (2012b). *Discovery report appendices* (Task Order HSFE04-11-J-0101 for Levy County, Florida). Retrieved from http://www.southeastcoastalmaps.com/PublicDocs/Discovery%20Report_Levy%20County_Appendices_July%202012.pdf

Florida Sea Grant. (2014). Coastal planning: Insurance issues. Retrieved from https://flseagrant.org/climatechange/coastalplanning/insurance-issues-coast/

Freeman, K. & Geselbracht, L. (2011). Unpublished data.

Friends of the Withlacoochee Gulf Preserve (FWGP). (2014). About the WGP. Retrieved from http://withlacoocheegulfpreserve.com/about/

Gillis, J. (2013, December 30). Spared winter freeze, Florida's mangroves are marching north. *The New York Times*. Retrieved from http://www.nytimes.com/2013/12/31/science/without-winter-freezes-mangroves-are-marching-north-scientists-say.html?pagewanted=all&_r=0

Grannis, J. (2011, October). *Adaptation tool kit: Sea-level rise and coastal land use: How governments can use land-use practices to adapt to sea-level rise*. Washington D.C.: Georgetown Climate Center, Georgetown Law. Retrieved from http://www.georgetownclimate.org/sites/www.georgetownclimate.org/files/Adaptation_Tool_Kit_SLR.pdf

Gonzalez-Tennant, E. (2012, Summer/Winter). Intersectional violence, new media, and the 1923 Rosewood pogrom. *Fire!!! 1(2)*: 64-110

Hoctor, T., Oetting, J., Noss, R. F., Volk, M., & Reece, J. (2014, January 20). *Predicting and mitigating the impacts of sea level rise and land use change on imperiled species and natural communities*. Final Report. Florida Fish and Wildlife Conservation Commission, Tallahassee, FL.

ICLEI Local Governments for Sustainabilty (2012). *Sea level rise adaptation strategy for San Diego Bay*. Retrieved from http://www.icleiusa.org/static/San_Diego_Bay_SLR_Adaptation_Strategy_Complete.pdf

Levy County. (2005, October 22). *Data and analysis to support an amendment to the Levy County comprehensive plan*. Retrieved from http://www.levycounty.org/Planning/CompPlan12.pdf

Levy County. (2011a). *Levy County comprehensive plan*. Retrieved from http://www.levycounty.org/comprehensiveplan.aspx

Levy County. (2011b). *Levy County local mitigation strategy*. Retrieved from http://www.levydisaster.com/files/LMS

Mitchem, G. T. (2011). Sea level changes in the southeastern United States: Past, present, and future. Florida Climate Institute and Southeast Climate Consortium. Retrieved from http://coaps.fsu.edu/~mhannion/201108mitchum_sealevel.pdf

NOAA/ National Ocean Service. (2013). *Mean sea level trend 8727520 Cedar Key, Florida*. Retrieved from http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8727520

Noss, R. F., Reece, J. S., Hoctor, T., & Oetting, J. (2014, August 27). Adaptation to sea-level rise in Florida: Biological conservation priorities. Final Report to The Kresge Foundation. Retrieved from http://conservation.dcp.ufl.edu/Downloads/Noss%20et%20al%202014%20adaptation%20to%20sea%20level%20rise%20in%20Florida_species%20and%20natural%20communities.pdf

Oetting, J., Hoctor, T., & Volk, M. (2014, February). *Critical Lands and Waters Identification Project (CLIP): Version 3.0*. Technical Report. Retrieved from http://fnai.org/pdf/CLIP_3_technical_report.pdf

Works Cited

Purvis Gray & Company (2012, 30 September). *Financial statements and independent auditors' reports, City of Cedar Key, Cedar Key, Florida*. Retrieved from http://www.myflorida.com/audgen/pages/mun_efile%20rpts/2012%20cedar%20key.pdf

Putz, F. E. (2012, Winter). Coastal forest retreat as sea levels rise. *The Palmetto - Florida Native Plant Society 29(1)*: 8-11.Retrieved from http://withlacoocheegulfpreserve.com/wp-content/uploads/2012/04/SeaLevelRise-Florida-2012-in-The-Palmetto.pdf

Raabe, E. A., Streck, A. E., & Stumpf, R. P. (2004). *Historic topographic sheets to satellite imagery: A methodology for evaluating coastal change in Florida's Big Bend tidal marsh*. US Geological Survey (Open File Report 02-211). Retrieved from http://pubs.usgs.gov/of/2002/of02-211/pdf/OFR_02-211.pdf

Seavey, J. R., Pine III, W. E., Frederick, P., Sturmer, L., & Berrigan, M. (2011, October). Decadal changes in oyster reefs in the Big Bend of Florida's Gulf Coast. *Ecosphere 2(10)*:114. doi: 10.1890/ES11-00205.1

Talen, E. (2009). *Urban design reclaimed*. Chicago: Planners Press, American Planning Association.

U.S. Army Corps of Engineers. (2011, October 1). *Sea-level change considerations for civil works programs* (Circular no. 1165-2-212). Retrieved from http://planning.usace.army.mil/toolbox/library/ECs/EC11652212Nov2011.pdf.

U.S. Census Bureau. (2010a). *2010 Demographic profile data: Cedar Key, FL*. Retrieved from http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

U.S. Census Bureau. (2010b). *2010 Demographic profile data: Yankeetown, Florida*. Retrieved from http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

U.S. Environmental Protection Agency (EPA) (2014a). Climate Ready Estuaries. Retrieved from http://www2.epa.gov/cre

U. S. Environmental Protection Agency (EPA) (2014b). Climate Ready Water Utilities. Retrieved from http://water.epa.gov/infrastructure/watersecurity/climate/index.cfm

U.S. Global Change Research Program. (2014). National Climate Assessment. Retrieved from http://www.globalchange.gov.

Wahl, T., Calafat, F. M., & Luther, M. E. (2014). Rapid changes in the seasonal sea level cycle along the US Gulf coast from the late 20th century. *Geophysical Research Letters 41(2)*: 491-498. doi: 10.1002/2013GL058777

Warren Pinnacle Consulting, Inc. (2011a, August 10). *Application of the Sea Level Affecting Marshes Model (SLAMM 6) to Lower Suwannee NWR*. Final Report. Prepared for the Gulf of Mexico Alliance Habitat Conser-

vation and Restoration Priority Issue Team, Corpus Christi, TX. Retrieved from http://warrenpinnacle.com/prof/SLAMM/GOMA/LSRT_Report_FINAL_8-10-2011.pdf

Warren Pinnacle Consulting, Inc. (2011b, August 17). *Application of the Sea Level Affecting Marshes Model (SLAMM 6) to Cedar Keys NWR*. Final Report. Prepared for the Gulf of Mexico Alliance Habitat Conservation and Restoration Priority Issue Team, Corpus Christi, TX. Retrieved from https://data.doi.gov/dataset/application-of-the-sea-level-affecting-marshes-model-slamm-6-to-cedar-keys-nwr

Warren Pinnacle Consulting, Inc. (2014). SLAMM: Sea Level Affecting Marshes Model. Retrieved from http://warrenpinnacle.com/prof/SLAMM/index.html

Appendices

Appendix A: Primary Sources of Geospatial Data

Primary sources of geospatial data that were used in this project for digital analyses are listed below. Several datasets used in the project were created by the project team from scratch, such as datasets showing building footprints and 100 year storm surge data produced with the help of Associate Investigator, Dr. Paul Zwick. The Florida Geographic Data Library (www.FGDL.org) was the primary source of a variety of general datasets such as county and city boundary data, existing open water, flood zones, parcels, ecological priorities, etc. In addition to data from FGDL and custom data created by the team, several other data sources were used as listed below:

Florida Natural Areas Inventory. (2014). "Critical Lands and Waters Identification Project (CLIP) Data". Last modified: February 2014.

The Critical Lands and Waters Identification Project (CLIP) is a GIS database of statewide conservation priorities for a broad range of natural resources, and was used to identify ecological priorities of various types within the study area.

Florida Natural Areas Inventory. (2014). "Florida Conservation Lands Data". Last modified June 2014.

Data identifying federal, state, local, and privately managed conservation lands in Florida was obtained from the Florida Natural Areas Inventory (FNAI) website: www.fnai.org. This data is updated quarterly and is provided directly to FNAI by the managing agencies.

Freeman, K., Geselbracht, L. (2011). Unpublished data.

The Nature Conservancy, Inc. provided unpublished Sea Level Affecting Marshes Model (SLAMM) results for the Waccasassa Bay area.

University of Florida GeoPlan Center. (2013). "Digital Elevation Model Data". Last modified: February 2013.

Custom elevation data were compiled for Levy County by GeoPlan Center staff based on the best available digital elevation data, including LiDAR data for areas near to the coast. This included basic elevation data, as well as inundation surfaces depicting various levels of sea level rise throughout the study area.

Warren Pinnacle Consulting, Inc. (2011). Application of the Sea Level Affecting Marshes Model (SLAMM 6) to Lower Suwannee NWR. Final Report. Prepared for the Gulf of Mexico Alliance Habitat Conservation and Restoration Priority Issue Team, Corpus Christi, TX. http://warrenpinnacle.com/prof/SLAMM/GOMA/LSRT_Report_FINAL_8-10-2011.pdf

SLAMM data was received from the Gulf of Mexico Alliance, as produced by Warren Pinnacle Consulting, Inc. for the Lower Suwannee River area.

Appendix B: Adaptation Strategy Examples

The following are strategies for coastal change adaptation taken from the Sea Level Rise Adaptation Strategy for San Diego Bay report published in 2012. While this is not our work, we believe that it is the most complete and informative reference guide to different adaptation strategies currently available. Each of the approaches has merit and this guide is a practical and concise overview of many different options for adapting to coastal change that may be applicable in any coastal area.

5. MANAGEMENT PRACTICES TOOLBOX

This section presents a toolbox of options for managing sea level rise that are generally more aggressive than the strategies recommended in previous sections. The comprehensive and targeted strategies presented in previous sections are mostly "no-regrets" approaches that can be implemented at relatively low cost, that can be integrated into existing work programs, and that have co-benefits for reaching other community goals. However, in the long run, no-regrets strategies will not be sufficient to ensure resiliency in the region's coastal zone. Successful implementation of the management practices described in this section will require significant technical and management capabilities, regional collaboration, financial investment, and political commitment.

Generally, sea level rise management practices can be classified into four categories: hard defense; soft defense; accommodation; and withdrawal. This toolbox illustrates specific practices in each of these categories through section diagrams and photographs. It also documents the opportunities and constraints of these four approaches, as determined in a map-based exercise in the second Stakeholder Working Group workshop. Each approach presents significant opportunities and constraints, and decision-making around these practices will require careful deliberation around the tradeoffs. Ultimately, a mix of hard defenses, soft defenses, accommodation, and withdrawal will likely emerge as the most optimal management approach, but existing frameworks for making these difficult decisions need to be enhanced, as recommended in Comprehensive Strategy #10.

HARD STRUCTURE STRATEGIES

strategy: HARD STRUCTURE

Hard defenses are designed to be impermeable structures intended to protect land, structures and investments along the water edge. Examples includes hard, impermeable defenses such as seawalls, revetments, dikes, and storm surge barriers that armor or "draw the line" between water and development and prevent flooding or erosion of edges.

Seawall at Lake Michigan, Chicago

opportunities:

- Stabilizes upland areas
- Protects existing development and infrastructure
- Maintains property values for bayfront and low-lying development
- Setbacks can be used for recreation, infrastructure and non-habitable structures.

constraints:

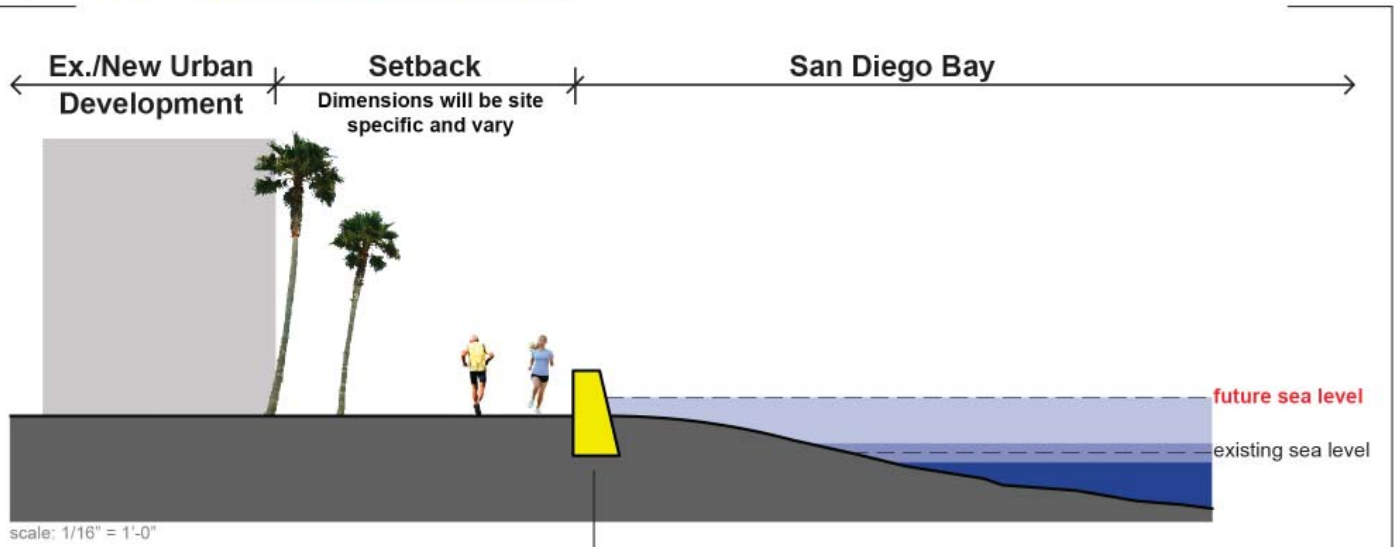
- Expensive to construct, with annual maintenance required
- Areas outside of protective zone are often more subject to erosion and ecological degradation
- Shoreline habitats will be lost as space to migrate is eliminated

unknowns:

- Potential loss of public access and aesthetic link to waterfront

Appendix B: Adaptation Strategy Examples

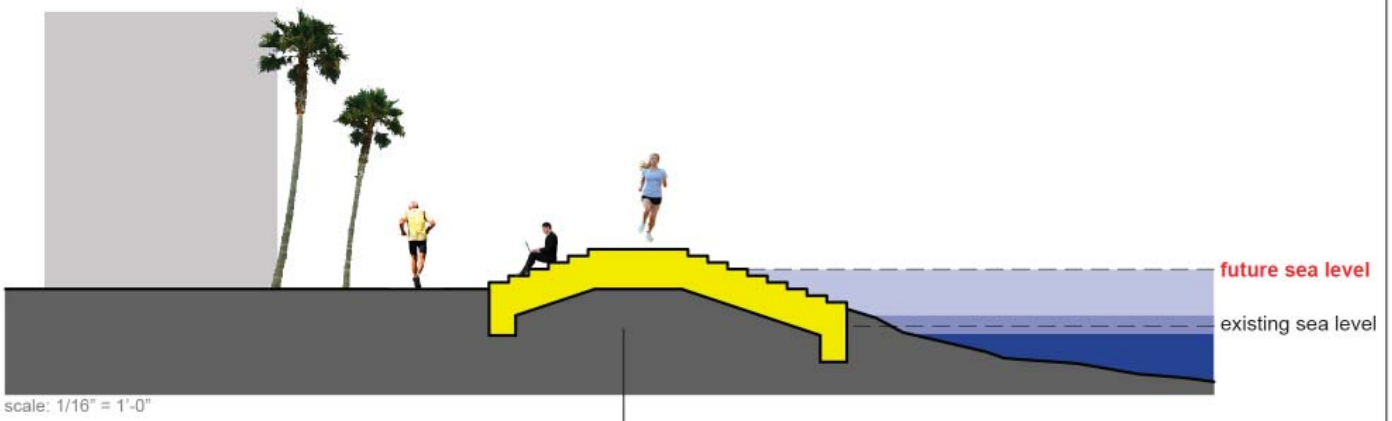
option A - Seawall - retaining



Seawalls are engineered, permanent barriers built parallel to shoreline to protect land and structures from flooding and erosion caused by wave action. Seawalls may be vertical or sloping, and massive gravity concrete walls or constructed of steel or timber.

HARD STRUCTURE STRATEGIES

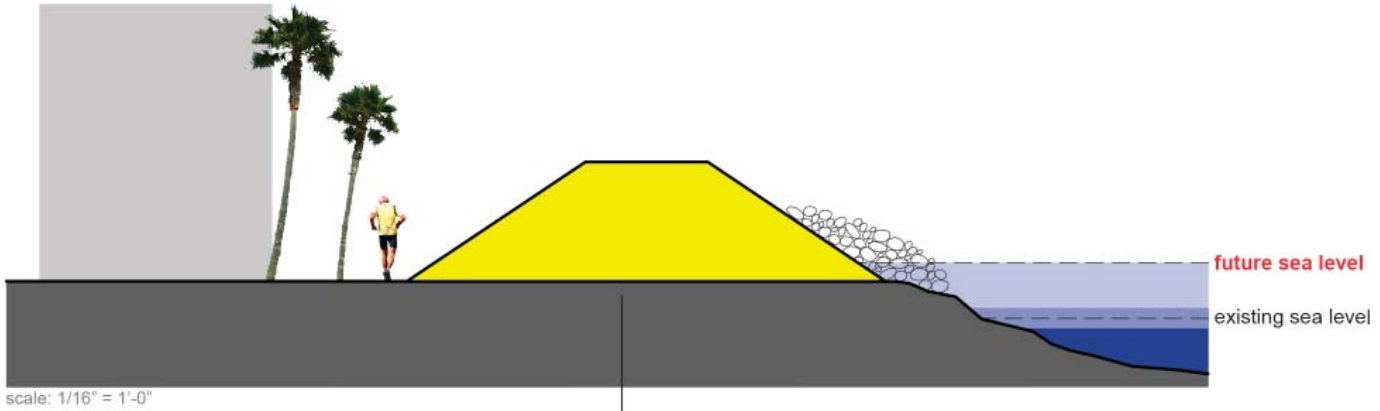
option B - Seawall - widened/stepped



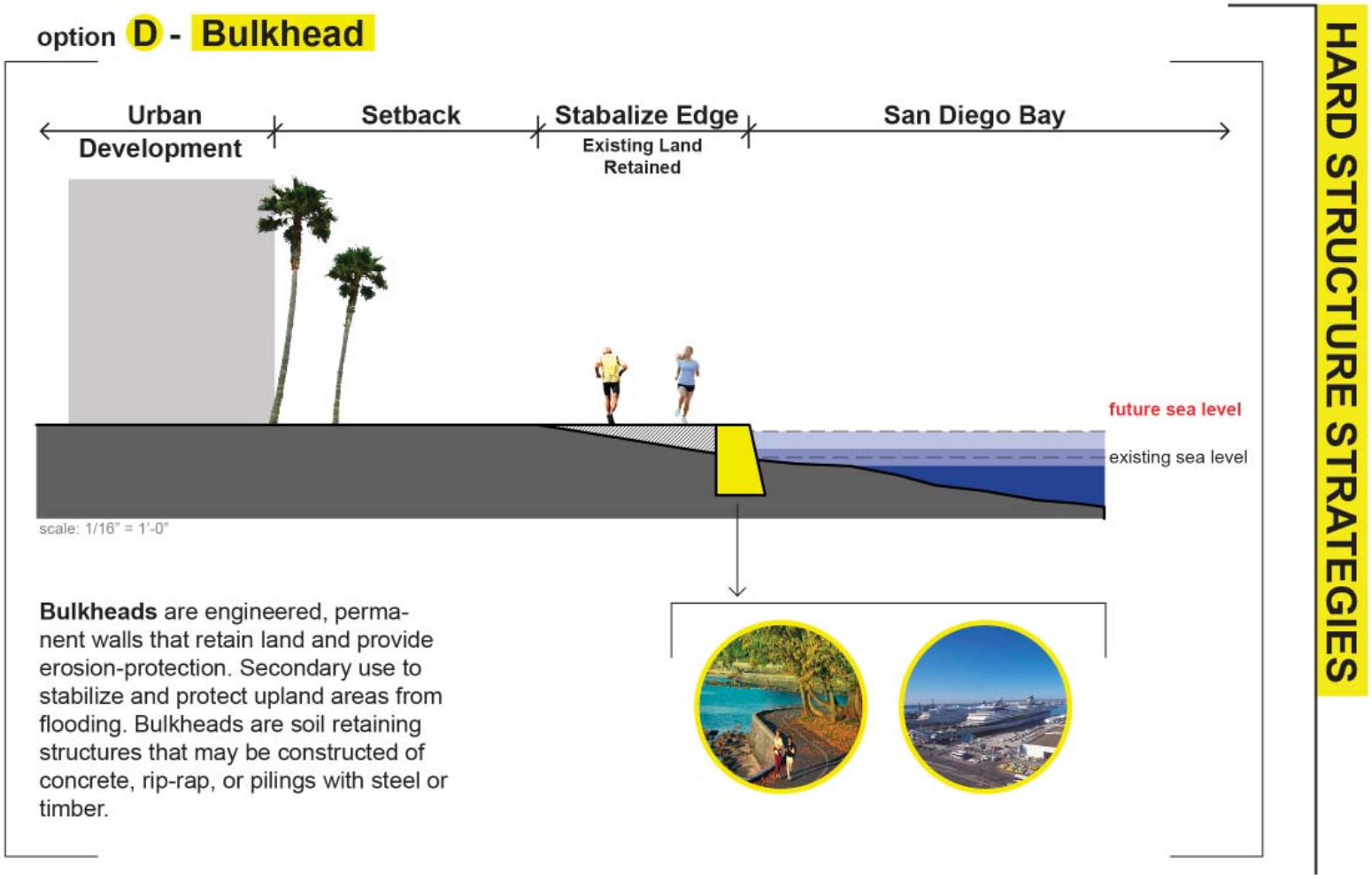
Seawalls may be stepped on both the bay and city sides, allowing for easier access and greater public uses while working to dissipate wave and tidal energy. More land would be required for this option, and construction expenses would increase

Appendix B: Adaptation Strategy Examples

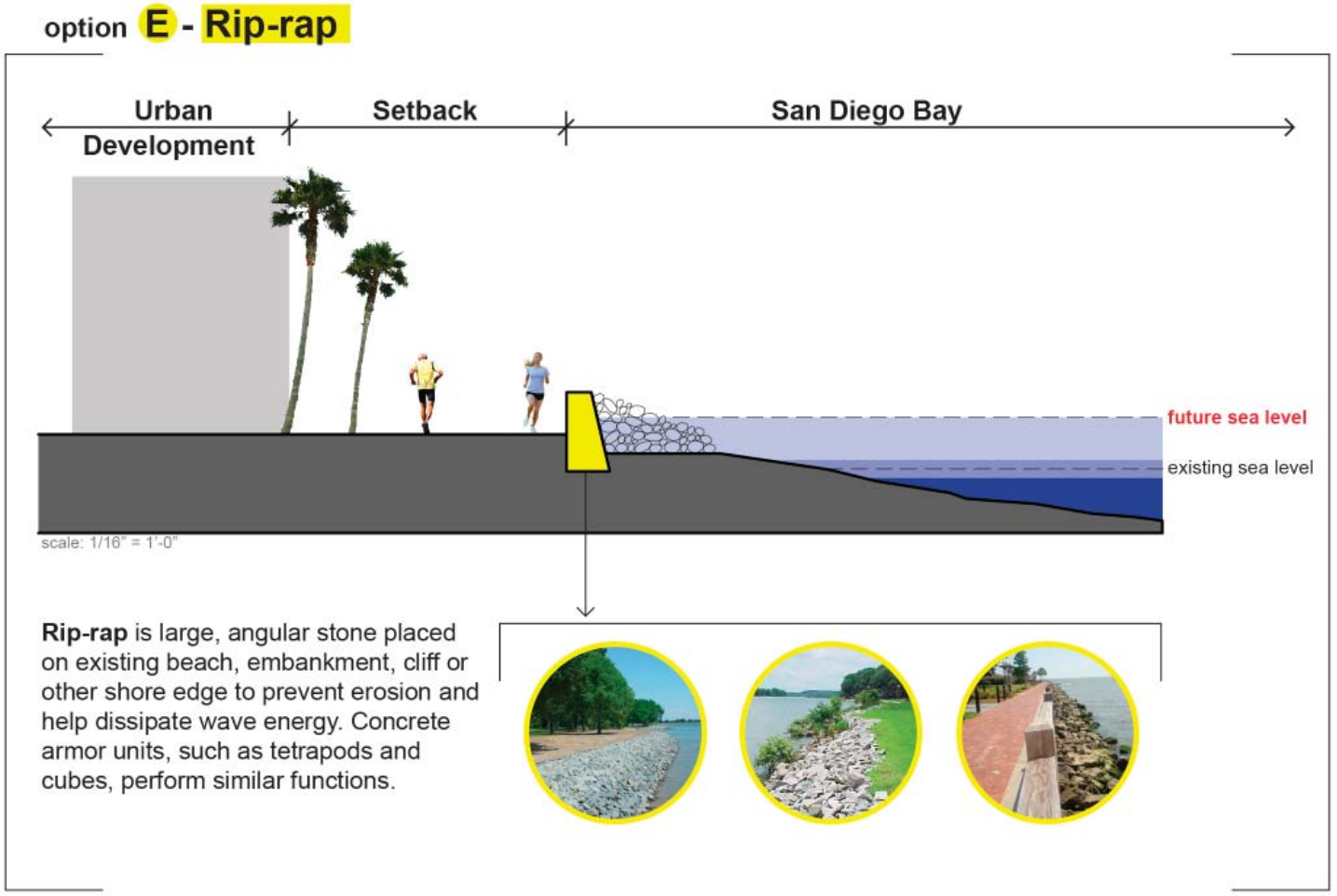
option C - Levee



Levees are engineered, permanent, impermeable barriers constructed to protect low-lying inland areas from flooding. The mounds are constructed of earth, sand and clay; the sloped sides are stabilized and protected from erosion and wave action by rip-rap or concrete armor units.


option D - Bulkhead
Urban Development
Setback
Stabalize Edge
Existing Land Retained
San Diego Bay
future sea level
existing sea level
scale: 1/16" = 1'-0"
Bulkheads are engineered, permanent walls that retain land and provide erosion-protection. Secondary use to stabilize and protect upland areas from flooding. Bulkheads are soil retaining structures that may be constructed of concrete, rip-rap, or pilings with steel or timber.
HARD STRUCTURE STRATEGIES

Appendix B: Adaptation Strategy Examples



strategy: SOFT STRUCTURE

Soft structures use natural systems and ecosystem services to protect development, investments, and ecosystem well-being. Soft defenses typically protect development through increasing the distance between the water and structures or through requiring space for percolation and retention of flood waters and runoff. Examples include wetland preservation and enhancement, and stormwater management with bioswales and detention basins to hold floodwaters.

Tijuana Estuary

opportunities:

- Reduction of intensity and frequency of flooding, correspondingly reducing size and cost of any required seawalls or hard structures
- Preserves or increases valuable habitat
- Provides recreation and open space areas
- Reduces water pollution in bay and enhances groundwater recharge

constraints:

- More extensive land required to provide benefits
- Continued maintenance required
- Green infrastructure is typically cost effective

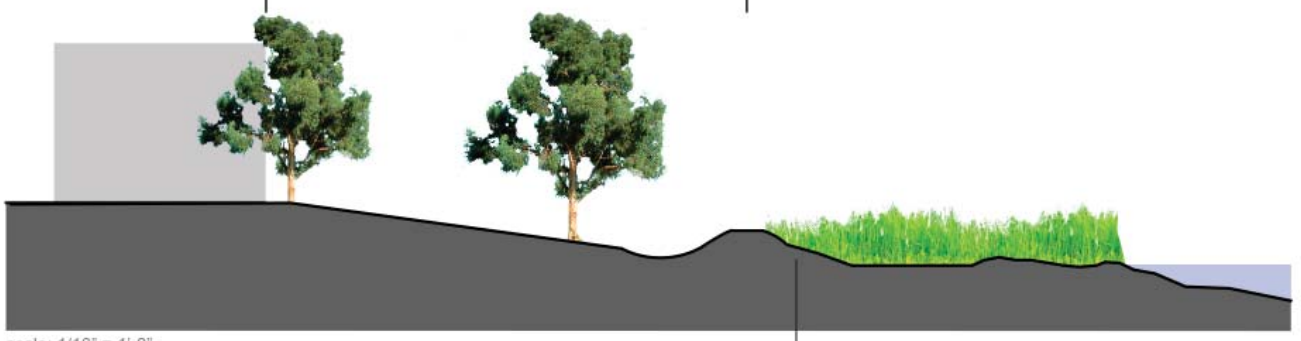
unknowns:

- Time to establish new habitat

SOFT STRUCTURE

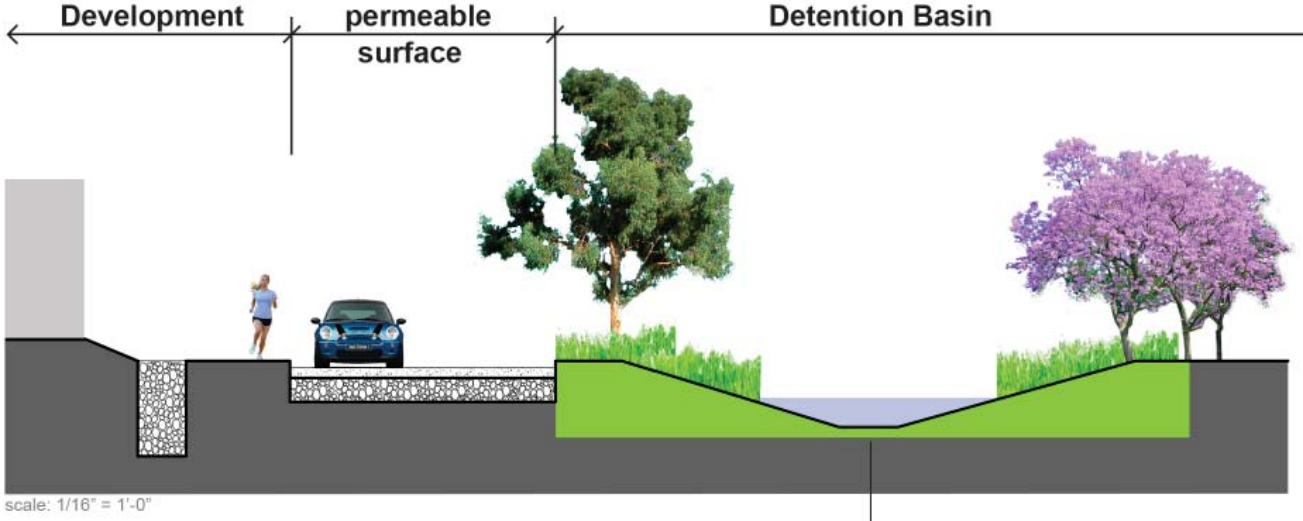
Appendix B: Adaptation Strategy Examples

option A - Wetland Restoration / Enhancement



Wetland restoration/enhancement and their natural filtration and absorptive qualities provide flood water storage, buffers from wave and tidal energy, and shoreline stabilization. Wetlands are also particularly sensitive and will "naturally" shift upland with the increasing salinity and water depth that results from sea level rises. Wetlands provide ecosystem services to local communities in the form of improved water quality, support for fisheries, and recreation.

option B - Low Impact Development (LID) and Green Infrastructure

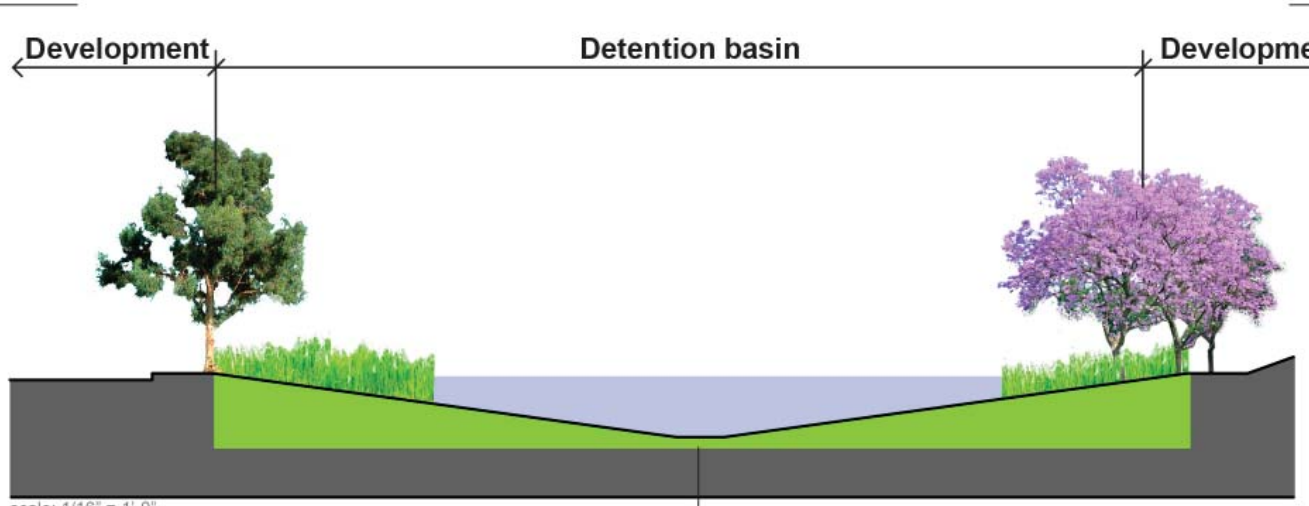


scale: 1/16" = 1'-0"

Low impact Development (LID) and Green Infrastructure work with natural systems to maximize the retention and percolation of stormwater. Green infrastructure includes the open, permeable spaces within a community, and seeks to adapt traditional "gray" infrastructure to allow for infiltration of stormwater and provide potential habitat.

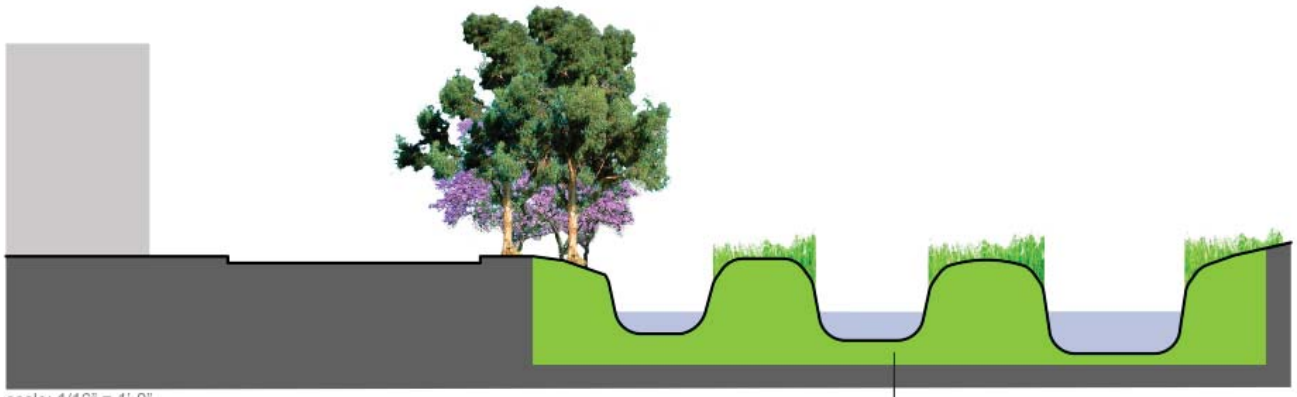
Appendix B: Adaptation Strategy Examples

option C - Detention basins or upland "mini-floodplains"



Detention Basins or Constructed Wetlands are engineered basins that collect stormwater, either allowing it to percolate on-site or releasing it after the major storm event has passed. Upstream basins help to prevent flooding by capturing it before it reaches the bay.

option D - Bioinfiltration / Stormwater Park



scale: 1/16" = 1'-0"

Bioinfiltration uses plants and topography to capture and filter stormwater, and create habitat areas. Examples are stormwater parks, rain gardens and small "pocket" wetlands that allow for "managed flooding".

Appendix B: Adaptation Strategy Examples

option E - Bioswales and other vegetated drain channels

scale: 1/16" = 1'-0"

Bioswales and other vegetated drain channels direct flood waters away from development, slow runoff, and allow for percolation of storm or flood waters.

strategy: ACCOMMODATION

Accommodation realigns traditional methods of planning and building with changing conditions of high water and tidal fluctuations. New building methods accommodate new flood plains and various degrees of flooding.

Loblolly House, Kieran Timberlake Architects

opportunities:

- Removes development from immediate threat of flooding
- May reduce flood insurance premiums• text here
- Property owner can control elevation of structure

constraints:

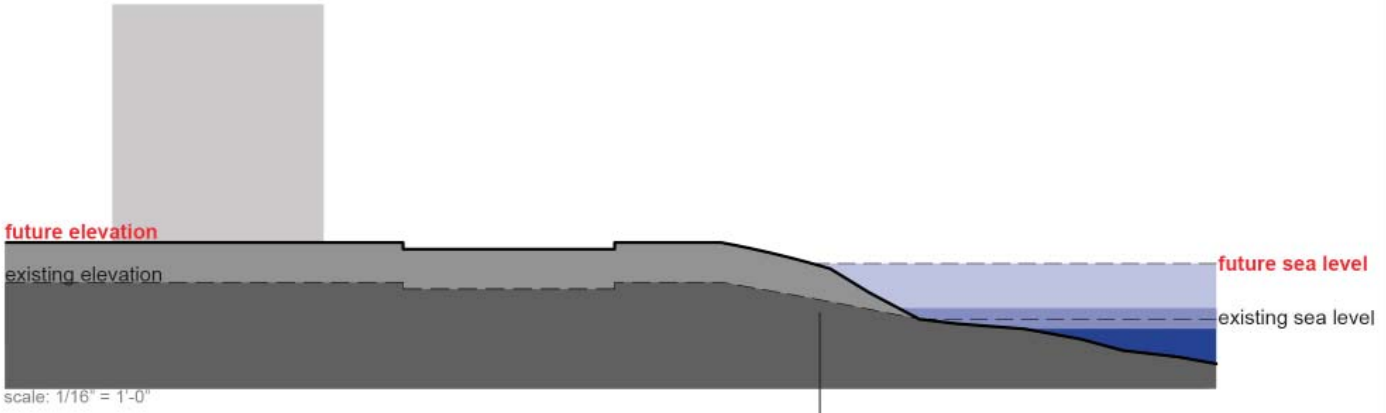
- Expensive to retrofit existing development
- Not useful in areas with permanent flooding
- Adding fill and raising grades may impact wetlands and other habitat

unknowns:

- Accessibility
- Costs of allowing flooding of development, even if temporary

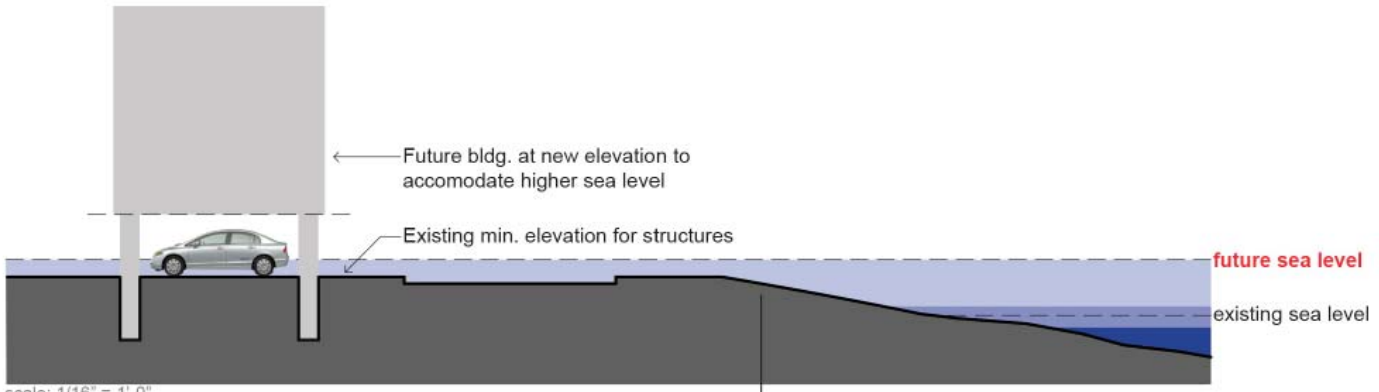
Appendix B: Adaptation Strategy Examples

option A - Elevated Grade Surface



Elevated grade surfaces raise elevations of pads for new structures, infrastructure, and other land uses. Earth or gravel, or raised foundation walls, can be used to raise building pads and infrastructure up out of low-lying areas that might be expected to flood. Depending on edge conditions, elevated grades may require rip-rap and other armoring for protection. It may be possible to raise the land surface of wetlands.

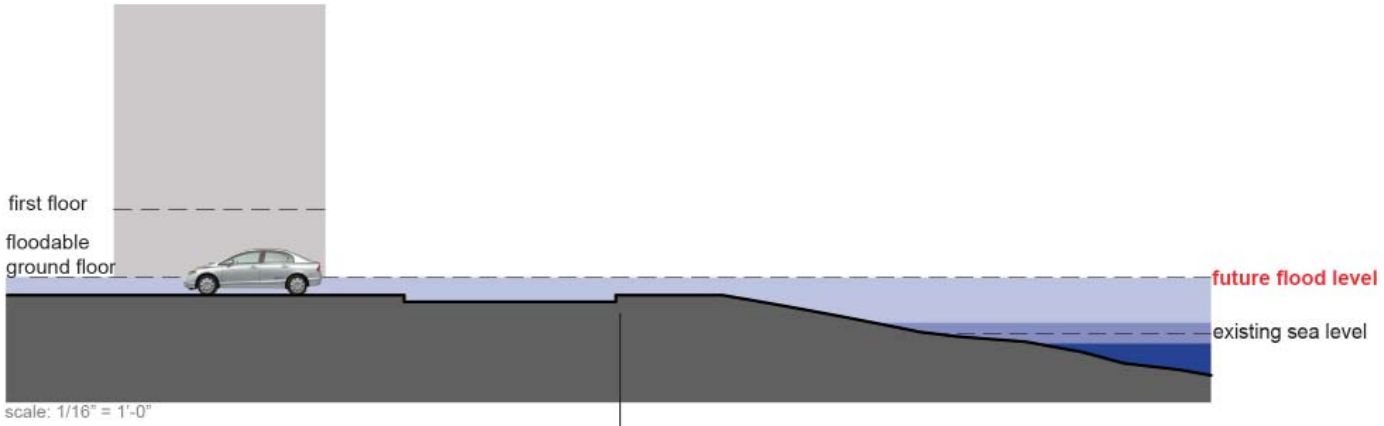
option B - Elevated Structure



Elevated structures built in known flood plains are often constructed on pilings to allow for flood waters to flow under the structure.

Appendix B: Adaptation Strategy Examples

option C - Floodable Development

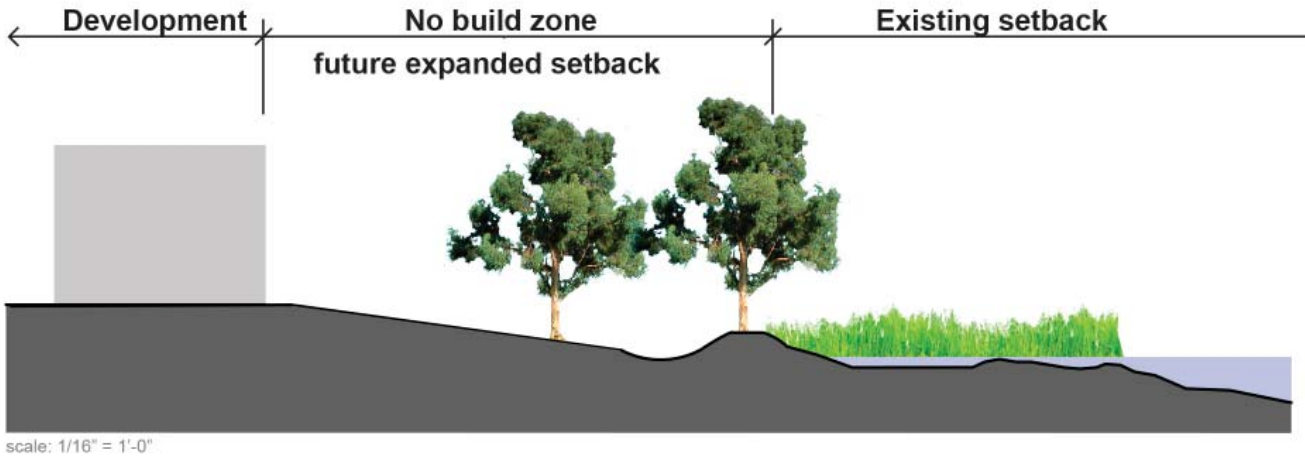


Floodable development allows for flooding of either built structures or open spaces. In built structures, the floodable area is designated as uninhabitable, and while habitable space is restricted to upper levels of development. Shore edge parks and plazas can also be flooded intermittently.

option D - Floating Structure

Floating structures range from houseboats to floating roadways and other infrastructure. The mooring or anchoring of the structure is critical to the success of this strategy.

option E - Buffers and Setbacks



scale: 1/16" = 1'-0"

Buffers and setbacks are land permanently dedicated to remain undeveloped and vegetated to protect adjacent land from flooding or other impacts. Setbacks from the water's edges are achieved through zoning, overlay zones, and land use restrictions. Buffers and setbacks are most effective when they are determined in conjunction with specific conditions, such as susceptibility to erosion or wave action, or capacity to provide valuable habitat. They may be established through regulation or land acquisition.

strategy: Withdrawal

Withdrawal from rising sea levels, or managed retreat, is a viable strategy when the economic and ecological costs of protecting development is prohibitive. The objective is to allow for flooding and rising sea levels through restricting development or moving structures out of the path of the water. New development would be prevented in vulnerable areas. Reducing federal or other subsidies for shore protection may help property owners manage the risk of bayfront development.

Shoreline in Dare County, North Carolina

opportunities:
- New space for tidal habitats
- New recreation and open space areas
- Increased or maintained public access to shoreline areas

constraints:
- Property owner opposition
- More expensive than hard structure strategies in urban areas

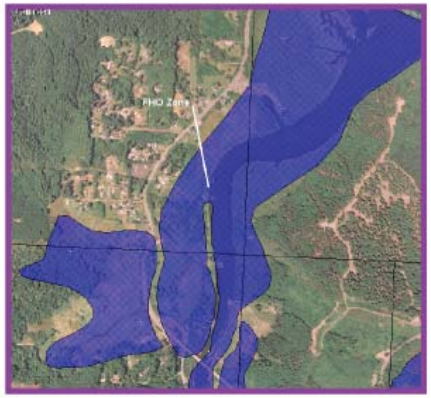
unknowns:
- Legal and insurance issues
- Public perception

Appendix B: Adaptation Strategy Examples

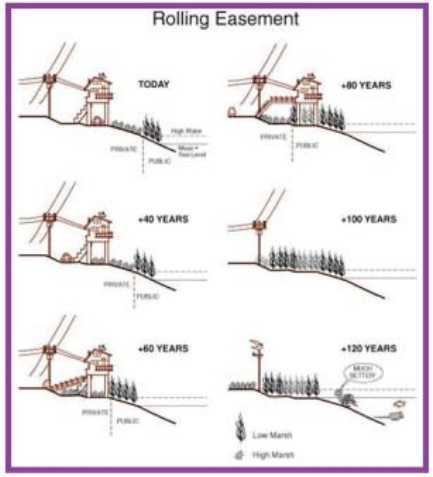
option A - Zoning and Overlay Zone

option B - Rolling Easements

Zoning and overlay zones guide the design and planning process for development and habitat areas through restricting land uses to avoid risks associated with flooding.



Rolling easements are a type of easement that prevents hard structures and armoring of the coastal edge, but otherwise doesn't prohibit land uses. The easement "rolls" or moves inland as the sea level rises, maintaining the area of public tidal lands, and allowing for shoreline habitats to also migrate inland. Structures may be moved elsewhere on the property, or elevated to allow for water flow.



option C - Design for Disassembly

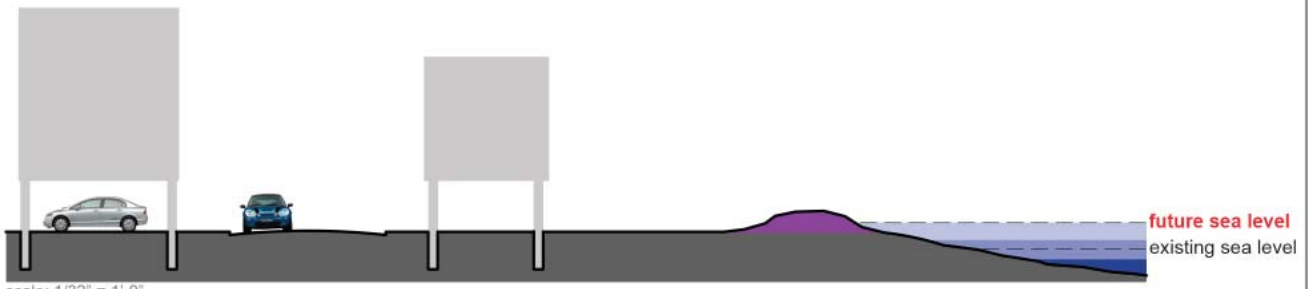
Design for Disassembly is a building process that plans for the future disassembly and reuse of building materials.

Appendix B: Adaptation Strategy Examples

option D - Managed Retreat

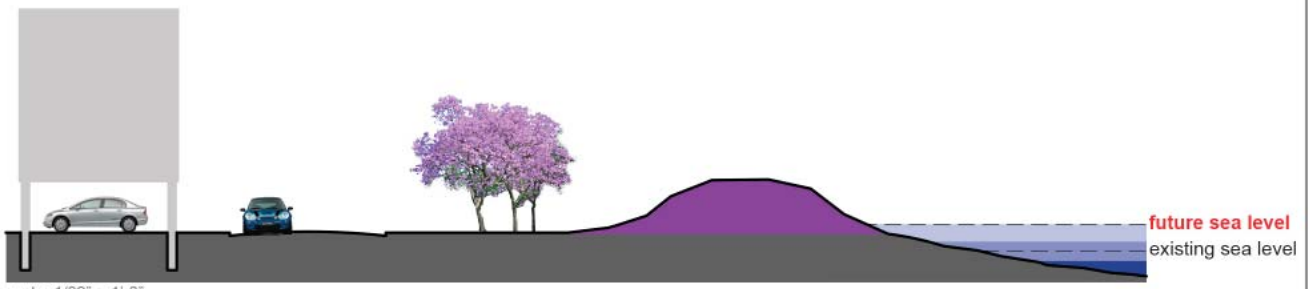
scale: 1/32" = 1'-0"

Existing development exposed to coastal storms and flooding



scale: 1/32" = 1'-0"

Phase 1: Shorefront homes removed and housing elevated for flooding.



scale: 1/32" = 1'-0"

Phase 2: Shoreline buildings removed, dune built up with vegetative coastal buffer

Managed retreat moves human settlement away from the fluctuations of the water-land interface. Structures may be removed or relocated inland as sea level rises and the existing shoreline erodes. Plans for withdrawal from the water's edge can be incorporated in long-range plans and visions, and include the planned relocation and/or disassembly of valuable existing structures and land uses as well as planned abandonment of less essential structures.

University of Florida Department of Urban and Regional Planning
PO Box 115706
Gainesville, FL 32611
Phone: 352-294-1485