

The image is a composite of two photographs. The top photograph shows a multi-story building with blue balconies under construction on a sandy dune. A yellow excavator is visible in the background. The bottom photograph shows a beach with large, broken concrete blocks and debris scattered across the sand and shallow water. The sky is clear and blue.

POST-DISASTER REDEVELOPMENT PLANNING

*Addressing Adaptation
During Long-term Recovery*

This report is funded in part, through agreement from the Florida Department of Environmental Protection, Florida Coastal Management Program, by a grant provided by the Office of Ocean and Coastal Resource Management under the Coastal Zone Management Act of 1972, as amended, National Oceanic and Atmospheric Administration Award No. NA10NOS4190178. The views, statements, findings, conclusions, and recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of the NOAA, or any of its sub-agencies.



Cover Photo: New Smyrna Beach, FL, -- The destruction of this seawall and the erosion behind was caused by the storm surge and wave action of Hurricane Jeanne. FEMA Photo/Mark Wolfe. (October 27, 2004).

Table of Contents

Executive Summary 1

How To Use This Addendum..... 3

Chapter 1: Getting Started..... 5

Understanding the Impacts of Sea Level Rise 5

 Southeast Florida Regional Climate Change Compact 6

Chapter 2: Planning Process 7

 Capacity Assessment and Plan Integration 8

 Local Comprehensive Plan 8

 Capital Improvement Element and Capital Improvement Program..... 9

 Economic Development Strategies 9

 Local Mitigation Strategy 10

 Vulnerability Assessment Methodology and Assumptions 13

 Transportation Infrastructure Vulnerability Assessment 17

 Public Infrastructure Vulnerability Assessment 18

 Public Facility Vulnerability Assessment 18

 Economic Vulnerability Assessment 19

 Land and Environment Vulnerability Assessment 19

Chapter 3: Plan Topics 21

 Adaptation Action Areas: Guiding Redevelopment Decisions 22

 Land Use and Housing Redevelopment Strategies 23

TABLE OF CONTENTS

Economic Redevelopment Strategies	31
Infrastructure Redevelopment Strategies	35
Public Facilities Redevelopment Strategies	43
Health and Social Services Redevelopment Strategies	45
Environmental Restoration Strategies	47
Chapter 4: Implementation Considerations	51
Pre-Disaster Implementation	51
Post-Disaster Implementation	52
Infrastructure Adaptation Decision Making Triggers	53
Financing Implementation	54
Including the Public in Implementation	54
References and Resources	57
References	57
Resources	59
Acronyms	61

Executive Summary

According to the Florida Oceans and Coastal Council, the potential for sea level rise may cause significant saltwater flooding of coastal property and infrastructure, greater vulnerability to storm surges and erosion, and the destruction of vital coastal habitats (Florida Oceans and Coastal Council, 2009). Water management infrastructure and regional water control structures located near the coast may be highly vulnerable (South Florida Water Management District, 2009). To date, few communities have developed specific policies to address the challenges of this emerging issue, nor do they incorporate adaptation strategies specifically targeting sea level rise. This is most likely due to the uncertainty of the planning horizon associated with sea level rise, a lack of data supporting appropriate adaptation strategies or an inability to dedicate financial and human resources to the long-term and controversial strategies associated with climate change. However, many communities engage in a range of activities to reduce their long-term exposure to hazards, which may inadvertently also address the potential risk from sea level rise.

This addition to the *Post-Disaster Redevelopment Planning: A Guide for Florida Communities* guidebook, referred to in this document as the Addendum, represents the fifth phase of the Statewide Post-Disaster Redevelopment Planning Initiative. The initial four phases provided vulnerable communities a planning process to guide post-disaster redevelopment activities that enhance community sustainability and ensure resilient redevelopment after any disaster. The purpose of this Addendum is to augment the best practices guidance related to coastal communities and also consider ways to address potential sea level rise adaptation during the long-term recovery process.

This Addendum focuses specifically on **Palm Beach County, Florida, as they served as the pilot for this process**, to explore a range of adaptation strategies, which may be employed in the post-disaster environment to enhance community sustainability. This Addendum provides an assessment of how sea level rise scenarios may alter the impacts of future storms and provides recommendations for local decision makers to consider when addressing long-term community sustainability in the aftermath of a large scale disaster.

Palm Beach County was selected as the pilot community for the following reasons:

- Palm Beach County was one of the first communities within the State of Florida to develop a comprehensive Post-Disaster Redevelopment Plan, which pre-dated the Statewide Post-Disaster Redevelopment Planning Initiative.
- The executive leadership within Palm Beach County demonstrated support and understanding of the importance of post-disaster redevelopment planning and community sustainability initiatives.

EXECUTIVE SUMMARY

- Palm Beach County is part of a larger regional initiative, the Southeast Florida Regional Climate Change Compact, which has devoted extensive research and consensus building efforts to develop sea level rise scenarios and adaptation policy options, which may be integrated into the post-disaster redevelopment planning effort.
- Palm Beach County was in the early stages of their Post-Disaster Redevelopment Plan update process, so integration was timely.

While Palm Beach County was selected as a pilot community for this planning effort, the range of adaptation strategies which are explored in this Addendum may be suitable for any community seeking strategies to enhance community sustainability. This Addendum provides a menu of adaptation strategies to explore for implementation in the aftermath of a disaster. As social, political, environmental and scientific dynamics continue to shape coastal communities in the future, it is ultimately up to local governments to decide which route to take regarding adaptation planning in the future.



Photo (above): New Smyrna Beach, Hurricane Wilma, Clark, R. and LaGrone, J.W., 2006, Hurricane Wilma Post-Storm Beach Conditions and Coastal Impact Report, Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems.

How To Use This Addendum

This Addendum is designed as a companion to the *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*. It provides guidance for communities who would like to enhance their existing Post-Disaster Redevelopment Plan by including adaptation measures to address the impacts of sea level rise (SLR). This Addendum provides steps which may guide the plan development process, an overview of how sea level rise might affect the hazard vulnerability process and a list of planning and policy considerations for communities to incorporate the potential long-term impacts of hurricane storm surge increased by sea level rise.

Chapter 2 provides guidance on how to assess existing plans, policies, and programs that may exist within your community and support community adaptation. The comprehensive plan, the Local Mitigation Strategy, economic development strategies, and Capital Improvement Plans are examples of plans which may incorporate specific policies, funding strategies, or initiatives aimed to enhance long-term community sustainability. This chapter will also provide a process to conduct a hazard vulnerability analysis to assess the risks and vulnerabilities posed by augmented hurricane storm surge due to sea level rise. This hazard vulnerability analysis section will provide instruction on how to produce a series of Geographic Information System based maps detailing vulnerable areas, structures, and facilities. These maps are designed for planning purposes only.

Chapter 3 explores a range of policy recommendations for addressing sea level rise impacts within the post-disaster redevelopment planning process. The goal is to ensure that the full ranges of strategies are addressed across organizations, jurisdictions, and disciplines. The chapter also offers sample policy language which each organization may consider during the plan update process. It is offered as a general guide to aid planners and should be modified to meet jurisdictional needs.

Chapter 4 reflects upon opportunities to support the post-disaster implementation of sea level rise adaptation strategies.

Throughout the Addendum, examples are provided from Palm Beach County, Florida which served as the pilot community during Phase 5 of the Statewide Post-Disaster Redevelopment Planning Initiative. Strategies and recommendations within this document do not reflect endorsement by Palm Beach County, but are offered for future consideration by local decision makers in the evaluation of sea level rise and possible adaptation strategies to mitigate these impacts.



WATER HAZARD

Chapter 1: Getting Started

Understanding the Impacts of Sea Level Rise

The specific time horizon for sea level rise remains uncertain; yet, any rise in the level of the ocean could eventually affect the level of threat from hazards that a community already experiences such as hurricane storm surge, coastal erosion, land subsidence, and saltwater intrusion of the aquifer. Over time, the condition of a rising sea level may magnify these impacts. Sea level rise may also place unanticipated stress on the gravity flow stormwater systems throughout Florida. Due to the interconnectivity of water management systems throughout the floodplain, slight changes in sea level could impact not only the coastal regions, but inland regions as well. Infrastructure systems, facilities, homes, businesses and coastal structures may also eventually feel the effects of the rising sea. Storm surge augmented by future sea level rise could produce a cascade of consequences affecting things such as land use, infrastructure, facilities, waterway navigation, local economies, public health and safety, drinking water supplies, and ecosystems.

Through numerous collaborative efforts such as the Intergovernmental Panel on Climate Change and the Southeast Florida Regional Climate Change Compact, scientists, environmentalists, engineers, community planners, and community leaders continue to evaluate emerging data, scientific findings, and long-term trends. The consequences of sea level rise may require local jurisdictions to consider a series of adaptive response options.

The post-disaster environment may offer unique “windows of opportunity” to build community resilience, such as preserving open space within designated Adaptation Action Areas where buildings have been destroyed or reconstructing roads and bridges stronger and more resilient to sea level rise. This Addendum will provide guidance, which local communities may want to incorporate within their post-disaster redevelopment planning efforts to address the impacts of rising seas.

Photo (left): Exclusive coastal golf resort. Seminole Country Club, Juno Beach, Florida. Palm Beach County, Division of Emergency Management, Sheridan Truesdale (2005).

Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme and the World Meteorological Organization and assesses the most recent scientific, technical and socio-economic information produced worldwide, relevant to the understanding of climate change. Scientists worldwide contribute to the work of the IPCC to ensure an objective and complete assessment of current information while remaining policy neutral. This body provides sea level rise projections, with the next release anticipated in September, 2013.

SOUTHEAST FLORIDA REGIONAL CLIMATE CHANGE COMPACT

The Southeast Florida Regional Climate Change Compact represents a joint commitment of Palm Beach, Broward, Miami-Dade and Monroe Counties to partner in mitigating the causes and adapting to the consequences of climate change, including sea level rise. The Compact was formalized following the 2009 Southeast Florida Climate Leadership Summit, when elected officials came together to discuss challenges and strategies for responding to the impacts of climate change. The Compact outlines a collaborative effort to participate in a regional effort to develop the Southeast Florida Regional Climate Change Action Plan. The Compact also commits the Counties to work on federal and state climate policies and joint advocacy in Tallahassee and Washington, DC on climate policies related to the shared challenges of climate change. Additional information related to the Compact may be located at: <http://www.southeastfloridaclimatecompact.org>



Chapter 2: Planning Process

During the update of the Post-Disaster Redevelopment Plan, jurisdictions will transition through the five stages of the planning process, which are detailed in the *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, **Chapter 2**. The steps include initiating the update process, organizing the stakeholders, research and analyses, facilitating input, and revising the plan for executive approval. During each of the phases of the planning process, it may be valuable to consider the impacts of sea level rise.

- **Initiate Process:** The local Post-Disaster Redevelopment Plan Coordinator will likely initiate the process based upon a number of factors including routine plan update cycles coinciding with the update of the comprehensive plan and/or Local Mitigation Strategy, changes in local regulatory policy, available funding opportunities to support the planning process, and actual disaster occurrences. While the integration of sea level rise alone may not drive the update of the Post-Disaster Redevelopment Plan, any updates or local initiatives to address sea level rise may be possible opportunities to incorporate greater community resiliency efforts.
- **Organize Stakeholders:** Many of the stakeholders engaged in the original Post-Disaster Redevelopment Planning Process will again be engaged in update process. Local communities, however, may also consider targeting organizations and agencies that are engaged locally in evaluating the impacts of sea level rise. See the insert on Page 9 for an example from Palm Beach County.
- **Research and Analysis:** Within this chapter, we will provide guidance on how to conduct a Capacity Assessment and Vulnerability Analysis in support of sea level rise integration during the Post-Disaster Redevelopment Plan update process. (See below for further instructions).
- **Facilitate Input:** The integration of sea level rise adaptation and community resilience in the post-disaster redevelopment process may involve numerous challenges. Building community support for enhancing community resilience remains a challenge at this early



stage of understanding potential impacts. Chapter 4 will address opportunities to facilitate input in the development strategies, which encourage sustainability goals.

- **Draft and Adopt Plan:** The development and adoptions may again parallel the local process, which was implemented during the initial implementation process.

Purpose of Plan Integration

Sea level rise policies may ultimately be addressed in a range of programs at the local level of government from environmental policies, economic development strategies and land development regulations, to long-range infrastructure plans. The post-disaster environment should maximize opportunities to reinforce, enhance, and expedite these existing community resilience efforts.

CAPACITY ASSESSMENT AND PLAN INTEGRATION

The Post-Disaster Redevelopment Plan is a guide that connects other policy documents during the long-term recovery process. The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, **Chapter 2**, provides an overview of the “Capacity Assessment” process. As stated in this chapter: “the capacity assessment provides a basis for assessing the community’s ability to implement the Plan and identify any potential gaps in capacity” (p.25). This Addendum provides important steps to incorporate sea level rise adaptation efforts, which may currently exist within the community or the greater region during this assessment process. The capacity assessment may include the evaluation of plans, policies, and programs that relate to not only sea level rise, but also incorporate coastal erosion, stormwater management, saltwater intrusion, surface and groundwater quality and quantity, floodplain management, and coastal high-hazard area policies among others. The following documents may incorporate specific policies, funding strategies, or initiatives aimed to enhance long-term community sustainability and, thereby, either directly or indirectly, support long-term community resilience, sustainability, and post-disaster redevelopment efforts.

LOCAL COMPREHENSIVE PLAN

The local comprehensive plan serves as a guiding vision for future development of the community, as well as, one of the jurisdiction’s regulatory policy documents. Comprehensive plans are comprised of numerous elements which may contain policies influential in the post-disaster environment and relate either directly or indirectly to sea level rise impacts. Elements such as Future Land Use, Transportation, Housing, Utility, Recreation and Open Space, Conservation, Coastal Management, and others may have policies impacting long-term community sustainability and resilience.

CAPITAL IMPROVEMENT ELEMENT AND CAPITAL IMPROVEMENT PROGRAM

Capital projects are relatively large-scale, nonrecurring projects that may require multi-year financing. The Capital Improvement Element evaluates the need for public facilities, estimates the cost of improvements, analyzes the fiscal capability of the local jurisdiction to finance and construct the improvements, and provides a schedule for the funding and construction of the improvements. Projected revenues are compared to the projected funding requirements to demonstrate the fiscal feasibility of the Plan. The criteria for prioritizing capital improvements is generally detailed in the Capital Improvement Element and likely address numerous issues such as public safety, improving existing deficiencies, and maintaining levels of service within the community. Most communities, however, currently do not incorporate criteria for the evaluation of adaptation strategies. The Capital Improvement Program outlines the budget and implementation plan for the construction, enhancement, or maintenance of infrastructure and facilities to support the levels of service as defined in the local comprehensive plan. As communities begin to incorporate greater community resilience strategies, the selection of projects may also reflect these priorities.

Generally, the Departments within the local jurisdictions will oversee the projects under their purview. For example, the Department of Engineering and Public Works may submit capital stormwater enhancement and roadway improvement projects. The Facilities Department may submit land acquisition projects. The Parks Department may advocate for land acquisitions to expand, enhance, or protect parks. Current capital projects may either directly, or indirectly, advance community resilience goals and mitigate the impacts of sea level rise. Communities may consider opportunities within the Capital Improvement Program's identification process to verify that all projects maximize impacts to community resilience and, at a minimum, consider the long-term implication of sea level rise. This evaluation and coordination may cross departmental lines and maximize opportunities for inter-jurisdictional coordination and cost sharing.

ECONOMIC DEVELOPMENT STRATEGIES

Economic development strategies set a framework for future actions and establish economic development priorities for the community. The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* **Chapter 3**, Economic Redevelopment (**pages 61-69**) provides

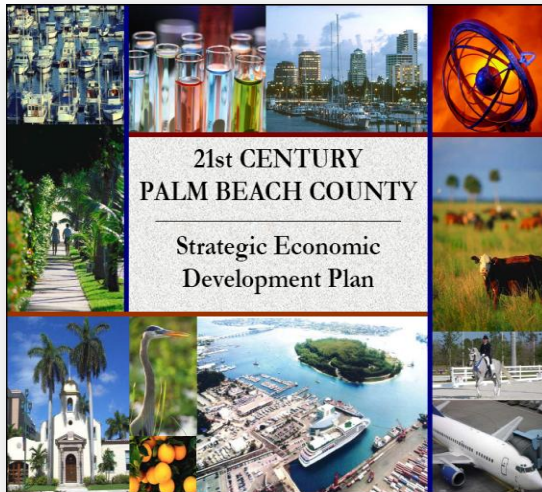
Palm Beach County Strategic Economic Development Plan (2007)

Page 25, Action I. 07

Develop a resilient and sustainable economy by implementing the Post-disaster Redevelopment Plan ... Future business recruitment and business retention depend heavily upon economic survivability during and after disasters. Preliminary discussions are underway to form public/private partnership initiatives that will strengthen business disaster resiliency and survival rates, as well as better utilize local business resources and capabilities in support of community disaster preparedness, and post-disaster recovery and economic redevelopment. This plan may also consider incorporating sea level rise adaptations strategies for the economic sector.

guidance on the development of post-disaster economic redevelopment strategies. These strategies incorporate opportunities for public/private partnerships, which allow the community to leverage private investment and ensure mutual cooperation and benefits in the post-disaster environment. The goals and objectives among communities vary extensively though generally post-disaster economic redevelopment activities reinforce any of the following:

- restore the local tax base,
- generate revenues,
- maintain and diversify the economic base,
- enhance and market the natural and built environment,
- highlight the arts, local culture, and history,
- generate smart transportation and land uses,
- maintain affordable housing,
- attract learning opportunities and diversify the local workforce, or
- support small business viability and opportunities.



Many Florida communities rely upon tourism to drive the local economic base. For coastal communities on the east and west coast of Florida, water-dependent uses, beachfront hotels, restaurants, retail, and conventions comprise a large segment of the tourism revenue. Increased levels and duration of flood inundation along the coastal waterfront may significantly impact tourism to the region, particularly, in the aftermath of a disaster. The public and private sectors within the tourism industry would likely benefit from the coordination of adaptive strategies.

LOCAL MITIGATION STRATEGY

Each county within the State of Florida develops a Local Mitigation Strategy on behalf of all jurisdictions within its boundaries. The purpose of the Local Mitigation Strategy is to **reduce or eliminate the impact of hazards** which exist within a community and are a threat to life and property. Local mitigation planning forms the foundation for short-term and long-term post-disaster recovery and mitigation activities. For jurisdictions seeking mitigation funds, the Local Mitigation Strategy may be an eligibility requirement.

The Local Mitigation Strategy contains valuable information related to hazards impacting the community. The Local Mitigation Strategy usually contains a variety of hazard maps, lists of impacted critical facilities, and details of vulnerable populations within the hazard vulnerability

analysis. This plan may also incorporate an assessment of how sea level rise could impact these hazards. Sea level rise could alter the impacts related to flooding, storm surge, coastal erosion, subsidence, and water contamination.

The Local Mitigation Strategy generally lists jurisdictional mitigation initiatives which enhance community resiliency. In Florida, most of the projects and policy initiatives target the impacts of flooding, wind, and beach erosion. The condition of sea level rise may augment these environmental conditions and reinforce the need for the previously identified mitigation projects and initiatives. Policies which enhance community sustainability may be broadly applicable to a variety of hazards.

The Local Mitigation Strategy details the authority for the development, maintenance, and implementation of the program. Programmatic components may consist of a leadership or steering committee and numerous subcommittees who are responsible for various elements of program implementation and maintenance. This committee structure may be instrumental in the development of a comprehensive community sea level rise integration strategy. The Local Mitigation Strategy organization may also provide a mechanism to educate the public and inform stakeholders regarding sea level rise adaptation strategies.



Photo (right): Melbourne Beach, FL, The Breakers Resort is at continued risk following beach erosion caused by Hurricane Irene. The Federal Emergency Management Agency's (FEMA) PROJECT IMPACT is working to assist communities with steps they can take to make residents and property safer and more disaster resistant. Photo by Ty Harrington/FEMA News Photo (October 1999)



Photos (above): Images depicting normal and astronomical high tides in South Florida. Photo Courtesy of Paul Krashefski, Broward County Natural Resources Planning, and Management Division. (October 2010)

VULNERABILITY ASSESSMENT METHODOLOGY AND ASSUMPTIONS

The following is a methodology to conduct a preliminary assessment of how sea level rise scenarios may alter the impacts of future storms. By understanding the influence of sea level rise on the jurisdiction's vulnerability to hurricane storm surge hazards, it may be possible to proactively implement adaptation strategies during post-disaster redevelopment efforts.

While the scientific community continues to evaluate the myriad of factors affecting the rise of the ocean levels, this Addendum suggests a methodology to evaluate adaptation strategies which will promote discussion among coastal communities in the aftermath of a large-scale disaster. This chapter will provide a process to conduct a hazard vulnerability analysis to assess the risks and vulnerabilities posed by augmented hurricane storm surge due to the sea level rise. At the completion of this hazard vulnerability analysis, each community will have access to a series of Geographic Information System (GIS) based maps detailing potentially vulnerable areas. These maps are designed for post-disaster redevelopment planning purposes only and may not reflect permanent sea level rise inundation areas. The impact of sea level rise may not be felt for decades to come, thus giving local planners, decision makers, and elected officials ample time to gradually implement the adaptation strategies which they deem appropriate for their individual communities. The adaptation strategies, which communities may implement over the coming decades, will also impact the prioritization of post-disaster redevelopment strategies.

Method Overview: This assessment evaluates the data from the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) model provided by the U.S. National Hurricane Center (NHC), National Oceanic and Atmospheric Administration (NOAA), which determines storm surge zones. SLOSH modeling integrates the maximum surge height for hurricanes of Saffir-Simpson Hurricane Wind Scale categories 1, 3, and 5. Using GIS tools, the model outputs are converted to raster grids and standardized to a base water elevation of the mean higher high water (MHHW) plus sea level rise. Water heights over land are then assessed against a Light Detection and Ranging (LiDAR) derived digital elevation model to delineate the overland inundation zones that result from hurricane storm surge and sea level rise. Damages to critical and public facilities, groundwater, inland canals, property, and infrastructure were then identified using GIS. These data outputs provide an initial analysis for community leaders and planners to discuss possible implications for adaptive response to create a more disaster resilient and sustainable community.

Palm Beach County Sea Level Rise Projections

The Southeast Florida Regional Climate Change Compact Steering Committee developed their estimated sea level rise projection using the U.S. Army Corps of Engineers July, 2009 Guidance Document, which uses Key West tidal data (1913-1999) as the foundation of the calculation of 3-7 inches by the year 2030 and 9-24 inches by the year 2060.

For additional information, reference the Analysis of the Vulnerability of Southeast Florida to Sea Level Rise, South Florida Regional Climate Change Compact Inundation Mapping and Vulnerability Assessment Work Group.

Using maps with inundation overlays and a series of tables and graphs, this hazard vulnerability analysis will allow communities to examine the high-risk areas and provide post-disaster redevelopment and adaptation recommendations. This methodology may incorporate a one to three foot rise in sea level (as determined appropriate by the local community) and various heights of surge. The sea level rise mapping effort should be based upon the latest scientific findings, the planning horizon which best suits the jurisdictional planning needs, and ongoing hazard vulnerability analysis conducted by the local jurisdiction. Prior to beginning the mapping effort, the community should ensure consensus among the local leadership team on the mapping assumptions and sea level rise scenarios.

Methodology Assumptions: Incorporate the following assumptions into the methodology when assessing post-disaster impacts of storm surge and sea level rise and potential recommended adaptation strategies during post-disaster redevelopment:

- The elected leadership and local stakeholders should evaluate appropriate adaptation strategies and identify those that are locally applicable in the post-disaster environment.
- Any local policy changes should be reviewed and approved by the executive leadership and local elected body as detailed by local policy and procedures.
- Disasters impact the political and socioeconomic dynamics of the community. Adaptation strategies, which may not be feasible prior to a disaster, may become politically, financially, and socially feasible when the community is devastated by a disaster.
- All adaptation strategy recommendations should avoid undue hardship to any one community, individual, business, or organization. The goal is to support public safety and community sustainability during reconstruction and redevelopment efforts.
- This recommended methodology is for planning, education, and awareness purposes only and is not appropriate for site-specific analysis, navigation, or permitting decisions.
- While maps will be developed that show a hypothetical future sea level condition, the digital elevation model used to map sea level rise is subject to vertical and horizontal measurement error and does not account for hydrology, erosion, subsidence, or future construction.
- Variations between modeled versus actual storm surge will occur due to variations in coastal bathymetry, hurricane forward speed, radius of the storm, and astronomical tides at the time of land fall.

Guidelines for Mapping Sea Level Rise Inundation: The methods and criteria for inundation mapping used for the Pam Beach County Analysis were derived primarily from the Southeast Florida Regional Climate Change Compact Steering Committee guidance which state as follows:

- All layers are projected to a horizontal coordinate system of NAD 1983 HARN State Plane Florida and vertical datum North American Vertical Datum of 1988 (NAVD88).
- The Florida Division of Emergency Management's Light Detection and Ranging (LiDAR) elevation data are available to employ in this analysis.
- The various Water Management Districts throughout the state may provide regionally consistent digital elevation models (DEMs).
- The community may decide to employ ten, twenty, or fifty-foot cell size digital elevation models at the county level for inundation/vulnerability analysis. The Southeast Florida Regional Climate Change Compact Steering Committee recommends a fifty-foot cell size.
- Fifty-foot grids have a minimum mapping unit of half acre or nine cells.
- Apply the Mean Higher High Water (MHHW) tidal datum relative to NAVD88 as the starting elevation for inundation scenarios.
- Apply Vertical Datum MHHW tidal grid surface in NAVD88 provided by NOAA to ensure smooth transitions across county boundaries.
- Map sea level rise (SLR) inundation on one (1) foot increments, which calculates uncertainty (75/25) using NOAA's recommended Z-score methodology.
- Indicate inundation polygons as areas at or below MHHW for the given scenario, including; unconnected low-lying areas and without differentiation from hydrologically connected areas.
- Use a minimum mapping unit of one half acre.
- Explore disclaimer language for maps based upon concerns by the local leadership. This language may include, for example, a statement that unconnected low-lying areas may not be impacted.
- The sea level rise inundation grids may be created using Florida Division of Emergency Management's digital elevation models, a MHHW tidal surface prepared by NOAA using the VDatum tool, and NOAA's recommended Z-score based uncertainty methods.

Methodology for mapping hurricane storm surge with sea level rise: Inundation layers for hurricane storm surge with one to three feet of sea level rise may be generated using the Statewide Regional Evacuation Study Surge Model Tool Version 2.9 j2. This model was created by Marshall Flynn with the Tampa Bay Regional Planning Council and was previously employed to produce the county level storm tide atlases for the State of Florida. The tool follows NOAA recommended methods for mapping inundation, which basically involves processing the SLOSH basin surge heights from polygon to raster grid using Spline interpolation, subtracting the DEM raster to determine the inundation areas, and processing to polygon. Detailed description of the Surge Tool processing methodology is provided in the Florida Statewide Regional Evacuation Study¹.

To incorporate sea level rise into the model, the water elevation of the SLOSH output (i.e. the SLOSH “mean” height, which is zero feet relative to NAVD88) should first be standardized to MHHW, then the water level should be raised by a total amount of feet the community wishes to simulate sea level rise.

Thus relative to NAVD88, inundation will occur where: $MHHW + SLR + SLOSH - DEM \geq 0$

OR the equivalent expression as input to the Surge Tool: $SLOSH - [DEM - MHHW - SLR] \geq 0$

Methods to Incorporate during the Vulnerability Assessment:

- Identify roadway segments with more than fifty percent inundation.
- Mileage for the entire segment may be aggregated by employing the Florida Department of Transportation’s Functional Classification System.

¹ Treasure Coast Regional Planning Council Special Project, Florida Statewide Regional Evacuation Study Program, Volume 8: Methodology and Support Documentation, Chapter IV: 2007-2010 SRESO Surge Inundation Model Tool Methodology

http://www.tcrpc.org/special_projects/RES/Disc%201%20Text%20Documents/FINAL%20%20Volume%208.pdf

- Quantify the impacts to beaches by measuring the average width of the existing beach impacted by the inundation zone.
- Quantify impacts to future land use by clipping the future land use polygons to inundation zones, and summing the total acreage.
- Quantify impacts to the natural habitat by clipping natural land cover polygons to inundation zones, and summing the total acreage.
- Quantify inundation impacts to parcels by identifying parcel polygons that intersect with inundation zones, and summing property value. This evaluation may not accurately capture the impact to specific structures based upon site location within the parcel.

Sources of Data for the Vulnerability Analysis: There are a variety of sources for data which may be used in a vulnerability analysis for sea level rise integration. Each community should have completed a vulnerability analysis within the context of the Local Mitigation Strategy. Data, data sources, methodology considerations, and definitions may have been compiled during this process and should form the initial foundation for data collection. Following is a list of data and data sources which may be helpful. This list is not definitive, but it should provide guidance.

TRANSPORTATION INFRASTRUCTURE VULNERABILITY ASSESSMENT

The assessment of transportation infrastructure components may include the evaluation of the location, elevation, construction type, project life span, and planned enhancements to local ports, marinas, airports, roads, bridges and railways. When evaluating all infrastructure components, inclusion of the expected life spans is vital. Within the extended planning horizon of expected sea level rise, many roads, structures, and facilities may require routine upgrades, which could incorporate adaptation measures at that time. The post-disaster environment, however, may open additional windows of opportunity. As bridges and marinas are reconstructed in the aftermath of a disaster, communities may decide to rebuild these components stronger and more resilient to impacts of future sea level rise. Understanding the infrastructure vulnerability prior to a disaster, therefore, is important. Transit/Traffic parameters may include ports, airports, marinas, railroads, rail stations, bus routes, bridges, roads, and evacuation routes, which may be available from the county and/or city GIS data sets, the Department of Transportation, local and/or regional transit authorities, the Florida Division of Emergency Management, regional metropolitan planning authorities, and regional planning councils.



Photo (above): Traffic signs in Kissimmee. Photo Courtesy of Helene Wetherington, Calvin, Giordano and Associates, Inc. (2011)

PUBLIC INFRASTRUCTURE VULNERABILITY ASSESSMENT

Stormwater and wastewater management systems, drinking water supplies and distribution systems, power utility systems, and communications system are essential to the post-disaster recovery of a community. The post-disaster environment may provide the only opportunity to relocate vulnerable treatment plants, bury power lines, or augment the capacity of stormwater systems. The vulnerability assessment may identify structures that are vulnerable and continuously evaluate the cascading effects which may impact interconnected stormwater systems and the vulnerable aquifer. Water and wastewater parameters including water and wastewater facilities, well field protection areas, and water control structures may be available through the county and/or city GIS data sets or directly from the various utility departments responsible for these infrastructure components. Additional data related to water and water management may also be available from the regionally responsible Water Management District.



Photos (above): Protected lakes in central Florida. Photo Courtesy of Helene Wetherington, Calvin, Giordano and Associates, Inc. (2011)

PUBLIC FACILITY VULNERABILITY ASSESSMENT

Public facility parameters will vary from community to community. Generally, communities consider public safety facilities important to the emergency response effort and define criticality within this context. During this recovery focused planning initiative, communities may expand the definition to incorporate facilities both vital in the redevelopment process and vulnerable to sea level rise. Long-term adaptation strategies for sea level rise may target public safety facilities and hospitals, but also schools, daycare centers, adult living facilities, special historic landmarks, city halls, county courthouses, government buildings, libraries, parks, and other types of facilities. A vulnerability assessment may include a ranking of criticality, geographic location, construction type and standard, and ability to relocate facilities. The impacts of increased storm surge due to sea level rise may subject some of these structures to increased levels of risk. The long-term strategy is to decrease the vulnerability of these facilities, decrease the amount of public funding used to make repairs, and ensure efficient expenditure of public funds. Reinvestment of public dollars in the reconstruction of vulnerable public facilities may not be a wise investment of taxpayer funds. The primary data source for publicly owned facilities and structures rests with the local jurisdiction.

ECONOMIC VULNERABILITY ASSESSMENT

Sea level rise does not only have an impact on the physical, tangible assets which have been discussed up to this point, but may significantly impact community economic viability. Many communities throughout Florida are dependent on tourism as a major economic base. Sea level rise poses a potential loss of assets and resources that support tourism such as beaches, beachfront resorts, marinas, fishing habitats, and ecotourism. Unless the local jurisdictions can develop creative strategies to adapt to the changing environment, long-term community viability could be threatened. Without adequate adaptation planning and long-term community vision, the impacts of sea level rise combined with a large-scale disaster could influence this economic engine driving local economies. Long-term economic development strategies may benefit by linking long-term community sustainability with the economic benefits.

LAND AND ENVIRONMENT VULNERABILITY ASSESSMENT

An assessment of land and environment may include the evaluation of managed natural areas, protected species, beach erosion, and beach access. The impact to the coastal shoreline and beach access due to increased surge and wave action will be progressive, though the magnitude and timing remain uncertain. Sea level rise will likely lead to the loss, fragmentation, and degradation of vulnerable coastal habitats as the salinity balance and the tidal flows are altered. Adaptation goals to minimize losses of biodiversity and maintain ecosystem integrity in the face of these changes will be a priority. This will in turn impact coastal species forced to disperse to more suitable habitats. Sea level rise may also result in the loss of and fragmentation of millions of acres of priority coastal areas which are being preserved for biodiversity conservation. The construction of sea walls and dikes may interfere with the ability of natural habitats to shift landward in order to allow the migration of species in response to sea level rise. To support the vulnerability assessment, land and environment parameters may include future land use composite data, land use cover, managed natural areas, threatened species, critical beach erosion, and beach access points, which may be available from local and state departments managing environmental resources including the Florida Department of Environmental Protection and the regional water management district.



Photos (right): Shoreline protection in Palm Beach County, Florida after Hurricane Frances. Courtesy of the Department of Environmental Resources Management for Palm Beach County, October 2004.



Photos (above): Images depicting normal and astronomical high tides in a south Florida residential area. Photo Courtesy of Paul Krashefski, Broward County Natural Resources Planning and Management Division. (October 2010)

Chapter 3: Plan Topics

This Addendum to the *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* provides a range of options to incorporate enhanced community resilience and sustainability by local decision makers in the aftermath of a disaster. For developed areas, the adaptive response strategies to increased sea level rise and increased storm surge due to sea level rise may be categorized into three general planning strategy areas as follows:

- **Protection** - Protection strategies involve hard and soft structurally defensive measures to mitigate the impacts of rising seas, such as shoreline armoring or beach re-nourishment. These measures decrease vulnerability, yet allow structures and infrastructure in the area to remain unaltered. Protection strategies may target areas that are location-dependent and cannot be significantly changed structurally (i.e. downtown centers, areas of historical significance, water-dependent uses, etc.).
- **Accommodation** - Accommodation strategies do not act as a barrier, but rather alter the design through measures such as elevation or stormwater improvements, to allow the structure or infrastructure system to stay in place. Adaptation measures do not prevent flooding or inundation of the property but do protect the structure. Accommodation strategies may be suitable for location-dependent structures that could be adapted to accommodate water, without compromising the use (i.e. bridge elevation, residential home elevation, downtown stormwater improvements, soft armoring, etc.).
- **Retreat** - Retreat strategies involve the actual removal of existing development and possible relocation to other areas and the prevention of future development in these high-risk areas. Retreat options usually involve the acquisition of vulnerable land for public ownership, but may also include other strategies such as transfer of development rights, purchase of development rights, rolling easements, conservation easements, etc. (Florida Department of Economic Opportunity, 2011).



Photos (right): Shoreline protection in Palm Beach County, Florida after Hurricane Frances. Courtesy of the Department of Environmental Resources Management for Palm Beach County (October 2004).

Policy considerations for post-disaster redevelopment within the Adaptation Action Areas:

Residential and business reconstruction: Should specific policies address timing and standards be considered for the reconstruction of homes and businesses within Adaptation Action Areas?

Public Funds: Is the reconstruction of costly infrastructure within the managed relocation/retreat area a wise long-term public investment?

Coastal Ecosystem: Within the managed relocation/retreat zone, should local leaders reevaluate the importance of preserving coastal ecosystems and promoting shoreline stabilization techniques that allow the natural shoreline migration processes to continue unimpeded?

ADAPTATION ACTION AREAS: GUIDING REDEVELOPMENT DECISIONS

In 2011, the Florida Legislature adopted optional sea level rise adaptation language into the Community Planning Act (Chapter 163.3177(6)(g)(10) and Section 163.3164(1)) for areas that experience coastal flooding and that are vulnerable to the related impacts of rising sea levels. Based upon risk and vulnerability, communities may identify Adaptation Action Areas. The purpose of designating these areas is to prioritize the use of these lands, prioritize funding for infrastructure enhancement, and evaluate adaptation policies. Local governments that adopt Adaptation Action Areas may consider policies within the Coastal Management Element of their comprehensive plan to improve resilience to coastal flooding through a range of strategic policy options.

Regulating redevelopment within these identified Adaptation Action Areas in the aftermath of a major disaster may be a “Window of Opportunity” to rebuild stronger, sustainable, and more resilient in these vulnerable areas. **Post-disaster redevelopment decisions within the Adaptation Action Areas could impact the full range of redevelopment priorities including future land uses, environmental considerations, infrastructure redevelopment, and economic redevelopment.** This chapter will discuss implications in each of these areas and provide a menu of options for the local leadership to consider.

The post-disaster environment may create additional political and community pressure to restore pre-disaster shoreline conditions. Decision makers and the public should understand the long-term implication of these post-disaster restoration efforts. Continued reinvestment of public funds into coastal restoration efforts may not be the best option in the defense against sea level rise impacts, in some areas.

LAND USE AND HOUSING REDEVELOPMENT STRATEGIES

Chapter 3 Plan Topics of the Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010), details the purpose of modifying land uses after a disaster in order to enhance community resiliency along with strategies to accomplish this goal (p.44). An assessment of current and future land uses that may be impacted by sea level rise may be valuable in the identification of high-risk areas and appropriate adaptation strategies. Increases in hurricane storm surge impacts due to sea level rise may create a greater need to balance economic prosperity with public safety and the conservation of natural resources.

Zoning and Overlay Zones: Communities that are vulnerable to the impacts of sea level rise should consider establishing sea level rise **adaptation overlay districts** or **Adaptation Action Areas** within their comprehensive plan. Criteria for the Adaptation Action Area may include, but need not be limited to, areas for which the land elevations are below, at or near mean higher high water, which have a hydrologic connection to coastal waters, or which are designated as an evacuation zone for storm surge. Local governments may delineate the Coastal High-Hazard Area to coincide or overlap with the Adaptation Action Areas.

Under Florida Statutes Section 163.3177(6)(g)(10), local governments that adopt an Adaptation Action Area may consider **policies within the Coastal Management Element** to improve resilience to coastal flooding resulting from high-tide events, storm surge, flash floods, stormwater runoff, and related impacts of sea level rise. Local government actions may consider the following actions within each zone:

- type and density of use,
- building code and design standards,
- setbacks,
- buffer zones,
- conditional development and exactions,
- rebuilding restrictions,
- hard and soft armoring permits and
- rolling easements or conservation easements.

Within the defined Adaptation Action Area, policies may emphasize post-disaster mitigation opportunities to reduce vulnerability to coastal flooding while, simultaneously, addressing the

Florida Statutes Chapter 163.3164: Community Planning Act

“Adaptation action area” or “adaptation area” means a designation in the coastal management element of a local government’s comprehensive plan which identifies one or more areas that experience coastal flooding due to extreme high tides and storm surge, and that are vulnerable to the related impacts of rising sea levels for the purpose of prioritizing funding for infrastructure needs and adaptation planning.”

long-term impacts of sea level rise. Policy decisions should consider the extended planning timeline of sea level rise adaptation and implementation. This long-term implementation period is likely to exacerbate current coastal flooding issues.



Photo (above): Lake County, Fla., - Power company employees work to restore power in Lake County. The central Florida tornadoes devastated this and other areas in the county. Mark Wolfe/FEMA (February 9, 2007).

Protection Strategies

Rebuilding Incentives and Restrictions: Rebuilding incentives and restrictions can require or encourage post-disaster reconstruction that is more resilient to flooding impacts within designated Adaptation Action Areas. Communities may employ protection strategies in areas of the community that are location-dependent and difficult to mitigate or reconstruct to accommodate sea level rise. Areas such as downtown urban centers, historic neighborhoods, and marinas may be encouraged to adapt during the reconstruction process through incentives or restrictions.

Hard and Soft Armoring Permits: Post-disaster protection strategies may include hard and soft structural defensive measures that mitigate the impacts of rising seas. Shoreline armoring may decrease vulnerability, yet allow structures and infrastructure in the area to remain unaltered. Soft armoring creates barriers that replenish or mimic natural buffers or elevate land, so that structures are less vulnerable to flooding, storm surge, and erosion. The Environmental Protection Agency suggests that governments prohibit hard armoring or replace hard armoring with living shorelines, thus allowing for shoreline migration (Environmental Protection Agency, 2009). Examples of **soft armoring include beach re-nourishment, dune creation, re-vegetation, wetlands restoration, and living shorelines**. Local governments could create permitting programs to encourage the use of soft armoring techniques, where feasible, in order to lessen environmental impacts of shoreline armoring. Consider involving environmental restoration volunteer groups in disaster recovery efforts to promote and advance soft armoring protection measures. Where other options are not feasible, jurisdictions may also use the permitting processes to regulate the construction of hard engineered structures that provide flood and erosion control focusing on areas with existing development and/or critical infrastructure. In the post-disaster environment, local governments rely on the financial support of federal agencies to rebuild the shoreline. In many areas, beach re-nourishment projects have been repetitively funded after consecutive storms eroded the same beaches. In the future it will be important to monitor whether the Federal Emergency Management Agency will continue to provide Public Assistance funding to reimburse beach re-nourishment projects after a disaster.

Integrating hazard mitigation into long-range transportation planning

In September 2010 the Florida Division of Emergency Management released a guide entitled “Taking the High Road, Integrating Hazard Mitigation into Long-range Transportation Planning.” This document features best practices for collaborative long-term transportation planning.

Accommodation Strategies

Inundation friendly uses: Accommodation allows the community to continue to use areas that will be impacted by sea level rise. Accommodation strategies may include converting to water-dependent uses or identifying uses that are adaptable to changing conditions. For example, expanding or adding marinas could have a positive impact in generating marine-based tourism. Converting land uses to permit more appropriately designed boat ramps, docks, and other water-dependent uses would accommodate for sea level rise and have the potential to generate more revenue and better public access to the waterfront. Converting golf courses into natural protection areas could potentially, 1) reduce the amount of chemical runoff into the waterways and 2) provide a mechanism for natural shoreline restoration.

Changing land use designation: Impacted jurisdictions may also consider adjusting land use designations to allow the natural shoreline and coastal ecosystem to continue to migrate inland with the rising sea. Integration of thoughtful waterfront design principles and the development of incentives for creative reuse, through revisions to the land development code, are accommodation strategies that can be incorporated into future land use planning.

Photo (right): Major Beach Erosion, New Smyrna Beach, Hurricane Wilma, Clark, R., and LaGrone, J.W., Hurricane Wilma – Post-storm Beach Conditions and Coastal Impact Report, Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems.(2006).



Building Codes and Resilient Design Incentives: Governments can create building code regulations or incentives within the Adaptation Action Areas to encourage more flood resistant construction of new structures. **Building elevation should account for increased coastal flooding from sea level rise and hurricane storm surge over the life of the structure (Grannis, 2011).** For existing structures, communities may encourage or impose retrofitting standards or adaptation actions while permitting reconstruction. National Flood Insurance Program (NFIP) communities must apply the fifty (50) percent “**substantial damage**” rule during reconstruction. This rule requires that buildings be rebuilt to conform to NFIP minimum standards if the cost of repair exceeds fifty (50) percent of the pre-damage market value of the structure.

Another mechanism by which local governments can implement rebuilding restrictions is by reducing densities or permitted uses within the Adaptation Action Areas. Existing structures can remain, but they become “**nonconforming**”. If a building is destroyed or damaged, reconstruction must conform to the current zoning and building requirements for new construction.

- **Allow limited rebuilding**—smaller, more resilient structures replace nonconforming damaged structures with additional setbacks requirements if appropriate.
- **Prohibit rebuilding**—prohibit rebuilding destroyed properties when they are located in identified Adaptation Action Areas (retreat/relocation) if repetitively damaged.
- **Allow reconstruction with conditions**—rebuild properties with conditions to not build protective armoring, or remove structures when threatened by erosion or inundation.

Conditional Development and Exactions: Local governments may choose to impose various special conditions when issuing a development permit. These conditions may be designed to mitigate the impacts of development through impact fees, land use restrictions, and dedications of lands for public purposes. Local governments can use conditions to define landowners’ rights to build hard coastal protection, require removal of structures that experience inundation as the shoreline recedes, require dedication of coastal buffers, require impact fees to pay for emergency response costs or to mitigate impacts from coastal armoring, or require that structures have greater levels of flood protection.



Photo (above): Private Docks during astronomical high tide, Stuart, Martin County, Florida, Helene Wetherington, Calvin, Giordano and Associates, Inc. (September, 2011).



Photo (above): Damage to the Singer Island shoreline in Palm Beach County, Florida after Hurricane Frances. Courtesy of the Department of Environmental Resources Management for Palm Beach County. (October, 2004).

Private Property Rights

“State and local governments in Gulf States generally have more tools to protect the coast than are generally acknowledged and that their defenses to coastal takings claims will become increasingly stronger as sea-level rise and coastal deterioration emerges as true emergencies and public health crises.”

Source: Craig, Robin Kundis, Public Trust and Public Necessity Defenses to Taking Liability for Sea-Level Rise Responses on the Gulf Coast. Journal of Land Use & Environmental Law

Hard Armoring Permits and Soft Armoring Permits: Jurisdictions may also use the permitting processes for hard armoring and soft coastal protection as accommodation strategies (*note these strategies may also be employed as protection strategies*). It may be necessary to harden the coast where there is considerable existing development or critical infrastructure. However, engineers should consider the cascading impacts of hard armoring along vulnerable coastlines with sensitive ecosystems. Coastal armoring should protect against storm surge combined with increased sea levels. Jurisdictions may also require the mitigation of structures in areas where hard armoring is permitted. As discussed above, soft coastal protection projects provide a natural buffer to protect the shores. Soft armoring may include beach re-nourishment projects, installation of living shorelines, or wetlands restoration initiatives. Local governments could create permitting programs or local incentives to encourage the use of soft armoring techniques.

MANAGED RELOCATION / RETREAT STRATEGIES

Set Back Requirements: Local jurisdictions may require structures to be set back a certain distance from an established baseline. This baseline is typically a shoreline feature such as the Coastal Construction Control Line, mean high water mark, or vegetative line. Property owners are required to maintain this portion of the property in a natural state to support natural and beneficial functions. This may include preservation of wetlands to prevent runoff and flooding, or maintenance of coastal dunes to protect the shore. In the aftermath of a disaster, local governments could establish or encourage increased setbacks within highly vulnerable areas or areas that are defined within specified Adaptation Action Areas such as the managed retreat/relocation zone.

Transfer of Development Rights: Another land use regulation tool that local jurisdictions may choose to employ in the aftermath of a large-scale disaster is the transfer of development rights. This tool may redirect development from highly vulnerable areas into targeted development areas. For example, the transfer of development rights may be employed to relocate residential structures within a managed relocation/retreat zone. Coordination and cooperation among neighboring jurisdictions may be valuable in an effort to comprehensively implement transfer of development rights strategy, particularly for densely developed coastal regions such as the Southeast and West Central portions of Florida’s coast. The use of the transfer of development

rights tool may be particularly effective in the aftermath of a major disaster to redirect reconstruction and redevelopment efforts if residents and businesses experience the heightened impact of the storm surge augmented by sea level rise. The program, however, may also be difficult to implement due to the cost differential between high priced coastal properties and less valuable and less vulnerable inland properties.

Rolling-Easement: “Rolling easements” require human activities to yield the right of way to naturally migrating shores. This strategy is a narrowly tailored method to ensure that natural shorelines survive rising sea levels. The simplest way to implement rolling easements is to prohibit the construction of bulkheads or any other structures that interfere with naturally migrating shores. Another approach is to purchase property rights to take possession of privately owned land whenever the sea rises above a threshold level which could endanger life safety. Alternatively, the deed to the property could specify that the boundary between publicly owned tidelands and the privately owned dry land will migrate inland to the natural high water mark, whether or not human activities artificially prevent the water from intruding. Rolling easements can be implemented with: (a) eminent domain purchases of easements, covenants, or defensible estates that transfer title if a bulkhead is built or the sea rises by a certain degree, or (b) local laws that accomplish the same result. The private sector could also play a role. For example, a land trust or an environmentally concerned owner selling coastal property could retain a rolling easement when selling the property, or donate the rolling easement to a conservancy. Other options could include the creation of an alongshore buffer or easement for management, and adaptation. This can include property purchase, purchase of development rights, setbacks, deed restrictions, development disincentives, or sale incentives.

Rebuilding Incentives and Regulations: A powerful tool in the post-disaster environment is the ability of local governments to influence when and how a structure is rebuilt once it sustains significant damage. For additional information on rebuilding incentives and regulations, which may also be employed as retreat strategies, see the section above.





Photo (above): Destroyed single family dwelling, Hurricane Wilma, Clark, R., and LaGrone, J.W., Hurricane Wilma – Post-Storm Beach Conditions and Coastal Impact Report, Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems. (2006).

ECONOMIC REDEVELOPMENT STRATEGIES

Hurricane storm surge augmented by sea level rise will likely amplify redevelopment challenges for the beachfront, water-dependent uses, natural environments, and long-term economic viability. The interconnectivity of the environment, tourism and the economy drives long-term recovery in many coastal communities. The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, in the *Economic Redevelopment* section (**page 61**) details strategies to support post-disaster economic redevelopment. Following are recommendations to further integrate sea level rise impacts in the economic analysis or economic redevelopment strategy.

Storm Related Damage: Florida State University researchers, Dr. Julie Harrington and Dr. Todd L. Walton, Jr. (2007), state that changes in sea level could increase damage costs associated with similar intensity storms in the future from ten to forty percent depending on the extent of sea level rise and other factors. Increases in hurricane storm surge inundation along the coastal waterfront may impact homes, businesses, parks, infrastructure, roads, bridges, retail outlets, and the full range of man-built environments. The will of the insurance industry and public entities to fund disaster assistance such as the Federal Emergency Management Agency, the Federal Highway Administration, and the Small Business Administration may waver in areas that experience frequent prolonged flooding. Public entities should also consider whether or not it is a wise financial decision to invest public funds in these high-risk areas.

Man-Built Environments: The most intense and densely developed areas within the State of Florida are near the coastal waterfronts. Advances in GIS modeling allow researchers to determine projected storm surge inundation to the parcel level. Most jurisdictions maintain electronically based property appraiser data. This data may be incorporated in the inundation maps to generate dollar estimates of impacted land and structures. Without site-specific analysis, however, these estimates may only represent general figures. These estimates do not consider the potential adaptation strategies that homeowners, business owners, and local governments may employ to protect the built environment throughout the upcoming decades. Similarly, actions to maintain natural buffers or construct structural solutions may alter inundation zones. The cost of building and maintaining protective measures, will further impact the benefit-cost equation of protecting structures in the vulnerable coastal areas.



Photo (above): Orlando, FL -- Angela Martinze with SBA and Marcia Guzman with Human Service FEMA talk with people about disaster assistance at the Puerto Rico Summit in Orlando. FEMA Photo/Michael Rieger (September 18, 2004).



Photo (above): Damage to the Singer Island shoreline in Palm Beach County, Florida after Hurricane Frances. Courtesy of the Department of Environmental Resources Management for Palm Beach County (October 2004).

Natural Environment: Loss of beaches in the aftermath of a disaster could result in substantive impacts on Florida's tourist-based economy (Bell, 2005). Sea level rise combined with storm surge inundation will impact beaches, dunes, sensitive marine habitats, saltwater marshes, mangroves, sea turtle nesting areas, coral reefs, and groundwater systems vulnerable to saltwater intrusion. These areas serve as important habitat and breeding grounds for numerous species vital to the fishing industry. These areas also serve as tourist destinations for recreational activities including boating, diving, and swimming. For additional information related to environmental impacts and the tourism industry, reference the *Environmental Restoration* section.

Tourism-Based Industry: Florida's economy is largely based on revenue generated from tourism. In the aftermath of a disaster, the national and international perception of the status of reconstruction and redevelopment efforts may influence the return of visitors to this State. Despite the advantages of subtropical climate, sandy beaches, marine habitat for fishing, diving, and snorkeling, the impacts a large-scale disaster and gradual long-term rising seas could create extended tourism interruptions. Water-dependent uses such as marinas, charter fishing, diving shops, beach hotels, and restaurants may suffer under these prolonged declines. Small businesses, in particular, are highly vulnerable to disasters because they generally lack sufficient reserves or maintain sufficient business interruption insurance to sustain an extended business downturn. Economic resilience is a vital component to creating a viable, sustainable community. In the post-disaster environment, it is important to link economic development initiatives within the post-disaster redevelopment process.

Protection

Land Use and Reconstruction Requirements: A diversity of adaptation strategies, such as shoreline armoring and rebuilding guidelines, may target business uses in the overall shoreline management strategy. The *Smart Growth in Coastal Areas* principle encourages commercial development along the waterfront, including water-dependent uses. Protection strategies, such as coastal armoring, are important when connected to local economic engine drivers. This connection distributes the benefits and costs across a greater population and affects the greater community. Adaptation strategies which affect major employers such as hospitals, hotels, or large retail venues will be far reaching. The failure to protect vital economic engines could have a ripple effect throughout the community and could stifle economic redevelopment efforts post-disaster.

Accommodation

Water-Dependent Businesses: Businesses that are water-dependent such as marinas, marina support facilities (restaurants, lodging, fueling sites) generate substantial revenue for local governments and private business owners. By incorporating design techniques such as heightened and hardened dock design when renovating or adding these structures, water-dependent businesses may continue to thrive.

Retreat Strategies

Relocation Support: Businesses which are water-based and/or water-dependent have limited adaptation options. Retreating to areas without water frontage or access will likely be inappropriate. Non water-dependent businesses located in the proximity of the shoreline vulnerable to sea level rise may be encouraged to work with community leaders and planners to identify safer, more appropriate commercial land. It is important to note that private property rights and shoreline management practices may conflict and require political balancing in the best interest of public safety and community resilience.



Photo (above): Pensacola, Fla., -- Boats pushed against the shore and damaged during hurricane Ivan in Downtown Pensacola. Many area residents were displaced from their homes or had damaged homes due to Hurricane Ivan. FEMA NewsPhoto/Bill Koplitz (October 16, 2004).



Photo (above): Images depicting normal and astronomical high tides in South Florida. Photo Courtesy of Paul Krashefski, Broward County Natural Resources Planning and Management Division (October, 2010).

INFRASTRUCTURE REDEVELOPMENT STRATEGIES

The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, Plan Topics Section, *Infrastructure and Public Facilities (page 71)*, details a variety of post-disaster strategies to restore infrastructure and critical public facilities after a disaster. In anticipation of adaptation planning, communities throughout the State of Florida could benefit by conducting a **capacity assessment of their existing inventory** including existing drinking water supplies and distribution systems, wastewater systems, stormwater treatment, delivery and collection systems, power utility systems and communications systems. Communities should begin the assessment with a comprehensive inventory of critical infrastructure components to determine the potential impact from sea level rise and storm surge inundation. The vulnerability assessment should be based upon the anticipated lifespan of the infrastructure components. Local governments may develop different climate change scenarios to assess the costs and adaptation strategies for high-risk utilities and/or infrastructure, which may require replacement, reinforcement, or relocation to ensure the long-term viability of the system. Additionally, communities may consider the level of damage to the infrastructure components, which would affect the benefit-cost ratio for implementation of adaptation actions. The adjacent text box identifies a number of factors to incorporate in the post-disaster decision making process which are further discussed in the Implementation Chapter.

A comprehensive vulnerability assessment can form the foundation for post-disaster redevelopment activities related to infrastructure and public facilities. As communities begin to prioritize reconstruction and redevelopment efforts, they will have a framework to identify high-risk facilities and systems and incorporate proactive adaptation measures. The post-disaster environment may provide a unique opportunity to relocate vulnerable treatment plants, bury power lines, or augment the capacity of stormwater systems. Any vulnerability assessment requires continuous reevaluation of the cascading effects which may impact interconnected systems such as stormwater systems and the vulnerable aquifer. Scientific findings and changing environmental conditions will continue to alter the understanding of sea level rise impacts affecting community priorities both pre-disaster and post-disaster.

Potable Water Systems: Areas throughout the State of Florida have detected saltwater intrusion within the valuable fresh water aquifer. The rising sea level and the increased demand

Post-Disaster Decision Making Triggers for Infrastructure Adaptation

In the aftermath of a large-scale disaster, communities may experience a “window of opportunity” to adapt vital infrastructure components that have been impacted by the disaster. With the infusion of additional external reconstruction funds, communities may use the following factors when prioritizing adaptation measures for infrastructure:

- Location within Adaptation Action area/inundation risk area.
- Post-disaster level of destruction.
- Lifespan of the infrastructure component.
- Purpose and function (public safety versus recreation).
- Adaptation cost versus no action alternative.
- Funding opportunities available post-disaster, to enhance community resilience.

for aquifer withdrawal may affect the rate of saltwater contamination. Powerful storms can generate storm surge that inundate submerged storm damaged water supply wells and contaminate boreholes (well casings and filter packs) in inundated low-lying areas. This can then lead to contamination of the surrounding coastal aquifer. The risk of bore contamination is increased as sea levels rise. (Carlson et al. 2007) Hurricane Katrina in 2005 contaminated boreholes in southeastern Louisiana flooded by storm surge which required purging of far greater volumes of water than conventionally used to re-establish water quality in wells of this kind. (Carlson et al., 2007) In order to assess the post-disaster storm surge impacts to the aquifer, well field, and water pumping sites, additional research is needed to evaluate the baseline of the hydrologic conditions and impacts of sea level rise on regional and local water resources. Communities may then identify and quantify vulnerable well fields, water supply infrastructure, wastewater collection, wastewater treatment infrastructure, and drainage facilities. The analysis will allow communities to devise strategies to protect or relocate vulnerable facilities and to establish post-disaster redevelopment priorities.

Stormwater Management Systems: Storm surge and sea level rise stress stormwater management systems both inland and near the coast, due to the complex, interdependent nature of stormwater infrastructure systems. The stormwater management systems have extensive interconnectivity within the greater floodplains, land uses and area topography. The infrastructure components **include stormwater sewers, catchment basins, drainage canals, and spillways**. No single entity or jurisdiction will likely be able to resolve the challenges faced by rising groundwater elevations combined with rising sea levels. Together these conditions may create drainage and flood control obstacles. Storm waves may overtop a seawall; and sediment and debris may block inlets, outlets, and storm sewer pipes and canals. During the worst storm surge, coastal areas may be completely inundated by the sea, leaving the drainage system ineffective until water levels have receded. Areas that are below sea level may require forced drainage. (Titus, et. al., 1987) Designers of coastal drainage systems recognize the unique characteristics of coastal flooding, particularly the impacts of tides, low elevations, and high groundwater tables. The rate at which gravity can drain an area depends in part on the difference in elevation between the area being drained and the place to which the water flows. The greater the difference in elevation, the greater the slope of the “hydraulic head” and the faster the water can drain. Coastal areas generally are low-lying and thus vulnerable to flooding. High tides and storm surge further decrease the elevation difference and may slow or stop gravity drainage. The image below illustrates the challenge posed by gravity flow systems.

Drainage Challenge with Sea Level Rise

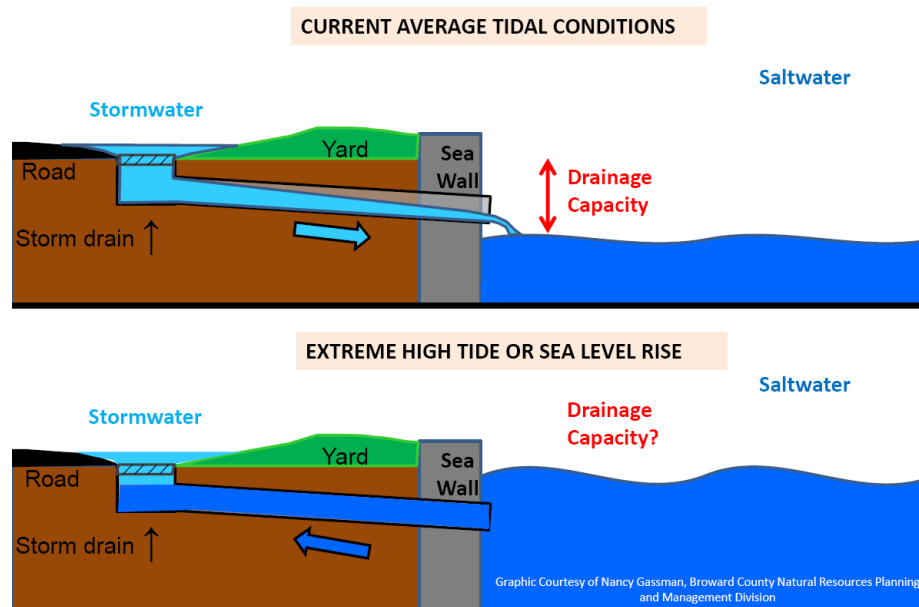


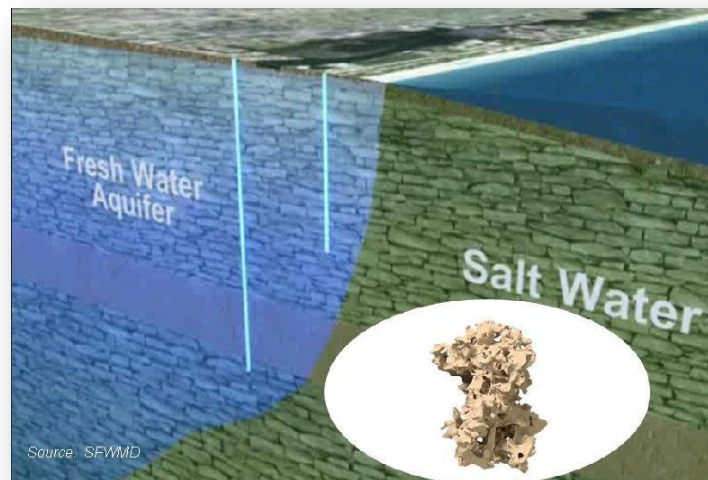
Figure 1: Illustration of drainage challenge with sea level rise decreasing stormwater drainage system head pressure.

Graphic courtesy of Nancy Gassman, Broward County Natural Resources Planning, and Management Division.



Topography and High Water Table: The imperviousness affects the amount of soil storage that is available, and the speed at which runoff leaves the catchment area in the form of stormwater. Some soil types have a greater ability to provide storage for stormwater runoff. Erosion prone soils may suffer increased erosion with increases in rainfall intensity or changes in wetting drying patterns. (Shaw, H., et. al, 2005) High water tables in coastal areas also limit natural drainage. With water tables just below the land surface, a rainstorm can rapidly saturate the soil (raise the water table to the surface). The saturated soil increases runoff by decreasing the ability of water to percolate into the ground.

Figure 2: Illustration of saltwater intrusion into the freshwater aquifer and encroachment on water pumping wells. Graphic courtesy of South Florida Water Management District



Future Federal Funding for Infrastructure Adaptation Actions

In 2011, Congressional Bill S. 1669: Water Infrastructure Resiliency and Sustainability Act was introduced to provide grants to owners or operators of water systems to increase the resiliency or adaptability of the systems to any ongoing or forecasted changes to the hydrologic conditions. While the future of this bill remains uncertain, *“It is realistic to expect that future federal funding will be made available for designated adaptation action areas”*

Source: Southeast Florida Regional Climate Change Compact. Draft Regional Climate Change Action Plan. December 2011.

Transportation Systems

Ports and Marinas: Ports and marinas may have vulnerable dockage slips, ramps, fueling sites, waste disposal areas, and marina support facilities. However, ports and marinas are water-dependent operations, therefore inland retreat may not be a viable adaptation strategy. One accommodation measure may include raising ramp height. Private owners, who wish to build docks, may consider elevating these structures or evaluating the use of floating docks. Protection measures may include hardening facilities and infrastructure. Port designers and engineers may wish to explore options that allow some type of temporary or removable barrier that can be deployed in the event of a storm to prevent surge waters from overtopping lower areas of dock slips.

Bridges and Waterways: The impact to Florida's primary commercial marine traffic should be minimal, due to the deep-water channels which are traversed by high span bridges or draw bridges. The non-commercial waterways, lower secondary bridges, low-lying roadways, and causeways are more likely to experience sea level rise impacts. Higher water levels could affect these secondary bridges and waterways causing decreased boat clearance under the bridges, erosion of bridge abutments, traffic blockage to bridges and causeways during high water events, and challenges to boat navigation due to increased sedimentation and development of sandbanks and shoals. Higher water levels during storm surge events could affect the clearance under low bridges. Access ramps, bridges, and causeways could be flooded more frequently and more severely during storm surge events and other high tide incidents. Bridges and causeways along hurricane evacuation routes may require closure sooner as rising tides and heavy rains affect drainage and accessibility of these routes. Increased sedimentation may also affect navigable waters. Water contains small-suspended particles such as sand, soil, and silt. The point at which these particles are no longer suspended and settle to the bottom of the water (flocculation), depends upon the chemical balance of the water. When these suspended particles flocculate and sink to the bottom of the water, sediment is formed. This process can lead to the creation of sandbanks and sandbars (shoals). Saltwater that advances upstream can alter the chemical balance thus resulting in the flocculation of particles that are normally suspended, thus causing them to settle. Sea level rise may result in changes in water levels within the navigable waterways, which could affect navigation. This minor effect, however, is likely insignificant compared to the deep draft of large vessels. As sea level rises, incidents such as the vertical displacement of bridge segments may occur more frequently, as may erosion of bridge abutments from storm waves and storm currents. In addition to interference with navigation, sea level rise may also increase the exposure of bridges to saltwater spray with



Taking the High Road: Integrating Hazard Mitigation into Long-Range Transportation Planning provides a series of best practices to build a sustainable transportation infrastructure that can withstand or quickly recover from the impacts of coastal inundation.



Photos (above): Road erosion on Old South Ocean Boulevard due to Hurricane Frances in 2004 in Palm Beach County, Florida (before and after). Courtesy of the Palm Beach County Department of Environmental Resources Management (2004).

resultant increases in spalling of concrete and more rapid corrosion of steel bridge components and rebar in older bridges. Accommodation strategies may include increasing the height of the bridge, based on the nature of passing vessels. To accommodate vessel traffic, communities may explore bridge designs that reduce sedimentation that may occur as a result of bridge pilings and abutments blocking tidal and current flow. Protection strategies may include shoreline stabilization and protection measures that are designed for the increased level of water and are resistant to corrosion. According to the Florida Department of Transportation (FDOT), bridges are generally designed to have a lifespan of approximately eighty (80) years. This extended planning horizon demands the consideration of adaptation actions whenever reconstruction projects are planned or disasters strike. The construction and design decisions made today may impact the operational capability of these systems for many decades to come.

Roadways: Transportation infrastructure within vulnerable areas and/or within designated Adaptation Action Areas may be hardened to withstand potential impacts from erosion over the life expectancy of the infrastructure system. Roads are typically designed for an average lifespan of twenty (20) years, which means there may be more frequent opportunity to adapt road design and construction. State road design standards mandate stormwater drainage for various flood return frequencies depending on the road's functional classification. These standards are generally considered to be adequate to prevent frequent flooding on new roads. Older roadways, however, may not meet these new design standards and future sea level rise may affect drainage. Increased storm surge due to sea level rise on transportation routes in low-lying communities may augment road flooding. When the road base is lower than the surrounding land, the road may act as a natural flood conveyance system. This phenomenon is frequently observed in barrier island communities where low-lying side streets commonly flood during rains. During astronomical high tides in areas reliant upon gravity conveyance of stormwater, flood levels and duration of flooding are further increased, during which they depend on the water elevation differential to move water off the streets and to the outfall. Frequent rising and receding of floodwaters may expedite erosion along vulnerable road segments. In the aftermath of a large-scale disaster, the increased flooding levels and duration of flooding may impede access by emergency, law enforcement, and recovery officials (Florida Department of Transportation, 2010). Planned transportation infrastructure within the Adaptation Action Area should be appropriate within the projected range of sea level rise, while meeting the greater community sustainability goals. Retreat options include realigning the impacted highways to reflect the changes in the inundation areas, which may only be feasible in the aftermath of a catastrophic disaster. Accommodation strategies may include enhanced stormwater drainage systems in vulnerable areas such as additional stormwater pumping

stations, expanded stormwater discharge areas, or the addition of one way flow valves designed for tidal discharge. Stormwater drainage projects may be eligible for funding through the federal Hazard Mitigation Grant Program and should, therefore, be included in the **Local Mitigation Strategy Project List** if not already scheduled for improvement. Communities should verify and track interruptions in road operation, which can boost the benefit cost ratio necessary for project grant funding. For roads along the rising water bodies, structural and nonstructural shoreline protection strategies may also provide relief for eroding roadways. Protection strategies may include roadway elevations. Protection is generally considered the least effective strategy in the long term; but, when it is implemented in conjunction with accommodation and/or retreat, it can provide the community with a more gradual transition to the impending realities of sea level rise and the inevitable, subsequent impacts.

If a bridge is damaged or destroyed post-disaster, then this may be another opportunity to consider incorporating enhancements that increase resiliency of these important structures. For additional information consult, *Taking the High Road: Integrating Hazard Mitigation into Long-Range Transportation Planning*.



Photo (above): County Road 707 in Martin County Florida damaged during Hurricane Frances. Photo courtesy of the Martin County Board of County Commission (October 2004).



Photo (left): High Span Martin County Intracoastal Waterway Bridge, Helene Wetherington, Calvin, Giordano and Associates, Inc. (2010).

Sea Level Rise in Key West



Potential four foot sea level rise impact in Key West.

Image (above): Current image and illustration of a projected four foot sea level rise on Duval and Front Street in Key West, Florida. Illustration produced by the Sea level Rise and Coastal Flooding Impacts Model of the National Oceanic and Atmospheric Administration available at: <http://www.csc.noaa.gov/slr/viewer>.

PUBLIC FACILITIES REDEVELOPMENT STRATEGIES

Public facilities and other important community facilities such as hospitals and nursing homes, may serve important functions in restoring community viability. The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, **page 71**, details recovery strategies for these public facilities. The impacts of increased storm surge due to sea level rise may subject additional public facilities to increased levels of risk.

Protection, Accommodation or Relocation: The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)*, **page 77**, provides an overview of a variety of mitigation actions communities may take after a disaster. The post-disaster environment may provide opportunity to build community resilience by flood proofing vital facilities or, in the event of a major disaster, to relocate highly vulnerable, damaged facilities to less vulnerable areas. Communities, in partnership with private sector partners, may conduct a detailed **vulnerability assessment for important public facilities and** incorporate similar decision-making factors as detailed in the previous infrastructure section.

Relocation: Critical facilities located within the Adaptation Action Area and/or the inundation zone may be prioritized according to a number of factors. Some vital public functions are more easily relocated because they rely primarily upon electronic data storage and transfer such as purchasing and payroll management. This assumes that these functions have been converted to electronically managed tasks with appropriate electronic data redundancy. In some cases, electronic systems and data are both managed and stored at an alternate, third party site. Under these circumstances, **physical location may no longer be a critical component of their performance.** Other functions continue to be location-dependent, such as hospital care and emergency dispatch, which rely upon specialized equipment to save lives. Communities may want to consider **permanently relocating life safety functions that are also location-dependent** to areas which are less vulnerable. It is equally important to consider the **economic impacts** of a relocation of a facility, which may also be a major employer within the community. The impacts to the affiliated businesses in close geographic proximity may be significant. Relocation of a hospital, for example, would impact the surrounding medical offices, laboratories, and suppliers, which tend to be located in close proximity. Similarly, the need to continue to operate these facilities may pose a challenge to local communities with limited public funds. Public, private, and non-profit stakeholders impacted by the relocation process should together consider the costs and benefits of relocating important community facilities.

Criteria for the prioritization of public facilities adaptation:

- hazard vulnerability
- criticality of the function (public safety vs. recreation)
- dependency on a single geographic location
- cost versus the benefit of relocation
- availability of external funding support



Photo (above): Port Charlotte, Fla., -- Firehouse is being restored to meet FEMA suggested construction standards. Hurricane ripped roof of the station almost causing death or injury to the 86 people using it as a shelter. Photo by Leif Skoogfors/FEMA photo (April 25, 2005).

Continuity of Operations Plans: Communities throughout Florida have actively developed Continuity of Operations Plans to ensure that mission critical functions supporting public safety can continue to be performed. However, with higher anticipated inundation levels, additional critical facilities may become vulnerable to inundation. Communities may choose to reevaluate their existing Continuity of Operations Plans in order to determine if they are sufficient to ensure ongoing governmental operations, particularly in facilities which may be newly identified as vulnerable to hurricane storm surge increased by sea level rise. These may include police and fire stations, communications centers, emergency operations centers, hospitals, nursing homes, dialysis centers, evacuation shelters, and others deemed important to the local community. These facilities should be assessed based upon higher surge inundation potential, evaluated for appropriate adaptation strategies, and potentially included in the project prioritization list of the Local Mitigation Strategy. Planning for post-disaster restoration and/or relocation should be developed for all functions considered essential to community recovery such as local building permitting functions, community services providing housing assistance, case management support, utility services restoration, health and medical services, public safety services, public transit, and others detailed within the departmental Continuity of Operations Plan.

HEALTH AND SOCIAL SERVICES REDEVELOPMENT STRATEGIES

Safe Drinking Water: The most immediate health impact from sea level rise to the greater community is the potential for drinking water contamination caused by saltwater intrusion. As saline ocean waters continue to create increasing pressure on the groundwater supply, the aquifer is likely to experience increasing saltwater infiltration. Similarly, the surface water supplies could also be impacted by rising sea levels due to the inability of the vast interconnected preserves, lakes, and canals to operate by gravity flow. Without an adequate supply of safe drinking water, regions within the State may experience critical shortages. “Rising sea levels will push salt water farther inland and make the water from those wells unusable. Municipalities with well fields close to the coast are particularly vulnerable” (South Florida Water Management District, 2010). Following are measures that may be taken during long-term recovery to verify a safe drinking water supply and adapt to changes in the aquifer.

- **Monitoring:** Coordinate with all local, state, and federal entities monitoring water quality and quantity in surface water, groundwater, estuaries, and coastal systems, to identify potential contaminants in the post-disaster environment which may impact drinking water supplies.
- **Testing:** Develop strategies to test private residential water wells located in highly vulnerable areas, post-disaster, to identify potential saltwater intrusion.
- **Relocate wells:** Identify post-disaster opportunities to relocate water-pumping systems away from highly vulnerable areas.
- **Sustainable alternatives:** The post-disaster environment may also provide opportunities to explore water supply alternatives such as expansion of grey water use throughout the community, use of desalinization, or pursuit of water conservation measures.

Environmental Health: Even moderate increases in sea level, could exacerbate storm surge inundation in the aftermath of a hurricane, and stormwater runoff capability after prolonged rain events. Flooding, both permanent and intermittent, may allow diseases such as cholera and malaria to extend their ranges further inland. Areas that continue to rely primarily upon private residential septic systems are also highly vulnerable to long-term standing water, and rising groundwater. These conditions, in the aftermath of a disaster, can pose a significant hazard to

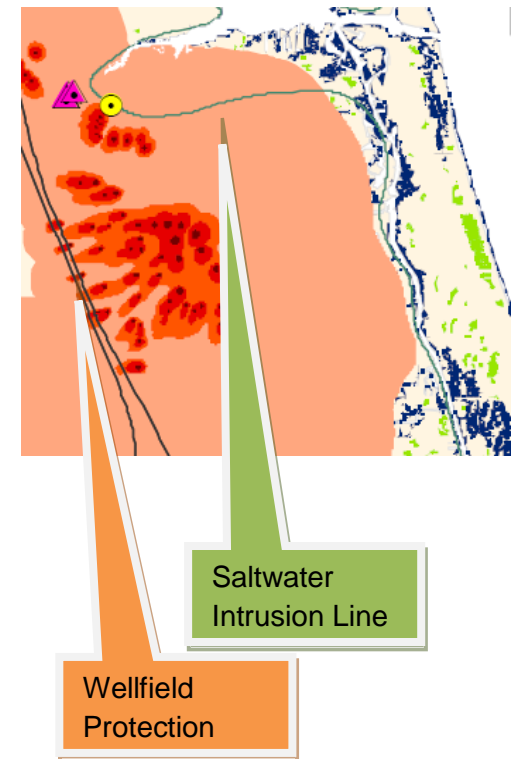


Figure 3: Illustration of saltwater intrusion into the freshwater well field protection area.

Impacts to low income groups

In the USA, lower-income groups were most affected by Hurricane Katrina and low-income schools had twice the risk of being flooded compared with the reference group (Guidry and Margolis, 2005).

IPCC

http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm

children who are exposed to sewage within the floodwaters. Vulnerable areas may be identified and monitored to anticipate escalating vulnerabilities over time.

Vulnerable Populations: Sea level rise impacts are not likely to occur rapidly, but instead create a gradual long-term condition threat to a multitude of community elements. The more vulnerable socioeconomic populations in the United States are often disproportionately impacted by disasters and often have less personal resources to recovery in the aftermath.



Photo (above): Jupiter beach access damaged by erosion, Nathan Schaeffer, Calvin, Giordano and Associates, Inc. (2011).

ENVIRONMENTAL RESTORATION STRATEGIES

Beach Erosion and Beach Access: *Post-Disaster Redevelopment Planning: A Guide for Florida Communities* (2010), Environment Section on page 95, provides a comprehensive overview of beach and dune restoration challenges in the post-disaster environment. These challenges may be further augmented as higher sea levels create additional inland flood inundation and more rapid beach and dune erosion. A multitude of environmental, social, and structural factors affect beach and dune erosion, which have cascading effects on the length, width, and quality of the shoreline. New inlets can be cut through barrier islands when waves and storm surge reduce dune elevation and completely inundate the beach (Sallenger et al., 2005). This overland flow of surge waters can cut a channel across the barrier island. The rising sea level may escalate this problem over time.

Shoreline Stabilization: Continuous and highly expensive beach re-nourishment and dune restoration initiatives throughout the State help maintain its pristine and economically valuable areas. Hurricane storm surge augmented by sea level rise will likely create extensive community challenges for the beachfront, water-dependent uses, natural environments, and long-term economic viability. It is difficult to estimate when beaches are no longer viable for recreational use and begin to endanger manmade structures along the waterfront. Narrowing beaches provides less protection from storm waves that reach oceanfront buildings, roads, and boardwalks. Beach access locations may also be impacted by rising seas blocking access not only to visitors but also to emergency workers, post-disaster.

Monitoring: In the post-disaster environment it will be vital to monitor the impacts and document the changes of the beaches and dunes. The additional destruction from hurricane storm surge combined with the sea level rise will likely create additional challenges in post-disaster redevelopment.

Natural Areas and Protected Species: In addition to the loss of beaches and dunes, rising seas will affect a myriad of sensitive coastal habitats and may endanger sensitive species that live and breed in these areas, such as saltwater marshes and mangrove swamps. In densely developed metropolitan communities, sensitive natural areas may have limited or no buffering with adjacent natural lands. Without adjacent natural buffers, sensitive marshes and swamps might not be permitted to migrate further inland. New areas of hurricane inundation may occur that did not previously exist, thus resulting in saltwater exposure to habitats that are intolerant to saltwater. This storm surge can create an influx of mud that results in a change in soil



Photo (above): Geneva, Fla., Tropical Storm Fay dumped 20 inches of water along the coast and it is still draining to this location along the St. John's River. George Armstrong/FEMA (August 28, 2008).



Photo (above): Martin County Florida, October 2011, Flooding in Stuart Florida due to high tide, Helene Wetherington, Calvin, Giordano and Associates, Inc. (2011)



Photo (above): Kissimmee Florida, Helene Wetherington, Calvin, Giordano and Associates, Inc. (October 2011).

According to Palm Beach County Department of Environmental Resources Management: "... nearly 50% of the Green turtle nests and 20% of the Loggerhead turtle nests were washed out as a result of the storm [Hurricane Frances]...1,200 nests were lost".

composition. The increases in salinity may have a direct impact on the rooting zones of plants. Saltwater intrusion into native freshwater wetland habitats can create a confluence of disturbances that can signal the end of freshwater-dependant species. The loss of freshwater habitats, even if replaced with native saltwater habitats, can alter the landscape of the area.

To protect the future of Florida's coral reefs, it is essential for the local agencies responsible for managing the reefs, marine natural resources, and adjacent lands and watersheds, to restore and maintain the resilience of the ecosystem. It is critical to protect biodiversity, improve water quality, and ensure sustainable fishing.

The structural shoreline protection measures that prevent loss of land, property, and infrastructure, may or may not be financially or environmentally sustainable in the post-disaster environment. Hard structural measures, including shoreline protection structures such as dikes, levees, seawalls, and floodgates, may not be effective as a long-term adaptation strategy in the most vulnerable areas and further degrade natural environments (Parkinson and Donahue, 2010). Sustainable low energy shoreline protection measures, including beach grass and dune restoration, beach re-nourishment, and secondary mangrove forest re-growth, when feasible, may be less destructive on overall natural systems.

Habitat Accommodation: Incorporating targeted land uses and construction design elements may allow for continued use of vulnerable natural areas, but still allow for species to exist or flourish. Although not related to sea level rise, an example of habitat accommodation would be the "key deer overpasses" found in Monroe County. Since retreat (moving US 1) was not an option, portions of the roadway known to be inhabited by key deer where elevated and fences constructed to allow the deer to pass under the roadway between habitats, and protect them from traffic hazards. As we begin to better understand the impacts of sea level rise to sensitive habitats and species, local communities may be able to identify habitat accommodation strategies to protect natural environments.

Land Use Changes: The post-disaster environment may provide opportunities to implement policies, such as rolling easements, to reclaim previously developed areas and change their land use to promote natural resource protection and preservation. These areas may be pre-identified (such as designations with the Adaptation Action Areas or adaptation overlays), so that they can be more easily implemented in the post-disaster environment.

Parks and Open Space: Local jurisdictions may also consider assessing existing and future publicly owned parks and recreational facilities that are located within the vulnerable areas in order to accommodate appropriate uses or to support retreat adaptation strategies. There may be funding opportunities to support the acquisition, enhancement, or expansion of these publicly owned lands or facilities in order to provide green space or designate passive recreation uses.



Photo (above): Palm Beach County coast, Palm Beach County Division of Emergency Management, Sheridan Truesdale (2010).

Section 161.088, Florida Statutes **Declaration of public policy respecting beach erosion control and beach restoration and nourishment projects.**--Because beach erosion is a serious menace to the economy and general welfare of the people of this state and has advanced to emergency proportions, it is hereby declared to be a necessary governmental responsibility to properly manage and protect Florida beaches fronting on the Atlantic Ocean, Gulf of Mexico, and Straits of Florida from erosion and that the Legislature make provision for beach restoration and nourishment projects, including inlet management projects that cost-effectively provide beach-quality material for adjacent critically eroded beaches. The Legislature declares that such beach restoration and nourishment projects, as approved pursuant to s. 161.161, are in the public interest; must be in an area designated as critically eroded shoreline, or benefit an adjacent critically eroded shoreline; must have a clearly identifiable beach management benefit consistent with the state's beach management plan; and must be designed to reduce potential upland damage or mitigate adverse impacts caused by improved, modified, or altered inlets, coastal armoring, or existing upland development.



Chapter 4: Implementation Considerations

The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* in **Chapter 4 (page 101)**, provides a detailed framework for pre- and post-disaster implementation required to ensure rapid and effective redevelopment. To ensure community integration of sea level rise impacts during this process, communities may benefit through ongoing engagement in the evolving scientific knowledge, data, and planning support tools, which will enhance knowledge of the risks and vulnerabilities that communities will likely face in the coming decades. Following is some general guidance which will support this effort.

PRE-DISASTER IMPLEMENTATION

During the post-disaster redevelopment plan update process, communities may consider the following actions:

- Evaluate sea level rise predictions and hurricane surge inundation models to determine the areas of greatest risk within short- and long-term timeframes.
- Support the implementation of hydrological studies and data which will advance local understanding of coastal and inland stormwater systems, surface water supplies, well field protection areas, and groundwater supplies.
- Ensure that adaptation strategies created by a community are appropriately referenced and incorporated in the post-disaster redevelopment planning process.
- Update institutional capacity as programs, personnel, and policies are developed to address sea level rise issues within the jurisdiction and ensure appropriate linkages to the comprehensive plan, Local Mitigation Strategy, economic development strategies and other local visioning tools.
- Incorporate resiliency issues in policy discussions, table top exercises, workshops and seminars, which address recovery and redevelopment.
- Monitor the availability of grants and private funding sources, which aim to building more resilient communities.
- Raise awareness and build political support toward building and rebuilding a more sustainable and resilient community.

Photo (left): Daytona Beach, FL, The beach has been closed to all cars because of beach erosion from Hurricane Jeanne. FEMA photo: Michael Rieger (September 29, 2004).

POST-DISASTER IMPLEMENTATION

Following are strategic recommendations for local decision makers to holistically address community resilience in the aftermath of a disaster. The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* on **page 106**, details a range of post-disaster actions to support plan implementation. After a catastrophic disaster, the local leadership may have a unique opportunity to create a more disaster resilient and sustainable community, which further enhances the community vision while implementing the strategies within the Post-Disaster Redevelopment Plan.

Climate Change Action Plan

The Southeast Florida Regional Climate Change Compact was formalized to encourage the discussion among the regional leadership of the challenges and potential strategies for responding to the impacts of climate change. Through collaborative efforts, the compact developed a Southeast Florida Regional Climate Change Action Plan summarizing recommendations for local policy development.

- Ensure appropriate technical expertise and information related to community resilience is available to the community leadership during the redevelopment process.
- During the post-disaster damage assessment and impact assessment process, integrate objectives which will identify vulnerable infrastructure, structures and facilities within the highest risk areas, including Adaptation Action Areas.
- Monitor the permitting process to promote residential and business opportunities for greater resilience.
- If Adaptation Action Areas have been established, ensure appropriate implementation of reconstruction policies within these areas.
- If community triggers have been established to enforce higher reconstruction standards in high-risk areas, ensure these standards are enforced.
- Monitor infrastructure and facility projects to identify opportunities to incorporate more resilient reconstruction for all publicly funded projects including those identified within the Local Mitigation Strategy, Capital Improvement Plan and others.
- Maximize the use of federal programs, state support, local funds, and private sector partnerships to build more disaster resilient communities.
- Document real-time evidence supporting ground truthing efforts for post-disaster evaluation.
- Evaluate infrastructure adaptation based upon the decision-making triggers discussed below.

INFRASTRUCTURE ADAPTATION DECISION MAKING TRIGGERS

The local leadership must determine when and how to adapt critical infrastructure components which are highly vulnerable and may have been impacted by the disaster. External reconstruction funds may be available to rebuild a more disaster resilient community:

- **Location within Adaptation Action Area/inundation risk area:** Once the sea level rise vulnerable areas have been identified, evaluate the critical facilities and vital infrastructure components located within these areas. While some facilities are location-dependent, others may have greater geographic mobility.
- **Post-disaster level of destruction:** Evaluate destroyed and severely damaged facilities, structures, and infrastructure for adaptation measures. Post-disaster reconstruction efforts may offer ideal opportunities to rebuild smarter, sustainable, and more resilient communities. Consider protecting, enhancing, or relocating facilities and infrastructure during reconstruction.
- **Lifespan of the infrastructure component:** The expected lifespan of infrastructure components will impact the planning timeline for incorporation of adaptation actions. Roadways, for example, have an expected lifespan of twenty years and are generally repaved more frequently. As the sea level rise begins to inundate roadways, transportation planners and traffic engineers will have sufficient opportunity to observe increased inundation levels and redesign traffic systems to accommodate the new conditions. Bridges, on the other hand, are expected to remain operational for seventy-five years. It is, therefore, important to anticipate potential impacts during any construction, reconstruction, or expansion opportunity. Understanding the lifespan of vital infrastructure components will support the prioritization of infrastructure adaptation measures.
- **Purpose and function:** The purpose and function of infrastructure components and public facilities impacts the priority level for post-disaster adaptation. Communities may remove, relocate, or repurpose structures which are not water-dependent and serve a non-critical function. Facilities and infrastructure with location-dependent uses and public safety function should be protected and/or accommodated.
- **Adaptation cost versus community benefit:** Communities must closely consider the cost of adaptation in comparison to the long-term community benefit of extending the lifespan of the critical infrastructure and facilities. Costly public investment in protection

Ask the following questions to prioritize infrastructure adaptation, post-disaster:

Is the critical infrastructure or facility located within an Adaptation action area?

How severely are the critical systems and components damaged?

What is the expected life span of the critical infrastructure system or facility?

What is the purpose and function of the critical infrastructure or facility?

What is the benefit versus cost ratio to adapt the infrastructure system?

How long will the adaptation measure extend the use of the facility or infrastructure component?

Are there sufficient funds, community support, and political will to support adaptation?



Photo (above): Image depicting Bathtub Beach area in Martin County, Florida with eroding shoreline after Hurricane Frances. Photo courtesy of Martin County Board of County Commission (October 2004).

and accommodation strategies for the benefit of a small portion of the community may not be an equitable public investment. The benefit-cost analysis of post-disaster adaptation should also consider the long-term impact to natural systems. Where landward migration is not feasible, vulnerable coastal habitats may be permanently affected. The economic impact of tourism related losses due to decline in fishing, eroded beaches, loss of diving reefs, and similar water related activities should also be incorporated.

- **External funding, community support and political will:** The post-disaster environment may provide external funding opportunities to reconstruct more resilient facilities and infrastructure. Federal disaster funds and insurance carriers may accommodate additional reconstruction expenditures in order to comply with local building codes, land development regulations, requirements within Adaptation Action Areas, and state law. Foster community support and political will to build consensus on rebuilding a more resilient community post-disaster.

FINANCING IMPLEMENTATION

The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* in the Finance Implementation Chapter (**page 115**) details the primary pre- and post-disaster funding sources which may be available to local communities to conduct post-disaster redevelopment planning and address redevelopment issues. In both the pre- and post-disaster environment, these funding sources may be important milestones toward building greater community resilience. Additionally, communities may consider the availability of grant funds associated with community sustainability, mitigation, and resilience such as funding for green construction, innovative renewable energy sources, and other similar initiatives.

INCLUDING THE PUBLIC IN IMPLEMENTATION

The *Post-Disaster Redevelopment Planning: A Guide for Florida Communities (2010)* in the *Implementation Considerations* Section (**page 118**), addresses the importance of pre- and post-disaster public engagement in all stages of the redevelopment process. Enhance resilient community redevelopment efforts by incorporating the following actions:

- **Engage community leaders** and technical experts knowledgeable in community sustainability issues.

- **Target highly vulnerable areas**, if appropriate, within Adaptation Action Areas, to raise awareness regarding adaptation strategies among stakeholders.
- **Utilize outreach tools and visual aids** to better communicate the risk associated with future sea level rise and hurricane storm surge.
- **Identify alternatives** that will ease the implementation of adaptation strategies on individual homeowners, business owners, and special populations.



Photo (above): Image depicting Erica Robbins from the US Army Corps of Engineers on Water Matters Day educating the importance of the South Florida Everglades Ecosystem. Photo Courtesy of Paul Krashefski, Broward County Natural Resources Planning, and Management Division (March 2011).



References and Resources

REFERENCES

Bell, F.W. (2005). Economic policy issues associated with beach re-nourishment. *Review of Policy Research* 6: 374–381.

Douglas A. Carlson, Thomas P. Van Biersel, and L. Riley Milner (2008). Storm-Damaged Saline-Contaminated Boreholes as a Means of Aquifer Contamination. *Ground Water*, Vol. 46, No. 1, pp. 69–79. Retrieved from <http://info.ngwa.org/gwol/pdf/081882559.pdf>.

Florida Department of Economic Opportunity. (2011). Adaptation Planning. Retrieved from <http://www.floridajobs.org/community-planning-and-development/programs/technical-assistance/community-resiliency/adaptation-planning>.

Environmental Protection Agency. (2009). Synthesis of adaptation options for coastal areas. Management Goal: Maintain Shorelines Utilizing “Soft” Measures. Retrieved from http://www.epa.gov/CRE/downloads/CRE_Synthesis_1.09.pdf.

Florida Department of Transportation, Office of Maintenance & U.S. Department of Transportation. (2010). Office of Maintenance, Florida Department of Transportation (January 2010) & U.S. Department of Transportation.

Florida Oceans and Coastal Council. (2009). The effects of climate change on Florida’s ocean and coastal resources. Tallahassee, FL. p. 34.

Grannis, Jessica, Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use, Georgetown Climate Center, October 2011. Retrieved from http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf.

Harrington J. and T.L. Walton. (2007). Climate change in coastal areas in Florida: Sea level rise estimation and economic analysis to year 2080. Center for Economic Forecasting and Analysis, Florida State University, Tallahassee, FL. p. 87 Retrieved from <http://www.tcsurfrider.org/documents/FLprojectedSeaLevelRise.pdf>

Parkinson, R.W., and J.F. Donahue. (2010). Bursting the bubble of doom and adapting to sea-level rise. *Shorelines*, March 2010. Retrieved from <http://flseagrant.org/images/PDFs/climate%20change%20and%20sea%20level%20rise.pdf>.

Sallenger, A.H., C.W. Wright, and J. Lillycrop. (2005). Coastal impacts of the 2004 hurricanes measured with airborne LIDAR; initial results. *Shore and Beach* 73(2&3): 10–14.

Photo (left): Erosion at Jupiter Beach Florida, Nathan Schaeffer, Calvin, Giordano and Associates, Inc. (2011).

REFERENCES AND RESOURCES

Shaw, H., A. Reisinger, H. Larsen and C. Stumbles. (2005). Incorporating climate change into stormwater design: why and how? Proceedings of the 4th South Pacific Conference on Stormwater and Aquatic Resource Protection. URS New Zealand Limited. Ministry for the Environment, North Shore City Council Retrieved from <http://www.climatechange.govt.nz/resources/localgovt/stormwater-design-mar05/stormwater-design-mar05.pdf>.

South Florida Water Management District. (2009). Climate Change and Water Management in South Florida, Interdepartmental Climate Change Group.

South Florida Water Management District. (2010). Climate Change and Water Management. Retrieved from http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/spl_climate_change.pdf

Southeast Florida Regional Climate Change Compact (2011). Draft Regional Climate Change Action Plan Draft.

James G. Titus, Chin Y. Kuo, Michael J. Gibbs, Tom B. LaRoche, M. Keith Webb (1987), Greenhouse Effect, Sea Level Rise, and Coastal Drainage Systems, Journal of Water Resources Planning and Management, Vol. 113, No. 2., pp. 216-224.

RESOURCES

Florida Department of Economic Opportunity, Technical Assistance

<http://www.floridajobs.org/community-planning-and-development/programs/technical-assistance>

The effects of Climate Change on Florida's Ocean and Coastal Resources

<http://www.floridaoceanscouncil.org/reports/>

NOAA annual Global Temperature anomalies

<http://www.ncdc.noaa.gov/cmb-faq/anomalies.html>

IPCC Fourth Assessment Report: Climate Change 2007 (AR4)

http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm#1

EPA projected Sea level rise

http://www.epa.gov/climatechange/science/futureslc_fig1.html

GRID-Arendal official United Nations Environment Program (UNEP) collaborating partner

<http://maps.grida.no/go/graphic/projected-sea-level-rise-for-the-21st-century>

University of Arizona, Department of Geosciences, sea level rise maps for Florida

http://www.geo.arizona.edu/dgesl/research/other/climate_change_and_sea_level/sea_level_rise/florida/slr_usafl_i.htm

NOAA Coastal Climate Adaptation Resources for Florida

<http://collaborate.csc.noaa.gov/climateadaptation/Lists/Resources/Florida.aspx>

ICLEI's program to help local governments plan for the impacts and costs of climate change

http://www.icleiusa.org/programs/climate/Climate_Adaptation

State of Florida Climate Change website

<http://myfloridaclimate.com/>

Southeast Florida Regional Climate Change Compact

<http://www.southeastfloridaclimatecompact.org>



ACRONYMS

AAR After Action Report
AHCA Agency Health Care Administration
ALF Assisted Living Facility
BFE Base Flood Elevation
CCCL Coastal Construction Control Line
CEMP Comprehensive Emergency Management Plan
CEOC County Emergency Operations Center
CERT Community Emergency Response Team
CFR Code of Federal Regulations
CIE Capital Improvement Element
CIP Capital Improvement Plan
COG Continuity of Government
COOP Continuity of Operations Plan
CRT Community Relations Team
CRS Community Rating System
DART Disaster Animal Response Team
DEM Division of Emergency Management
DEP Florida Department of Environmental Protection

DFO Disaster Field Office
DHHS Department of Health and Human Services
DHS Department of Homeland Security
DMAT Disaster Medical Assistance Teams
DMS Debris Management Sites
DOC Disaster Operations Center (Red Cross)
DOD Department of Defense
DOH Department of Health
DRC Disaster Recovery Center
ECO Emergency Coordinating Officer
EIS Emergency Information System
EMAC Emergency Management Assistance Compact
EMS Emergency Medical Services
EO Executive Order
EOC Emergency Operations Center
F-SERT Forward State Emergency Response Team
FAC Florida Administrative Code
FCO Federal Coordinating Officer

ACRONYMS

FDACS	Florida Department of Agriculture and Consumer Services	HUD	US Department of Housing and Urban Development
FDCF	Florida Department of Children and Families	IA	Individual Assistance
FDEM	Florida Division of Emergency Management	IAO	Individual Assistance Officer
FDLE	Florida Department of Law Enforcement	IFAS	Institute of Food and Agricultural Services
FDOF	Florida Department of Forestry	IRS	Internal Revenue Service
FDOT	Florida Department of Transportation	ISO	Insurance Service Office
FEMA	Federal Emergency Management Agency	IT	Information Technology
FFWCC?	Florida Fish and Wildlife Conservation Commission	JIC	Joint Information Center
FIMA	Federal Insurance and Mitigation Administration	LEPC	Local Emergency Planning Committee
FLNG	Florida National Guard	LiDAR	Light Detection and Ranging
FLU	Future Land Use	LMS	Local Mitigation Strategy (2009)
FMAP	Flood Mitigation Assistance Program	MACC	Multi-Agency Coordination Center
FSA	Farm Service Agency	MHHW	Mean Higher High Water
GAR	Governor's Authorized Representative	MOU	Memorandum of Understanding
GIS	Geographic Information System	NAVD88	North American Vertical Datum of 1988.
HMGP	Hazard Mitigation Grants Program	NFIP	National Flood Insurance Program
HSEEP	Homeland Security Exercise Evaluation Program	NGO	Non Governmental Organization / Non For Profit Organization
HSPD	Homeland Security Presidential Directive	NHC	National Hurricane Center

NIMS	National Incident Management System	ROC	Recovery Operations Center
NOAA	National Oceanic and Atmospheric Administration	RPA	Request for Public Assistance
NOI	Notice of Intent	SBA	Small Business Administration
NTC	National Tele-registration Center	SEOC	State Emergency Operations Center
NWS	National Weather Service	SERT	State Emergency Response Team
PDA	Preliminary Damage Assessment	SFWMD	South Florida Water Management District
PDM	Pre-Disaster Mitigation	SLOSH	Sea, Lake and Overland Surges from Hurricanes
PDRP	Post-Disaster Redevelopment Plan	SLR	Sea Level Rise
PIO	Public Information Officer	SMAA	Statewide Mutual Aid Agreement
PSA	Public Service Announcement	SOG	Standard Operating Guideline
PW	Project Worksheet	SOP	Standard Operating Procedure
RD	Federal Emergency Management Agency Regional Director	TDR	Transfer of Development Rights
RIA	Rapid Impact Assessment	USDA	United States Department of Agriculture

Photo (back cover): Structure damaged after Hurricane Wilma, Clark,.R., and LaGrone, J.W., Hurricane Wilma – Post-Storm Beach Conditions and Coastal Impact Report, Florida Department of Environmental Protection, Bureau of Beaches and Coastal Systems (2006).

