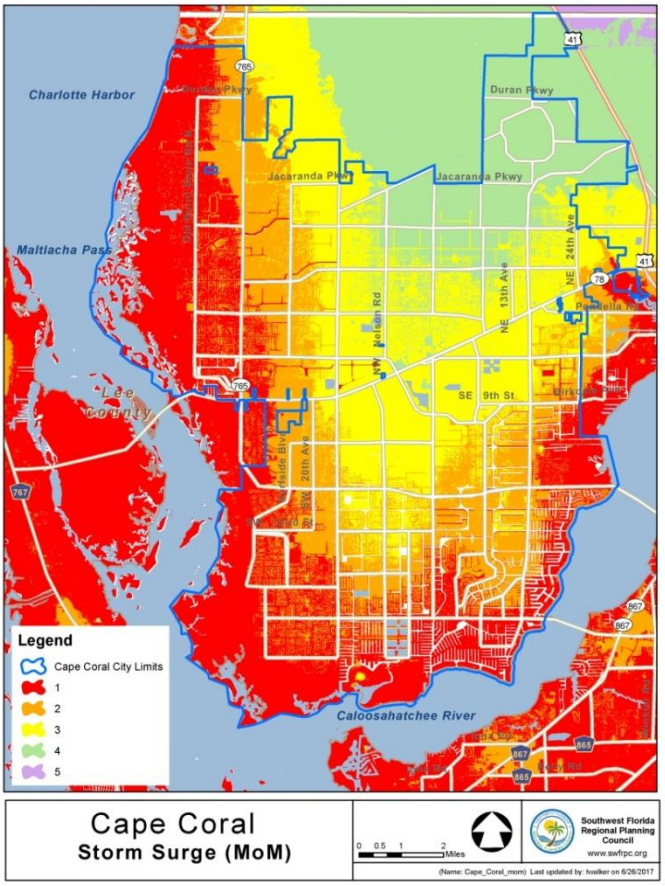
City of Cape Coral Climate Change Resiliency Strategy (CCCCRS)



Southwest Florida Regional Planning Council
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James W. Beever III, Tim Walker, and C. J. Kammerer

1400 Colonial Boulevard
Fort Myers FL 33907
(239) 938-1813
www.SWFRPC.org

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James W. Beever III
Southwest Florida Regional Planning Council
1400 Colonial Boulevard, Suite 1
Fort Myers, FL 33907
239- 938-1813, ext 224
jbeever@swfrpc.org

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Executive Summary

Climate change resilience is the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function at an acceptable level. It is the ability to survive, recover from, and/or live with the effects of climate change. It includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular consequence to minimize negative effects and maintain the ability to respond to changing conditions.

On October 1, 2016 the City of Cape Coral contracted with the Southwest Florida Regional Planning Council (SWFRPC) to develop a Climate Change Vulnerability Assessment (CCVA) for the unincorporated portions of the city. This was completed on January 31, 2017 and provided to the City for review.

That project included an assessment of significant potential effects of climate change on the human and native ecosystems of Cape Coral, including consequences for human and natural resources resulting from and related to (1) sea level rise, (2) aquatic and atmospheric temperature rise, (3) changes in rainfall patterns, (4) increased storm intensity, (5) waterbody chemistry, and (6) general weather instability.

A second part of the same contract was to develop the following City of Cape Coral Climate Change Resiliency Strategy (CCCCRS). The CCCCRS includes a process for identifying potential climate change resiliency strategies through coordination and consultation with local government leadership in 8 City of Cape Coral departments and divisions, including constitutional offices. Identification of resiliency strategies that could be utilized by Cape Coral to reduce the negative effects of climate change will also help in positioning the City to take advantage of potential climate prosperity opportunities. The CCCCRS is a toolbox that contains a wide variety of ideas and opportunities for the City to employ in climate change planning, energy savings, and cost savings. The CCCCRS informs the City of options and opportunities but it *does not prioritize those actions or direct City policy*. Prioritization would require a full public planning process incorporating public participation as part of a *full adaptation plan*.

Note that the CCCCRS is not an adaptation plan. In addition to a full public participation component that involves the total Cape Coral community in partnership with City leadership in setting adaptation goals and identifying the priority of adaptation actions to address the various climate change vulnerabilities, an adaptation plan also results in fully developed strategies for implementation. This extent of planning can be accomplished after the city determines an appropriate funding priority for the project.

Successful resilience and adaptation to climate change requires plans and strategies that respond to both the unique vulnerabilities and the priorities of the places they protect. Plans and strategies need to be flexible, to respond to changing conditions and information and to have realistic assessments of the degree of risk and cost that can be sustained. This document

identifies the key elements of climate change resiliency for the City of Cape Coral, and provides some of the information and resources that the City can use in climate change resiliency planning.

There are several critical elements that are recommended by the EPA for climate ready adaptation plans and resiliency planning. These elements will be found in this report and include:

- Description of specific implementation actions
- A summary of considerations used to set priorities and select actions
- Communication with stakeholders and decision makers; and
- Monitoring and evaluation of results.

Following the completion of the CCVA, an online survey was sent to City of Cape Coral division heads, the Cape Coral City Council members and the City of Cape Coral constitutional officers. The purpose of the survey was to gather baseline data on key staff and leadership members' perceptions and experiences with respect to weather, climate, storm events and climate change. The survey results were compiled and used to inform follow-up in-person interviews. Results from both the surveys and the interviews provided a wealth of information from Cape Coral personnel about the ways in which City programs and assets might be made more resilient to the effects of climate change in the near-, middle- and long-term. Literature review pertinent to Cape Coral provided additional alternatives.

Resiliency strategies are alternatives to consider. In this document, resiliency strategies are organized according to groups of identified vulnerabilities. The strategies are not prioritized; prioritization should be the work of a full adaptation planning process. Some areas have many resiliency strategies, and some have few. (existing efforts in the resiliency strategy in its efforts to increase energy efficiency, fuel economy, and water efficiency. These efforts are noted with a special symbol in the tables.

None of the lists of possible strategies should be taken to be all inclusive, or exclusive, but should represent a place at which to begin discussion.

Resiliency strategy areas included in this document address the following:

- City buildings and infrastructure
- Policy and program-related resiliency strategies
- Coastal erosion and sea level rise
- Emergency and hazard planning
- Health and human services
- Land use planning
- Urban, suburban, and rural land use
- Public water supply and domestic self-supply projections of population
- Water and wastewater
- Waste management

- Natural systems and resources
- Renewable, green energy
- Transportation
- City vehicle fleet
- Education and outreach

Introduction

Changes in the climate of City of Cape Coral will occur in the future even if mitigations, such as reductions in greenhouse gas emission, were to be implemented today. The stressors of air temperature and water temperature increases, with subsequent changes in air quality and water quality, can be expected to continue and the impacts of climate change variability and sea level rise, in particular, are inevitable. Climate change impacts from sea level are already evident in the growing demand for and costs of beach nourishment, increased coastal flooding, and more pronounced storm surges during tropical storm events.

Successful resilience and adaptation to climate change requires plans and strategies that respond to both the unique vulnerabilities and the priorities of the places they protect. Plans and strategies need to be flexible, to respond to changing conditions and information and to have realistic assessments of the degree of risk and cost that can be sustained. This document identifies the key elements of climate change resiliency for the City of cape Coral, and provides some of the information and resources that the City can use in climate change resiliency planning.

There are several critical elements that are recommended by the EPA for climate ready adaptation plans and resiliency planning. These include:

- An assessment of vulnerability;
- Description of specific implementation actions;
- A summary of considerations used to set priorities and select actions;
- Communication with stakeholders and decision makers; and
- Monitoring and evaluation of results.

A resiliency plan can be a stand-alone document or be incorporated as an additional or new element in an existing management plan, such as the Comprehensive Plan. Regardless of where the resiliency plan is housed, some of the key considerations include:

- How the plan affects existing management goals;
- Additional climate change-induced goals and objectives beyond the existing management goals;

- Management actions associated with achieving those goals and objectives; and
- Steps required for implementation (including the associated tools and resources that can be deployed).

Finally, any climate strategy or plan needs to be seen as a "living document" - one that allows for relatively easy revisiting and updating in response to changing conditions and lessons learned from monitoring and evaluation of results. Initial plans can be updated and enhanced as information changes regarding vulnerability, uncertainty, management priorities, technology, adaptation methods and costs.

Elements of Resiliency Plan

In August of 2007, the Rockefeller Foundation launched its Building Climate Change Resilience initiative. While the global attention on climate change has been focused on mitigation through the reduction of greenhouse gases, in the long term there is a need to build resilience to the natural and enhanced climate changes that will come. The impacts of climate change have already begun to manifest and there are irreversible impacts that will continue and worsen within the span of a lifetime. Current and future consequences of climate change will result in significant costs in financial and human capital.

There is a need to build climate change resilience, and to be able to plan for, survive, recover from, and even thrive in changing climatic conditions, as a core part of the mission of local governments in southwest Florida. Climate change resilience is most critical in those places where vulnerability is high, such as City of Cape Coral, located in coastal southwest Florida.

In the field of ecology, resilience means building the capacity of a system to withstand perturbations and shocks and to rebuild and respond to change, including unanticipated change. The Resilience Alliance defines resilience as the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks (http://www.resalliance.org/560.php).

Climate change resilience is the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function at an acceptable level. It is the ability to survive, recover from, and/or live with the effects of climate change. It includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular consequence to minimize negative effects and maintain the ability to respond to changing conditions.

Historically, the term ***adaptation*** has been used to describe the individual actions required to respond to change. The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, an adjustment that moderates harm or exploits beneficial opportunities (IPCC 2007).

Resilience, on the other hand, refers to the *capacity over time* of a system, organization, community, or individual to create, alter, and implement *multiple* adaptive actions. Resilience is

a more accurate, positive, and comprehensive term, describing the dynamic, systemic transformation that is needed to respond to the consequences of climate change, especially future impacts that are difficult to predict.

A **Climate Change Resilience Plan** should include the following elements:

Flexibility at an individual, organizational, and systemic level, with each level able to respond and contribute to each situation, and to respond to shifting and unpredictable circumstances;

A multi-faceted skill set, including abilities that enable thorough preparation, such as comprehensiveness and detail-orientation; survival, such as quick decision-making and resourcefulness; or rapid recovery, such as innovation and diligence;

Redundancy of processes, capacities, and response pathways within an institution, community, or system, to allow for partial failure within a system or institution without complete collapse;

Collaborative multi-sector approaches to planning, execution, and recovery, since no one sector has a monopoly on a particular impact and thus understanding the overlaps and gaps between sectors is critical;

Planning and foresight to prepare for identified impacts and risks: While it is impossible to plan for every possible set of impacts, and in many cases the cumulative effect of impacts is unknown, the process of planning brings learning, builds skills, and helps to create resilience;

Diversity and decentralization of planning, response, and recovery activities: A diversity of options has greater potential to match the particular scenario of impacts that occurs, while decentralization allows for parts of the system to continue operations even if other parts of the system are down; and

Plans for failure so that break-downs happen gracefully, not catastrophically—for example, when flood gates break, they do so in a way that channels floodwaters to uninhabited flood zones, perhaps damaging property, but protecting human lives. Accepting that the unpredictability and uncertainty of climate risks and responses will ultimately lead to failure of some element of the system allows for failure-planning. In some cases returning to a pre-existing state will not be possible or will not be appropriate. Incremental failures and planning for failures will allow for real-time response and revision and will limit social, environmental, and economic costs. Total system failure limits response options and results in greater suffering.

Resilience is a combination of activities that reduces risks and vulnerability to those risks, and provides a safety net or recovery path.

A resilient system for storm events might include stronger building codes for homes (a risk reduction strategy), an evacuation plan (a risk reduction strategy), and catastrophe-bond insurance (a recovery strategy). In other cases, resilience might be possible only by increasing the overall strength of a system by removing or reducing other stressors—unrelated to climate change. For example, a coral reef might be able to recover from high-temperature related bleaching events faster if it is not stressed by polluted water. While it might be impossible to

prevent coral bleaching events, it could be possible to reduce the level of pollution in the water (vulnerability reduction strategy).

The complexity of resilience requires the integration of strategies into the variety of *existing* activities and institutions. It is difficult to imagine a network of specialized institutions that could direct and manage the extent of complex changes required for climate change resilience without the involvement of the existing institutions. Indeed, climate change resilience must be a part of the plans, infrastructure, and day-to-day operations of existing institutions and systems.

Resilience is not simply the result of adding up resilient individuals. The uncertain nature of climate impacts means that no one individual or institution can possibly prepare for, or recover from, all of the potential scenarios. Therefore, resilient *systems* are required. Systems are combinations of resources, institutions, individuals, and processes that combine to accomplish a set of specific functions. To achieve resilience, systems build redundancies of resources, multiple response paths, and safety nets. Resilient systems survive a greater range of situations and, for extreme or unexpected impacts, fail gracefully, giving time to recover key functions.

Effective response to climate change impacts will require action from multiple sectors.

• Financial services and insurance companies will need to develop and distribute products that insure against new combinations and permutations of risk, as well as products that hedge against new types of risk.

• Agriculture, water, tourism, and energy businesses will need to understand the risks and impacts of climate change on business sustainability, and be prepared to react accordingly, including capitalizing on new business opportunities.

• Infrastructure will need to accommodate new standards and incorporate a new flexibility that can respond to climate change uncertainty.

• Health workers will need to build local response capacity for widespread events such as heat waves, while simultaneously extending the reach of efforts to mitigate climate-related diseases such as malaria, dengue fever, or schistosomiasis.

• Disaster relief organizations will need to plan for new types of disasters on a larger scale.

The Current Climate of Southwest Florida and the City of Cape Coral

The climate of southwest Florida is subtropical or tropical savanna (Hela 1952). This results in alternating wet season flooding and severe drought. There is an average of approximately 53 inches (135 cm) of annual rain (Bradley 1972). The dry season runs from November to April and the wet season from June to September (Riebsame et al. 1974). Typically, from 18 to 23% of annual rainfall occurs in the dry season and 60 to 72% of the rainfall occurs in the wet season (Drew and Schomer 1984). Seasonal wetlands, such as hydric pine flatwoods and wet prairies, usually become saturated and attain standing water in the middle to late wet season. It is interesting to note that the distribution of large, landscape scale hydric pine flatwoods in southern Collier and southern Lee Counties corresponds with areas of higher rainfall of 60+ inches annually (Bamberg 1980).

Rainfall in the wet season follows a bimodal pattern, with the first peak in May or June and the second in September or October. It is of note that this pattern corresponds with peak flowering periods for the understory components of the freshwater wetland plant community. Thunderstorms are more frequent (over 100 annually) in the Fort Myers area, in the center of the southwest Florida, than at any other location along the eastern Gulf coast (Jordan 1973). Seventy-five percent of the thunderstorms occur in the summer (Jordan 1973, Duever et al. 1979). These short duration, high intensity thundershowers are the result of a cyclic land-sea breeze convection in a diurnal pattern peaking during late afternoon or early evening. Thunderstorm rainfall can be very localized, resulting in differences of up to five inches per month between areas less than five miles apart (Duever et al. 1979). It is this type of rainfall event that causes the highest volumes of stormwater runoff with the potential of spot flooding and damaging effects to the estuaries of City of Cape Coral and Charlotte Harbor. Individual cloud volumes during thunderstorms in south Florida can range from 200 to 2,000 acre-feet (Woodley 1970).

The wind patterns of south Florida are determined by the interactions of prevailing easterly tradewinds, local diurnal convective patterns in the summer, and continental cold fronts in the winter. Summer wind patterns are dominated by a daily wind shift that peaks between noon and 2:00 P.M., with an onshore sea breeze during the day and an offshore land breeze at night. Winter dry season cold fronts occur approximately once a week (Bamberg 1980). On a seasonal basis, the highest average wind speeds occur in late winter and early spring, and the lowest speeds occur in the summer. Localized strong winds of short duration are generated by summer thundershowers, extreme cold fronts, and tropical storms (Bradley 1972). On a typical day, wind speed is lowest at night, increasing through the day to the afternoon, and decreasing again in the evening (Gutfreund 1978).

Temperature in southwest Florida is primarily controlled by latitude and maritime influences (Bradley 1972). The mean annual temperature is 74 degrees Fahrenheit, the average January temperature is 64 to 65 degrees Fahrenheit, and the average August temperature is 82 degrees Fahrenheit. Southwest Florida is one of only two areas in the southeastern United States where air temperatures exceed 90 degrees Fahrenheit more than 120 days of the year. Typically, there is a one degree Fahrenheit difference between Charlotte County and Collier County. Inland areas display a greater daily range in temperature than coastal habitats.

In winter, sharp drops in temperature occur following cold fronts containing cool, dry arctic air from Canada. Cooling begins after sunset and reaches the lowest temperatures at dawn. Temperature gradients of about six to 15 degrees F can occur between coastal and inland areas a few miles apart. A similar gradient of about six to 10 degrees F occurs between high, dry land (xeric pine flatwoods) and adjacent moist lowlands (hydric pine flatwoods). On calm, cold, clear nights, frost may form in moist inland areas. A severe freeze occurs approximately once every 20 years (Bamberg 1980). According to the Federal Emergency Management Agency, since 1953 alone, disaster declarations were made in Florida six times for freezing conditions (Federal Emergency Management Agency (FEMA) 2009).

The mean annual relative humidity averages approximately 75% with the highest (80-90%) in early morning and lowest (50-70%) in the afternoon. Seasonal differences are not great: mean relative humidity tends to be lowest in April (71%) and highest in summer and fall (80%).

Evapotranspiration refers to the sum of evaporation and plant transpiration into the atmosphere. Evapotranspiration from wetland plants and saturated soils of is an important control of sea breeze intensity and the formation of convective thunderstorms. Because evapotranspiration is a cooling phenomenon, land-to-water gradients are reduced, convective processes are reduced, and recently rained-upon areas receive less rainfall. The effect is a natural feedback mechanism that results in a more even spatial distribution of seasonal rainfall (Bamberg 1980). This can also ameliorate the tendency towards formation of tornadoes over hot convective dry lands. Evapotranspiration estimates for southwest Florida range from 30 to 48 inches per year (Drew and Schomer 1984).

South Florida is subject to more hurricanes than any other area of equal size in the United States (Drew and Schomer 1984). The area is subject to both Atlantic and Caribbean hurricanes. Of the 38 hurricanes that passed over southwest Florida from 1901 to 1971, 30 occurred between August and October (Jordan 1973). Tropical storms strike about once every three years in southern Collier County and about once every five years in the northern extents of the southwest Florida area (Bamberg 1980).

The three primary climatic effects of hurricanes are high wind, storm surge, and heavy rain. Wind force increases by the square of the wind speed such that a 93 mph wind exerts four times as much force as a 47 mph wind. Thus, when hurricane winds attain 249 mph, as reported for the 1935 Labor Day hurricane, the effects on forested ecosystems, including tree fall, substrate disturbance, and propagule (pinecone) distribution, can be considerable (Drew and Schomer 1984).

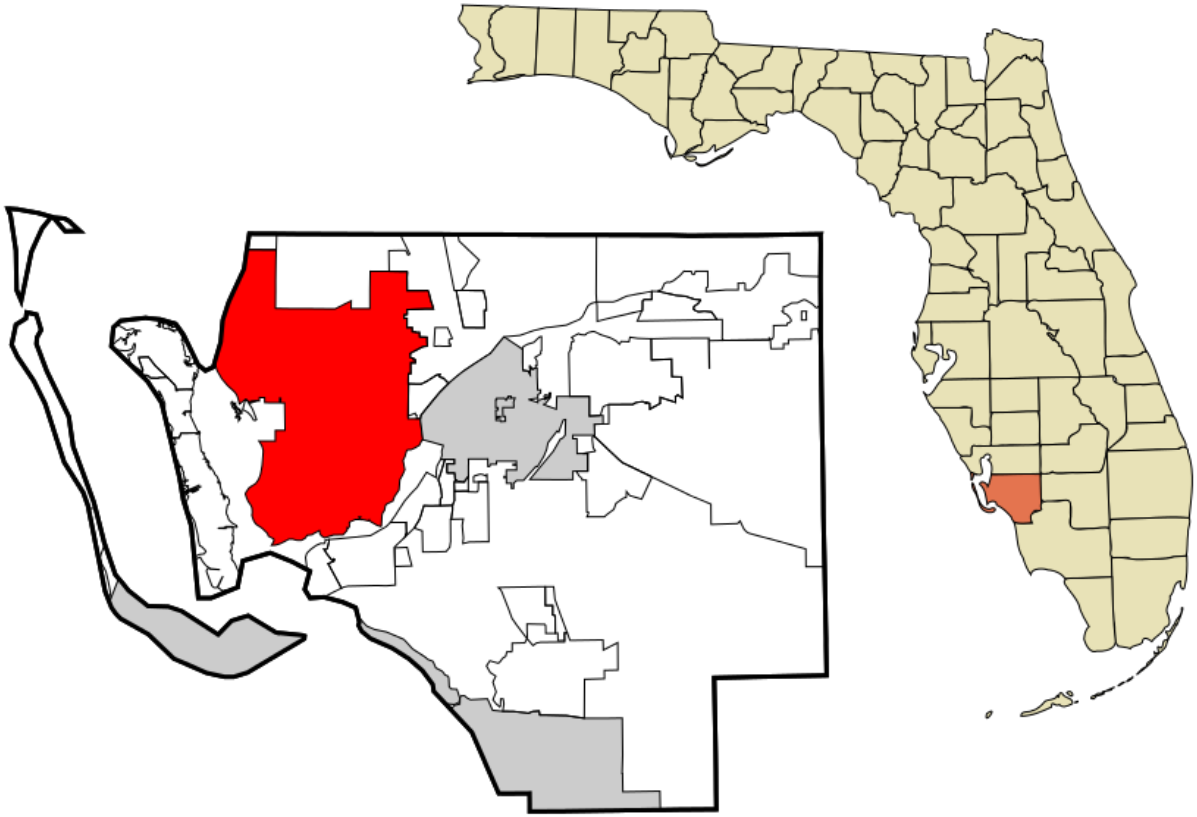

Figure 1: Total study area of unincorporated City of Cape Coral Climate Change Vulnerability Assessment

Figure 2: Lidar topographical map of the City of Cape Coral

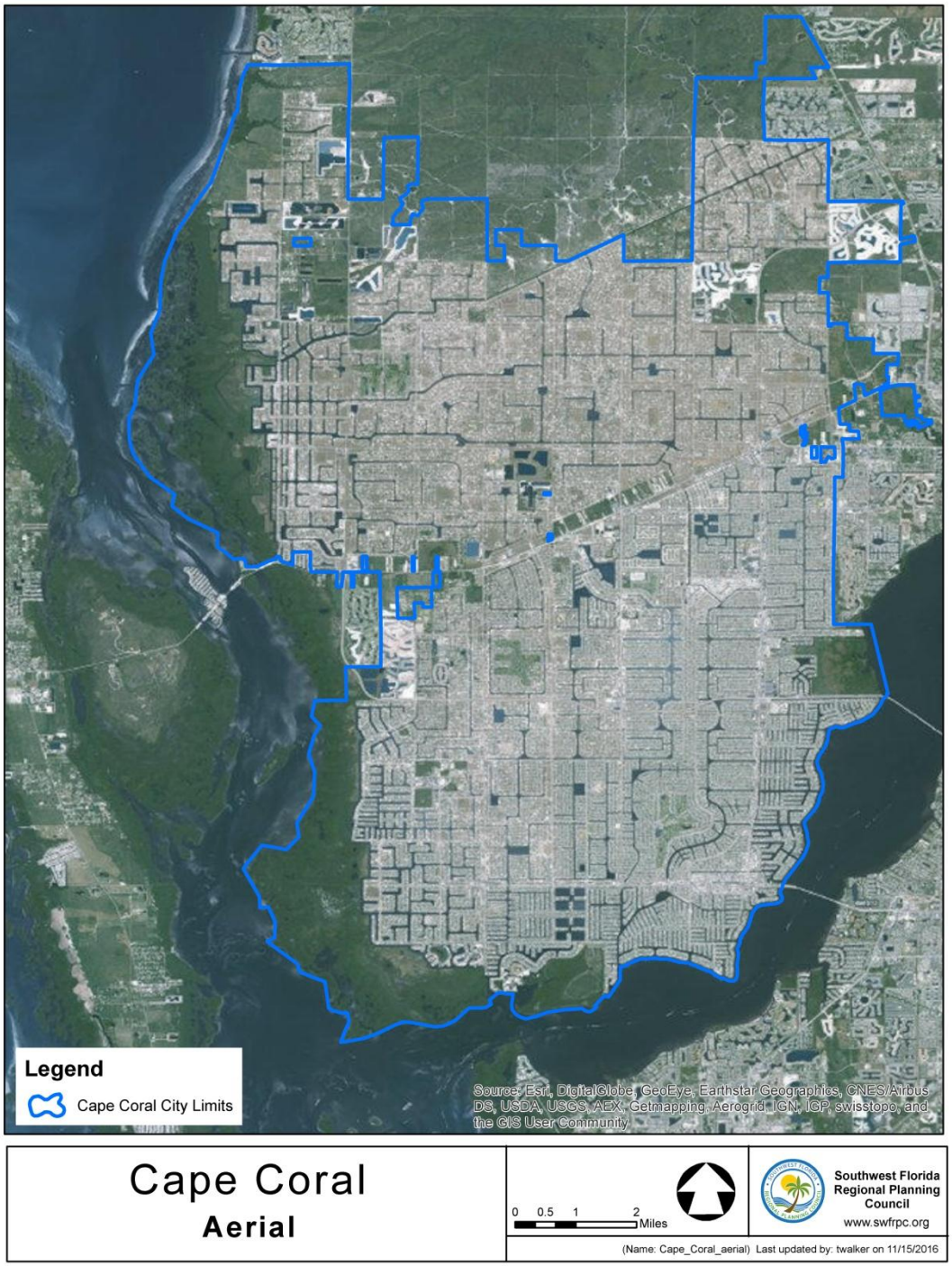

Figure 3: Aerial photograph of the City of Cape Coral

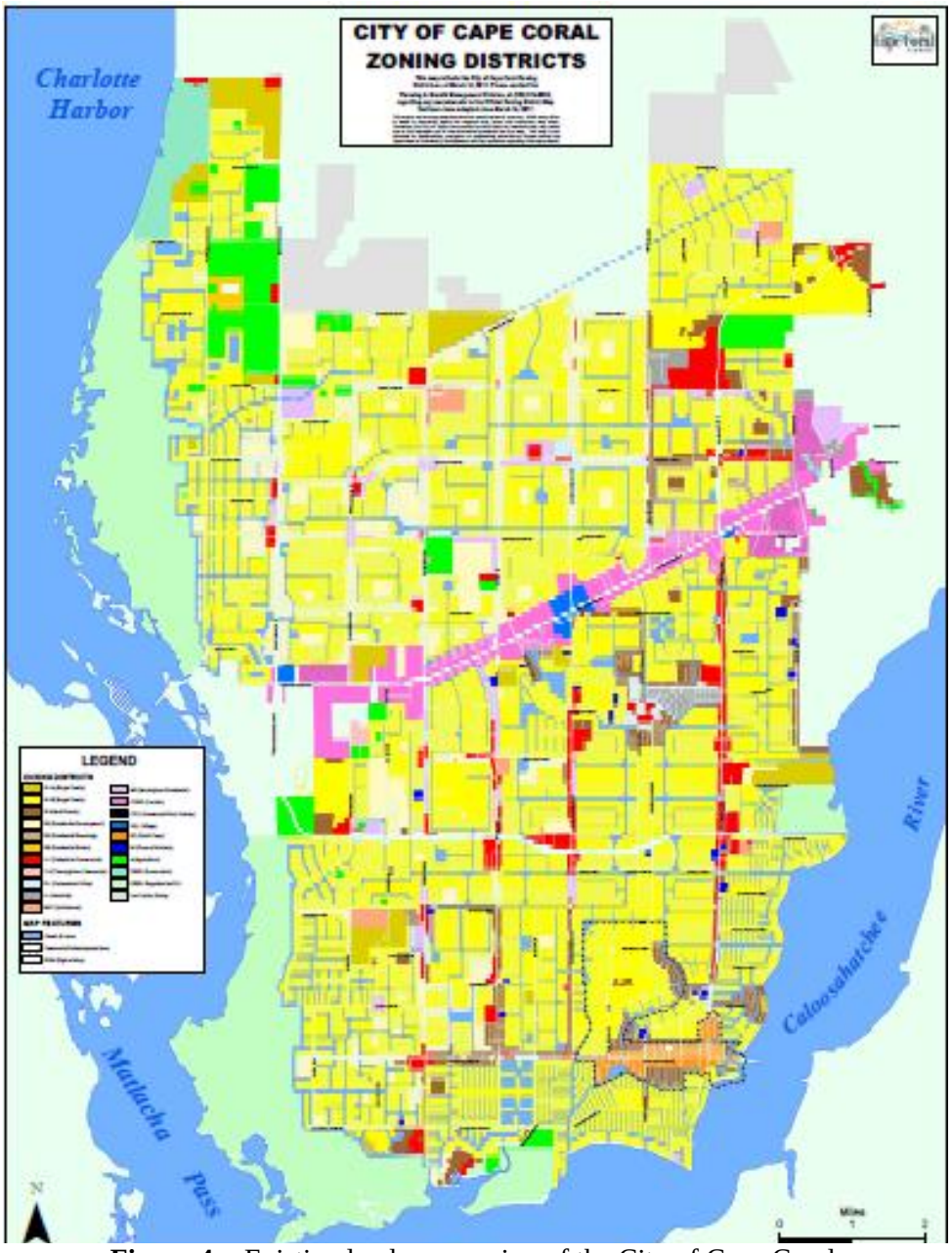

Figure 4a: Existing land uses zoning of the City of Cape Coral

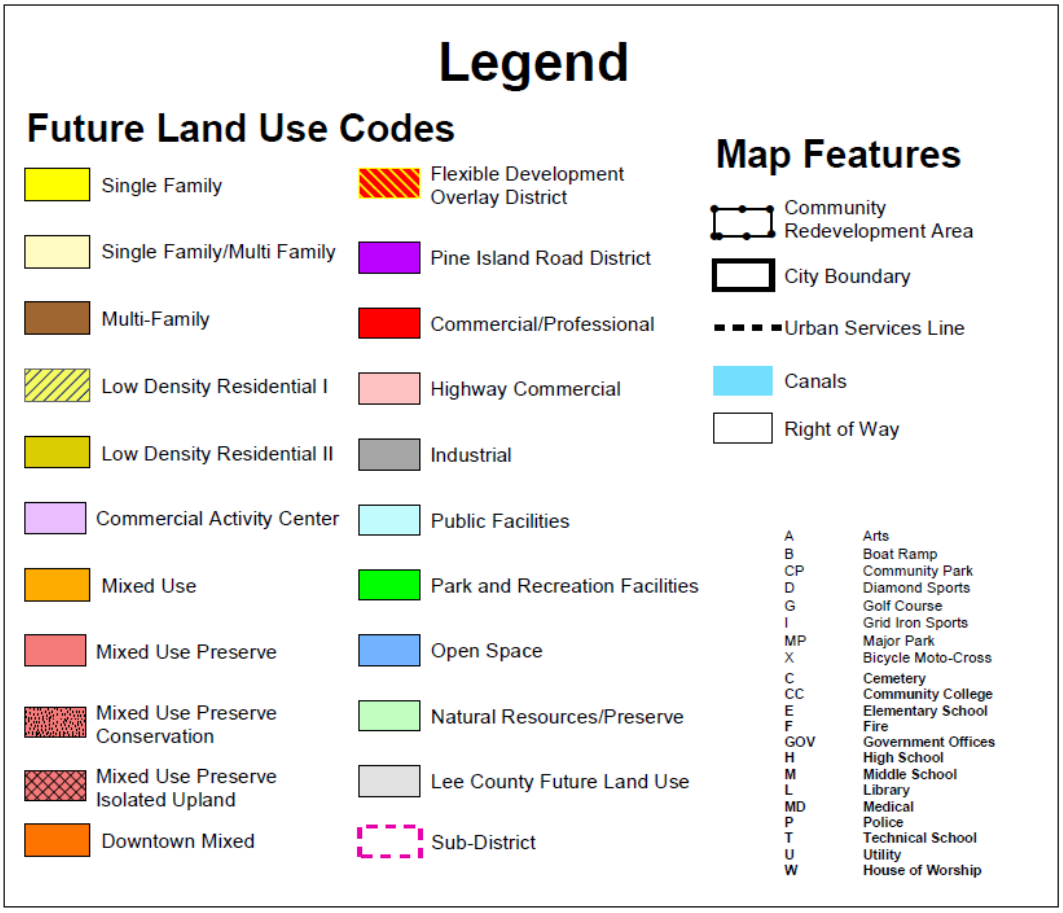

Figure 4b: Legend for the existing land uses zoning of the City of Cape Coral

Land Use	FLUCCS Level 1	Area in acres	Percentage
Developed	100	47,256.44	64.54
Agriculture	200	178.72	0.24
Rangeland	300	3,801.98	5.19
Upland Forests	400	3,237.75	4.42
Waters	500	7,907.44	10.80
Wetlands	600	9,769.39	13.34
Barren Land	700	351.15	0.48
Transportation, Communications, and Utilities	800	713.58	0.97

Table 1. Generalized existing land uses in the City of Cape Coral

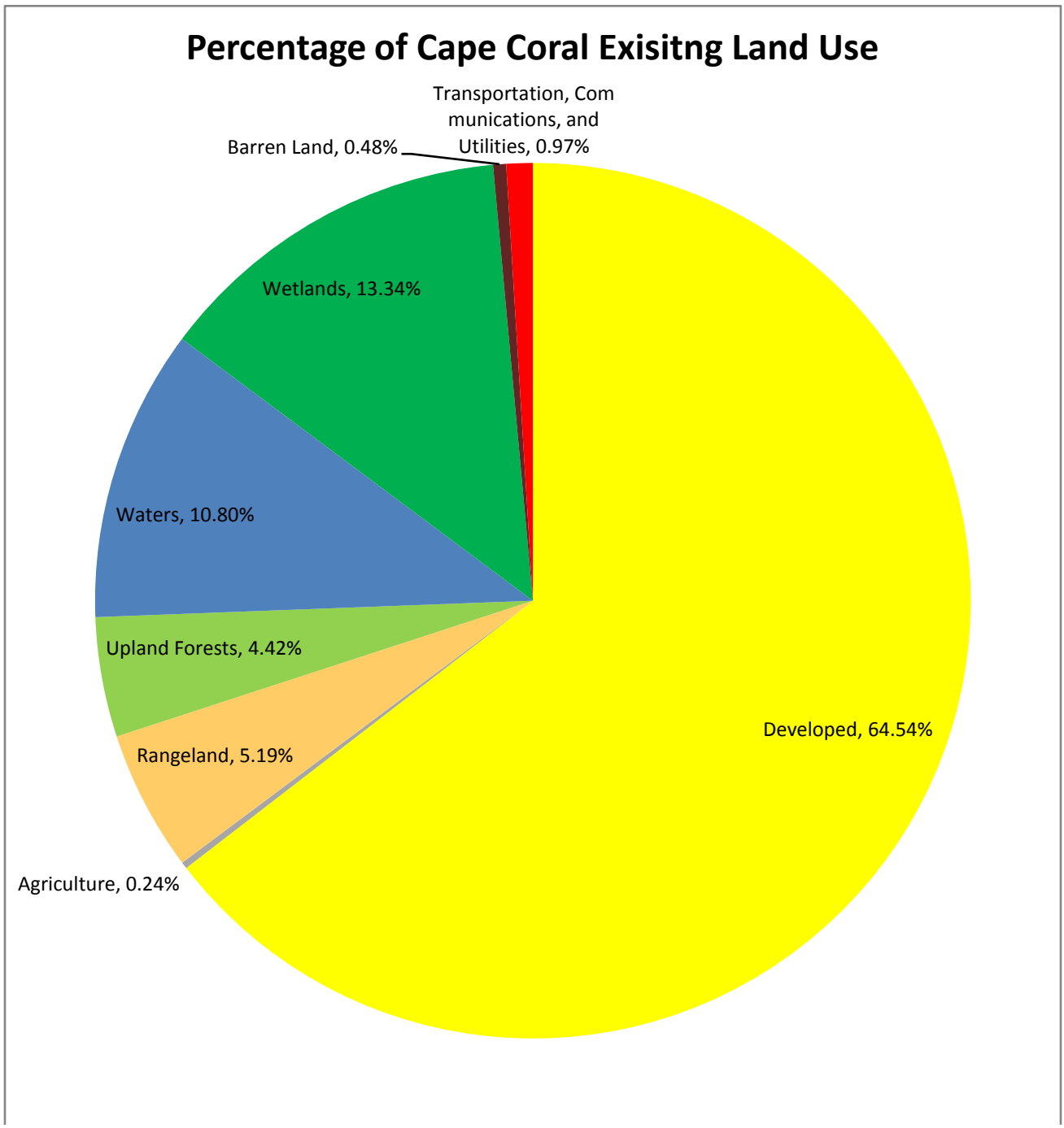

Figure 5: City of Cape Coral existing land uses
Percent of total land uses

City of Cape Coral Climate Change Vulnerability Assessment

On October 1, 2016 the City of Cape Coral contracted with the SWFRPC to develop a climate change vulnerability assessment (CCVA) for the incorporated portions of the city. This was completed on December 31, 2016 and the draft provided to the City for review.

City of Cape Coral is currently experiencing climate change. The natural setting of City of Cape Coral coupled with extensive reinvestment in the areas closest to the coast have placed the region at the forefront of geographic areas that are among the first to suffer the negative effects of a changing climate. More severe tropical storms and hurricanes with increased wind speeds and storm surges have already severely damaged both coastal and interior communities of southwest Florida. Significant losses of mature mangrove forest, water quality degradation, and barrier island geomorphic changes have already occurred. Longer, more severe dry season droughts coupled with shorter duration wet seasons consisting of higher volume precipitation have generated a pattern of drought and flood impacting both natural and man-made ecosystems. Even in the most probable (90%), lowest impact future climate change scenario predictions, the future for southwest Florida will include increased climate instability; wetter wet seasons; drier dry seasons; more extreme hot and cold events; increased coastal erosion; continuous sea level rise; shifts in fauna and flora with reductions in temperate species and expansions of tropical invasive exotics; increasing occurrence of tropical diseases in plants, wildlife and humans; destabilization of aquatic food webs including increased harmful algae blooms; increasing strains upon and costs in infrastructure; and increased uncertainty concerning variable risk assessment with uncertain actuarial futures.

Maintaining the status quo in the management of City of Cape Coral in the face of such likely changes would result in substantial losses of ecosystem services and economic values as climate change progresses. In the absence of effective avoidance, mitigation, minimization and adaptation, climate-related failures will result in greater difficulty in addressing the priority problems identified in the City of Cape Coral Comprehensive Plan (CCCP): hydrologic alteration, water quality degradation, fish and wildlife habitat loss, and stewardship gaps.

This study examines the current climate and ongoing climate change in southwest Florida along with five future scenarios of climate change into the year 2100. These scenarios include:

1) a condition that involves a future in which mitigative actions are undertaken to reduce the human influence on climate change (Stanton and Ackerman 2007),

2) a 90% probable future predicted by the Intergovernmental Panel on Climate Change (IPCC 2007b),

3) a 50% probable future predicted by IPCC,

4) a 5% probable future predicted by the IPCC, and

5) a "very worst" future in which no actions are taken to address climate change (Stanton and Ackerman 2007). This fifth scenario also corresponds with some of the other worst case scenarios postulated by scientists who think the IPCC estimations are under-estimated (USEPA CRE 2008).

This report also assesses significant potential climate-related changes in air and water and the effects of those changes on climate stability, sea level, hydrology, geomorphology, natural habitats and species, land use changes, economy, human health, human infrastructure, and variable risk projections, in southwest Florida. Among the consequences of climate change that threaten estuarine ecosystem services, the most serious involve interactions between climate-dependent processes and human responses to those climate changes.

Depending upon the method of prioritization utilized, some climate change effects will be experienced and can be compensated for in the relative near-term. Other effects with longer timelines will be more costly in habitat impact or human economic terms. There are a number of planning actions that, if undertaken now, could significantly reduce negative climate change effects and their costs in the future while providing positive environmental and financial benefits in the near term.

There are crucial areas where adaptation planning and implementation will be needed in order to avoid, minimize and mitigate the anticipated effects to the natural and man-altered areas of southwest Florida. Some effects, such as air temperature and water temperature increases, will be experienced throughout the region. Others, such as sea level rise and habitat shifts, will occur in specific geographic and clinal locations. In a regional vulnerability assessment 246 climate change management adaptations were identified (Beever et al. 2009) that could be utilized to address the various vulnerabilities identified for the region. Future adaptation plans will identify the management measures best suited for each geographic location.

Based upon a variety of effects analyses the prioritization ranking for the climate change vulnerabilities is in descending order Altered Hydrology; Climate Instability/ Storm Severity; Habitat and Species Changes; Geomorphic (Landform) Changes; Sea Level Rise and Water Temperature and Chemistry Changes ; Infrastructure Impacts and Land Use Changes; Air Temperature and Chemistry Changes and Human Health; Human Economy; and Variable Risk.

Monitoring of the effects and results of climate changes will be necessary to assess when and where adaptive management needs to be and should be applied. A critical goal of this monitoring is to establish and follow indicators that signal approach toward an ecosystem threshold that, once passed, puts the system into an alternative state from which conversion back is difficult to impossible. The likely effects of climate change, particularly tropical storms, drought and sea level rise, on southwest Florida ecosystems and infrastructure development are too great for policymakers, property owners, and the public-at-large to stand by and wait for greater evidence before considering strategies for adaptation. It is essential to plan and act now to avoid, mitigate, minimize, and adapt to the negative effects of climate change, and to examine the possibilities of providing benefits to human and natural systems by adapting to the changing planet.

Risk Analysis

Natural hazards are a threat the people and property of the City of Cape Coral face on a daily basis, and most analyses project that these hazards are likely to increase in intensity and/or frequency with climate change. The level of risk differs by hazard type, time of year, and location of the person or piece of property. Risk analysis is an essential first step in helping the people of Cape Coral prepare to face these risks. This risk analysis includes four main components: hazard identification, profiling hazard events, asset inventory, and estimation of potential loss.

An important step in the risk analysis process is to identify those hazards that are most likely to impact Cape Coral. While there is a long list of natural hazards that have the potential of occurring in Cape Coral, the majority of these hazards have a low probability of occurring. Thus, the hazards that have been identified for analysis in this plan because of their potential to impact the city include (in no particular order): flooding, coastal storms, wildfire, tornadoes, thunderstorms and high wind events, coastal erosion, drought, winter storms and freezes, and exotic pests and diseases.

Profiling hazard events describes the causes and characteristics of each hazard, how the hazard has impacted Cape Coral in the past, and what part of Cape Coral has been vulnerable to each specific hazard. A profile of each hazard that is covered in the Unified Local Mitigation Strategy for Cape Coral, Florida was adopted in February 2007. This plan has a section on each individual hazard. For a full description of the history of hazard events, please see the appropriate hazard chapter and Appendix B of that report.

The asset inventory is a way to assess vulnerability from each hazard by looking at the types and numbers of existing buildings, infrastructure, and critical facilities located in each identified hazard area. In order to assign a monetary value for each structure, the structure's replacement value, content value, and functional use value were determined. Appendix A in this document explains the methodology used to determine these values.

"Replacement value" is the current cost of returning a physical asset to its pre-damaged condition. It reflects present day cost of labor and materials to construct a building of particular size, type, and quality. For this analysis, value of the building, as listed in the property appraiser's records, was used. In instances when the building value was not available, the total value of the property was used.

Summary of Priority Considerations

Planning typically requires some narrowing of the scope to focus efforts on managing risk where most needed. Determining the greatest needs for a particular city will likely entail both quantitative and qualitative analyses of risk and vulnerability, as well as discussion and

agreement among key estuary managers, stakeholders, and collaborators. Quantitative and qualitative climate change risk and vulnerability assessments need to be balanced with the city's management goals and objectives. In many cases, climate change will not necessitate creation of new management goals or initiatives, but rather consideration of how existing programs will be able to address or be impacted by a changing climate. A summary of this information in an adaptation plan should describe the approach taken, decisions on priorities and any uncertainties or other considerations that may affect the selection of specific activities.

Key considerations in assessing management priorities and risk include:

1. Timing of projected impacts (e.g., short-term, mid-term, long-term) relative to the timing of management decisions and actions;
2. Severity of projected impacts (e.g., catastrophic, severe, major, minor, insignificant), and geographic scale (i.e., localized vs. city-wide);
3. Probability of the occurrence of different impacts;
4. Economic or social significance/value of economic, social or environmental assets (i.e., what is being protected); and
5. Capacity of the community to undertake the action compared to the scale of the impacts, which could include:
    a. Costs associated with implementing adaptation actions (e.g., budget availability, funding opportunities);
    b. Information availability, including ongoing monitoring and research (e.g., LIDAR, GIS, mapping, indicators);
    c. Availability of adaptation options suitable for addressing risks;
    d. Timing and time horizon (e.g., decision frequency, planning horizon, implementation period);
    e. Linkage to other decisions (i.e., will adaptation actions impact other decisions within the city or externally);
    f. Regulatory, operational, political, and legal constraints;
    g. Public awareness, support, and concern about the issue; and
    h. Ability to act under uncertainty (of either the likely impacts or the effectiveness of the actions).

The City of Cape Coral Resiliency Strategy

Communication with Stakeholders and Decision Makers

Resiliency actions will require consent from the decision makers who will have to provide approval, and funding in carrying out the selected actions, as well as the City of Cape Coral staff that live, work, and play in the city. Local governments tend to be very experienced with appropriate communication tools for their locales, and should be able to readily incorporate climate adaptation planning into ongoing information and education programs. However, in many places communication for climate change resiliency may demand either a different approach or new expertise for the city. In particular, some plans will involve trying to develop alternatives to prevent future negative outcomes that are either uncertain or unimagined. Rather than returning to historic conditions of water quality or ecosystem health, staff and officials may have to anticipate conditions that, as yet, have not manifested in the system.

A "multi-modal" communication strategy may be necessary to address some of these unfamiliar concerns and to provide specific information on the actions that will be necessary in the watershed.

Climate change resiliency strategy (CCCCRS) planning must be a cooperative effort involving all stakeholders: citizens; construction, business, real estate, and agricultural interests; retirees; families; emergency services; city and city government and more. The effort should be done in cooperation with the city government, preferably as a part of the comprehensive plan update and other existing planning processes. This enables the resulting CCCCRS to take on the authority necessary to make sure recommended actions are eventually implemented and an ongoing process for adaptive planning is put in place. Comprehensive plan amendments, land development regulations and community initiatives should result, informed by the people on the ground, and approved by decision makers.

Communication efforts should stress the transparency of the process and the accountability of the entity leading the effort, whether it is the city government, a contractor, a state agency, or a citizen group. The planning effort should involve as much of the public as possible, increasing responsiveness of the plan to local citizenry and resulting in public buy-in.

The next step in the development of the CCCCRS was a survey devised to gauge the awareness, attitudes and experience of high level City of Cape Coral staff members, City Council members, and constitutional officers regarding climate change. The survey was sent out via e-mail. Introductory information included a storm surge map. The survey (Figure 6) was sent via email to the principle departments of the city government potential respondents; 6 departments participated, with a total of 18 survey respondents. Some respondents within a department combined the answers to some of the questions.

The City of Cape Coral Climate Change Resiliency Planning
The City of Cape Coral Staff Survey

1. How many years have you lived in Florida?
2. How many years have you lived in The City of Cape Coral?
3. How many years have you worked for The City of Cape Coral?
4. Winter in Florida is typically the dry, cool season.
    - Do you think winters have been wetter, drier, or the same since you began living in Florida?
    - Do you think winters have been cooler, warmer, or the same since you began living in Florida?
5. Summer here is typically the warm, rainy season.
    - Do you think summers have been wetter, drier, or the same since you began living in Florida?
    - Do you think summers have been cooler, warmer, or the same since you began living in Florida?
6. Do you think fishing around The City of Cape Coral is improving, declining, or about the same, or are you not sure?
7. Do you think water quality in The City of Cape Coral lakes and rivers is improving, declining, or about the same, or are you not sure?
8. Do you think water quality in The City of Cape Coral's salt water environments is improving, declining, or about the same, or are you not sure?
9. Do you think the presence of wildlife in The City of Cape Coral increasing, decreasing, or about the same, or are you not sure?
10. Have you noticed any changes in the weather generally in the time you've lived in The City of Cape Coral?
11. Do you think storms are getting more severe? More frequent?
12. Do you expect the weather generally to be better, worse or about the same in the future?
13. What impacts, if any, did Hurricane Charley have on your department/responsibilities?
    - ☐ Damage to or loss of facilities
    - ☐ Damage to or loss of equipment
    - ☐ Damage to or loss of non-tangible assets, such as data, etc.
    - ☐ Loss of personnel from any storm-related cause
    - ☐ Spending/budget impact
    - ☐ Change of goals/objectives/focus
14. In what ways did Hurricane Charley affect your department's goals and operations for the 2003-2004 fiscal year?

15. In what ways did Hurricane Charley affect your department's goals and operations for the 2004-2005 fiscal year?
16. Did Hurricane Charley change the way your department "did business"? In what ways?
17. Does your department have assets in a flood zone?
18. Does your department have assets in any storm surge zones? Which zones?
19. What percentage of your department's activities would you say are weather-dependent?
20. Has weather ever impacted your department's activities in the past?
21. Given that climate change has the potential to result in a 5" rise in sea level by the year 2025, how do you think your department/facilities might be impacted? How do you think other departments/facilities might be impacted?
22. Given that climate change has the potential to result in a 2.4°F increase in average temperatures in The City of Cape Coral by the year 2025, how do you think your department/facilities might be impacted? How do you think other departments/facilities might be impacted?
23. Are there any energy-saving changes that could be made to your department's facilities?
24. Do you encourage any energy-saving activities in your department/facilities, such as turning off lights in unused rooms or programming thermostats for energy efficient settings?
25. Are there any changes that could be made to your department's facilities that would make them more wind- or rain-resistant?
26. How old are your facilities?
27. Do any of your employees carpool? Job share? Telecommute? Use public transit? Have flexible hours?
28. Do you encourage carpooling, job sharing, telecommuting, use of public transit, or flexible hours in your department? In what ways?
29. What do you think is the most important thing The City of Cape Coral could do to prepare for potential climate change over the next 25 years?
30. What do you think would be the worst thing The City of Cape Coral could do to prepare for potential climate change over the next 25 years?

Figure 6: The on-line survey

The first few questions gathered information about the respondents' history in The City of Cape Coral, and their perceptions of weather and climate conditions.

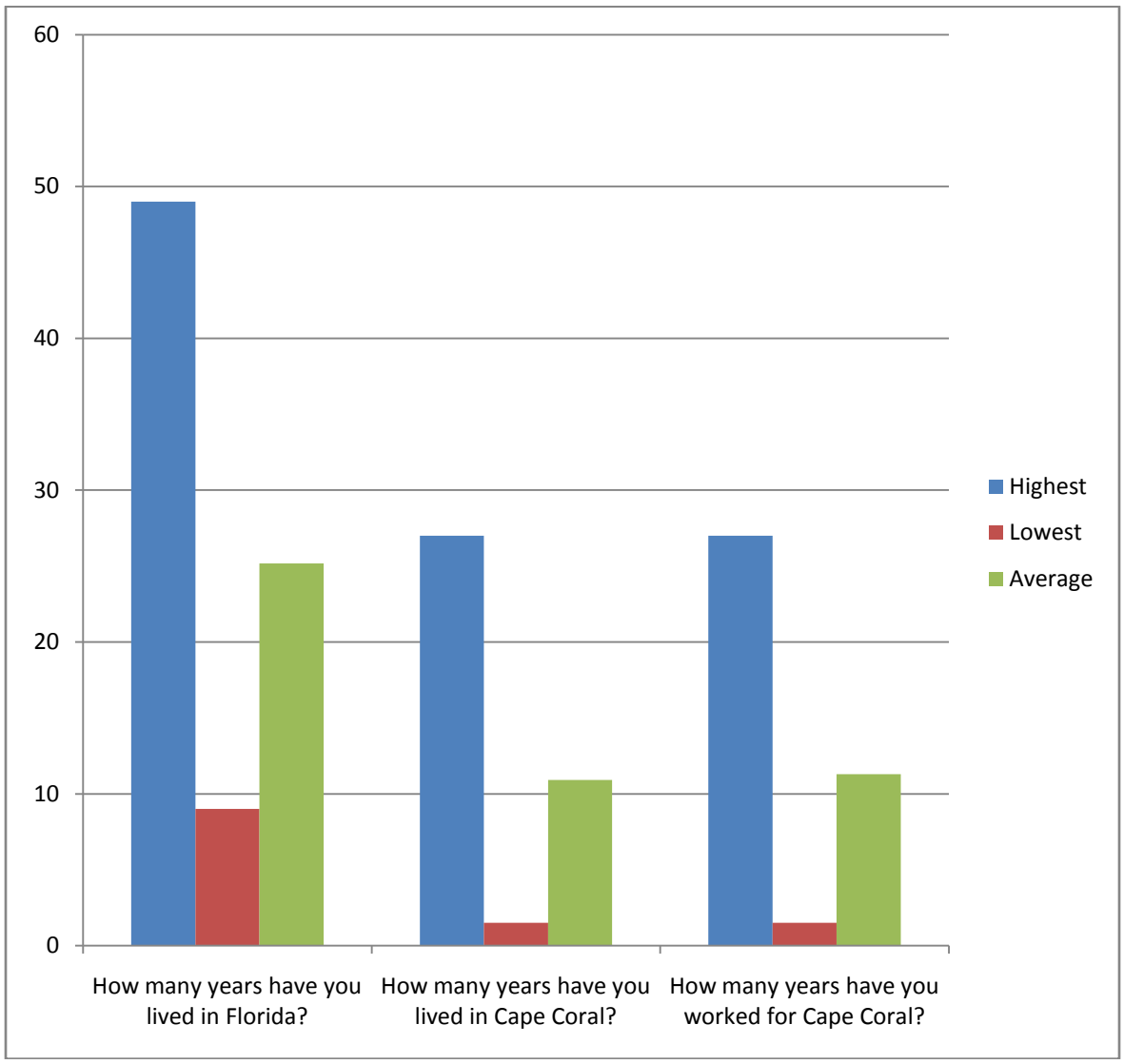

Figure 7: Demographic information

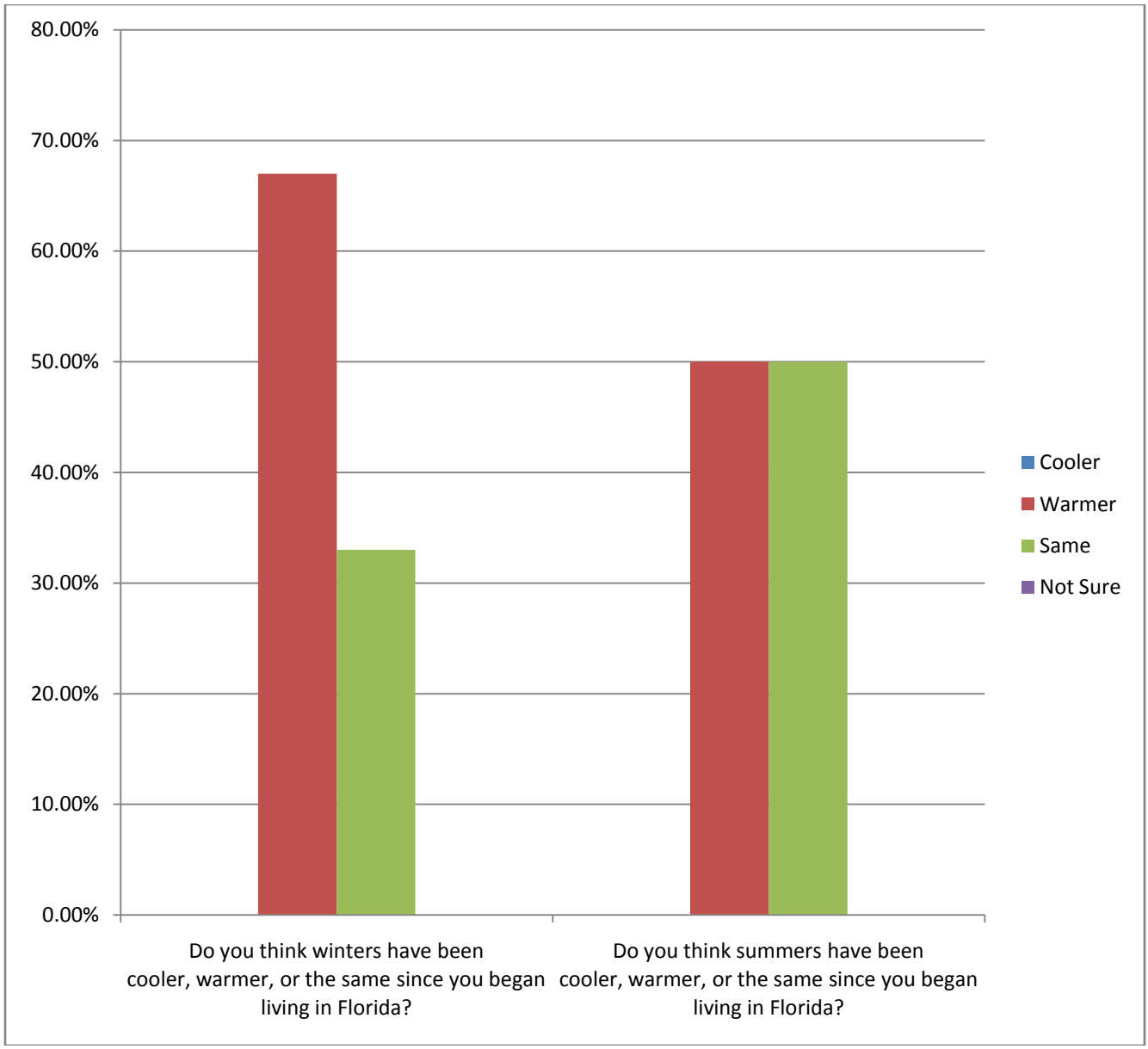

Figure 8: Perceptions of temperature changes

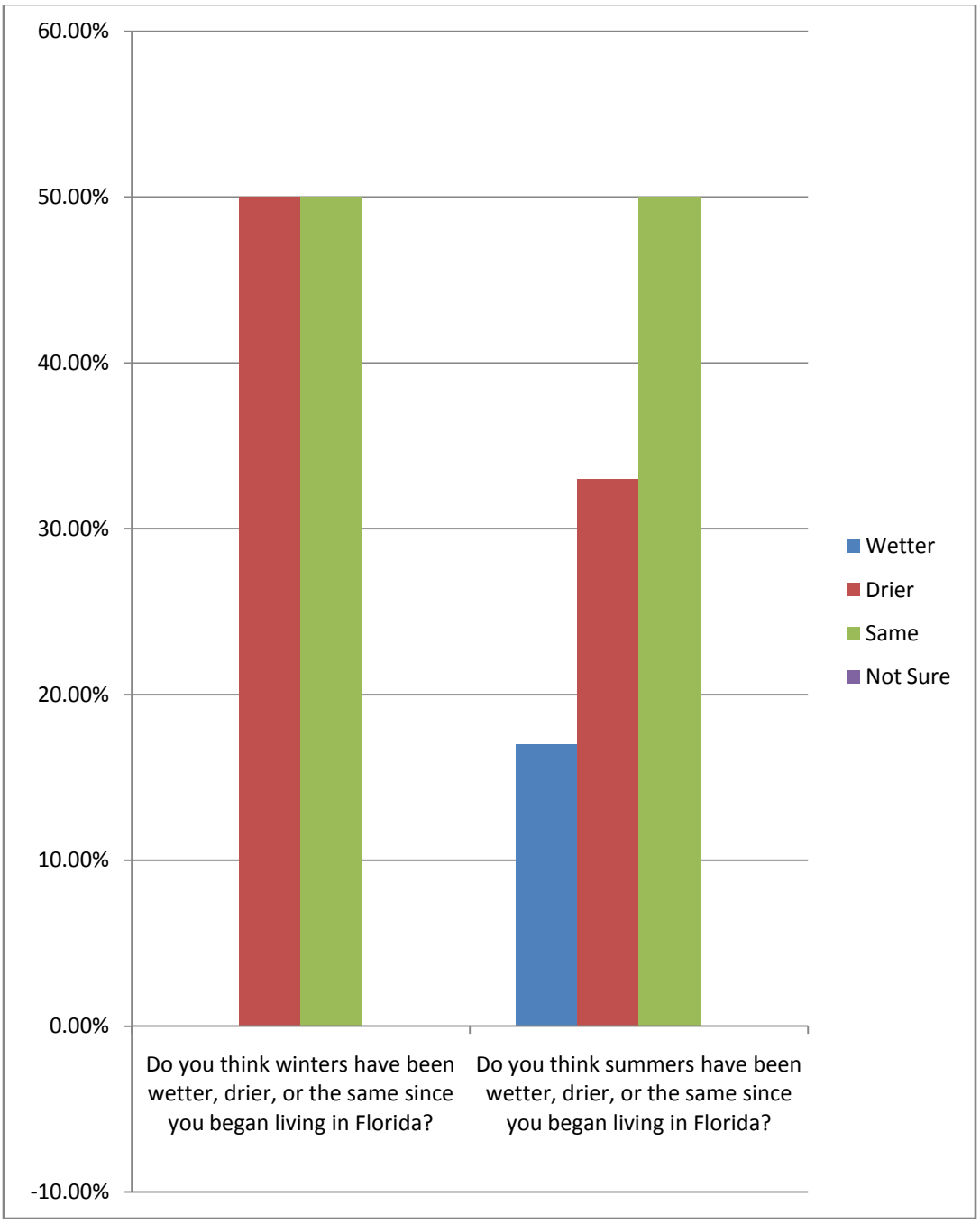

Figure 9: Perceptions of precipitation changes

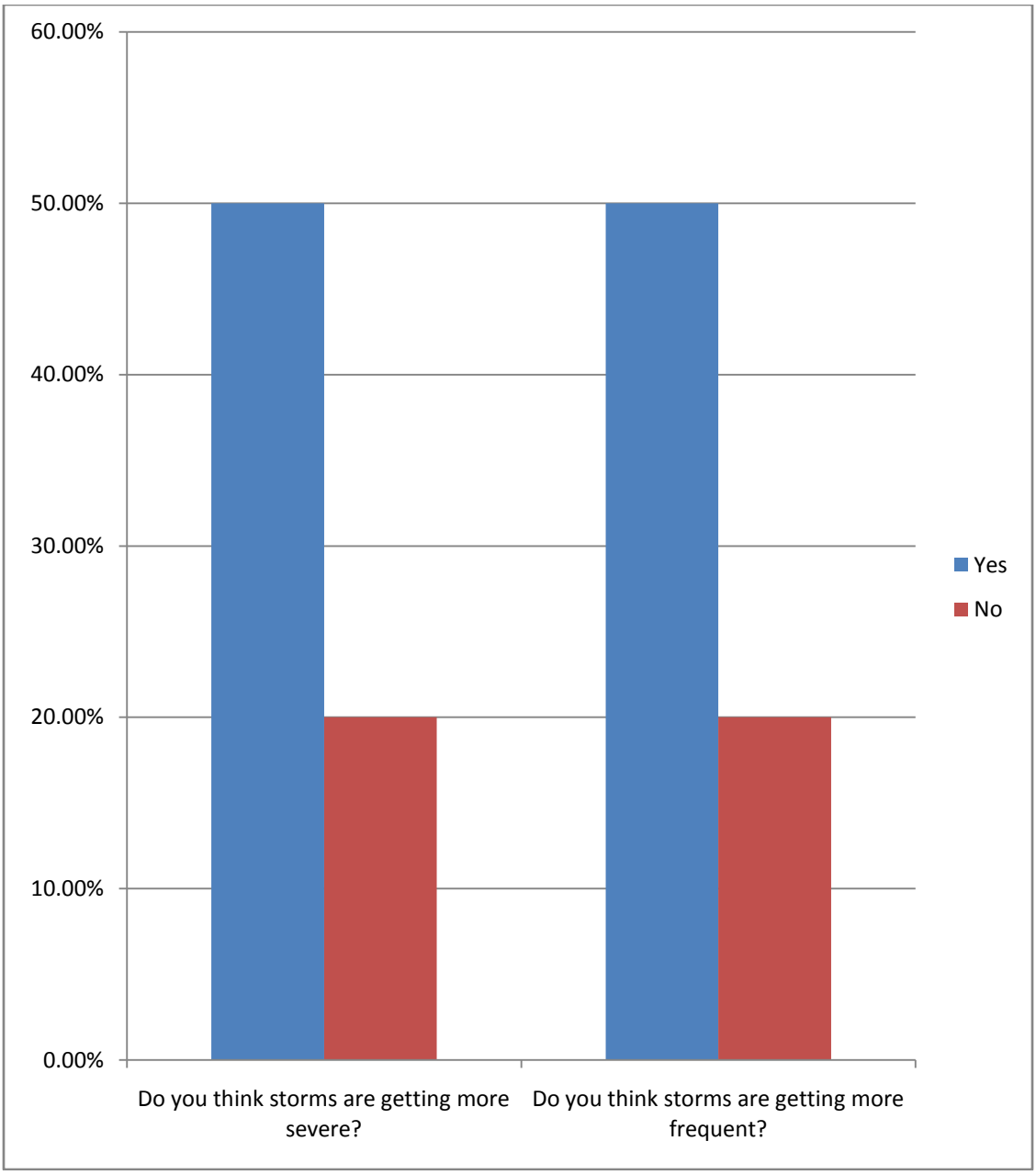

Figure 10: Perceptions of storm severity and frequency

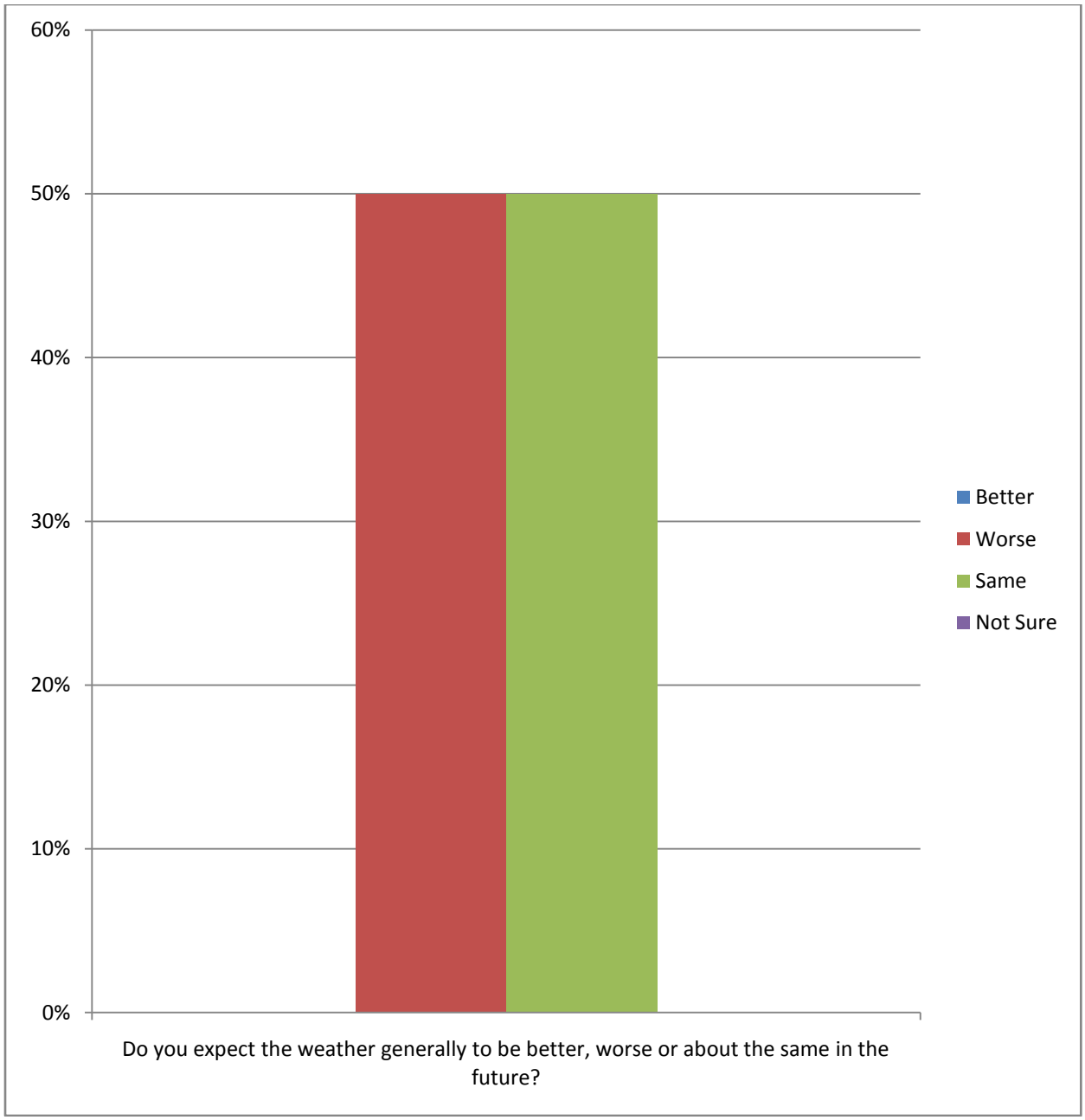

Figure 11: Perceptions of weather/climate

Participants were also asked about their perceptions of natural resources in the area.

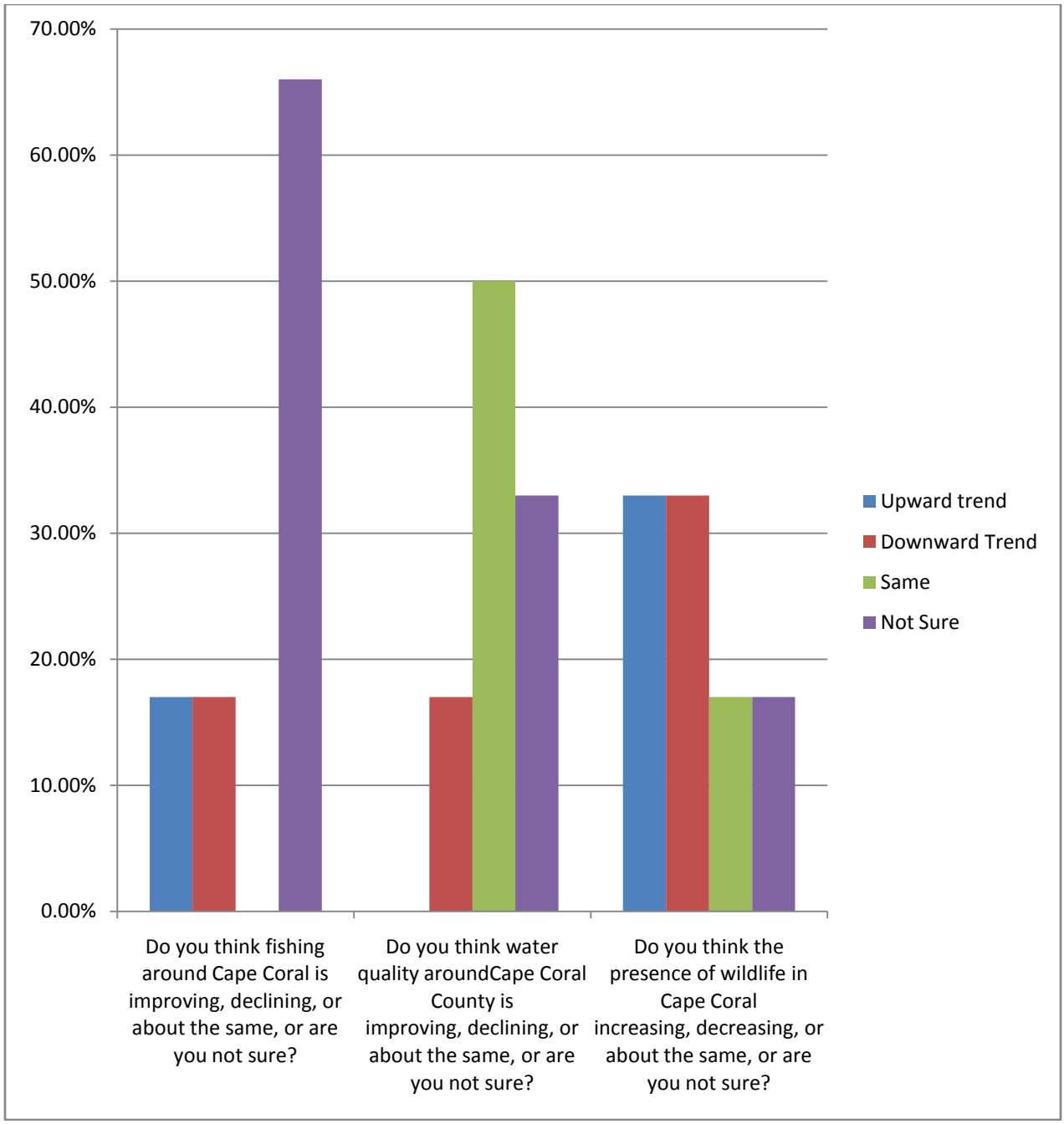

Figure 12: Perceptions of natural resources

Survey questions then turned to the effects of Hurricane Charley in 2004 on city departments – facilities, personnel, processes, and activities – and on any changes that may have resulted. Many effects of climate change have results analogous, in the long term, to the short term consequences of major tropical storms, such as flooding, damage from storm winds, electrical power surges and problems with personnel transportation.

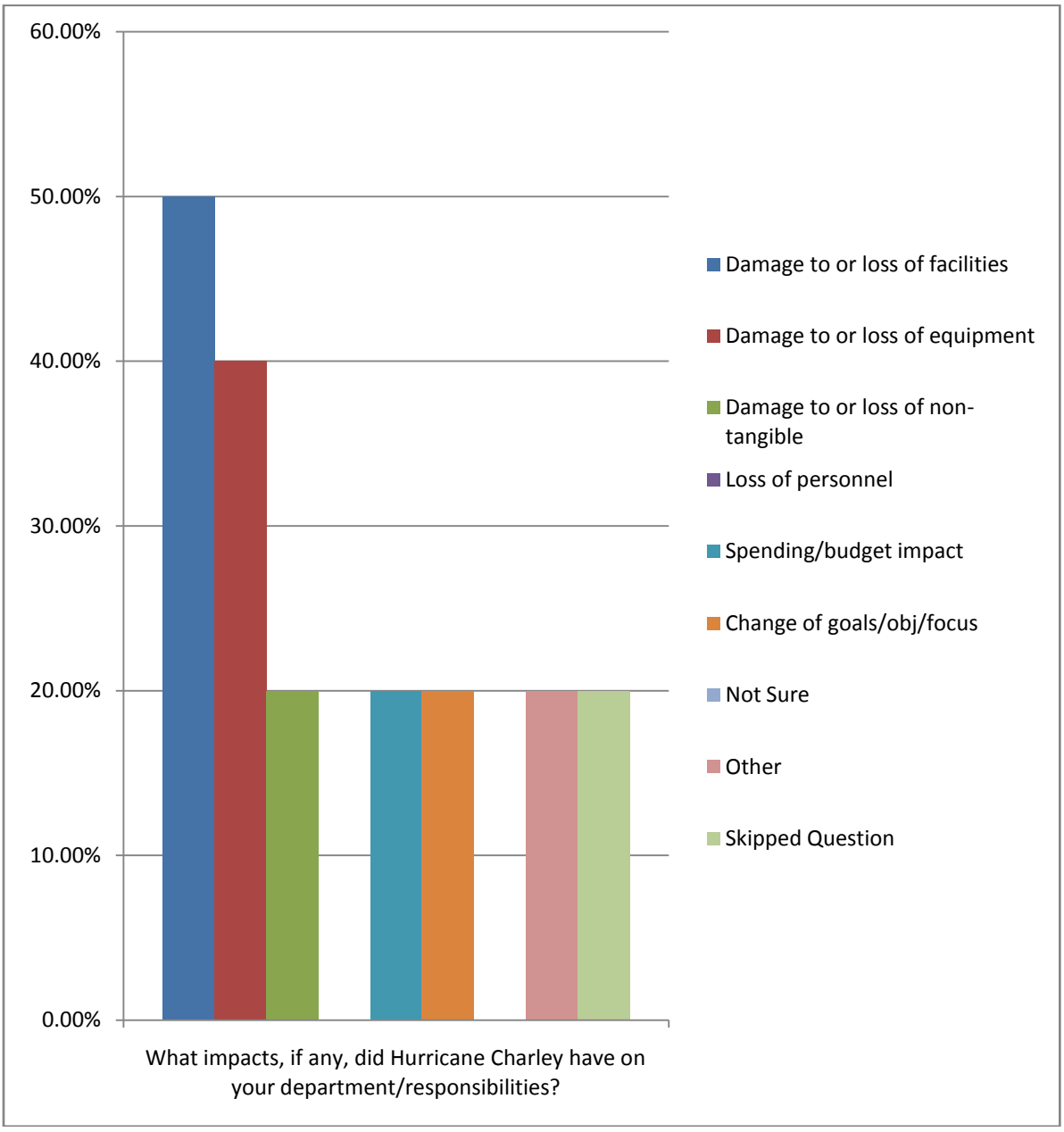

Figure 13: Impacts of Hurricane Charley on City departments

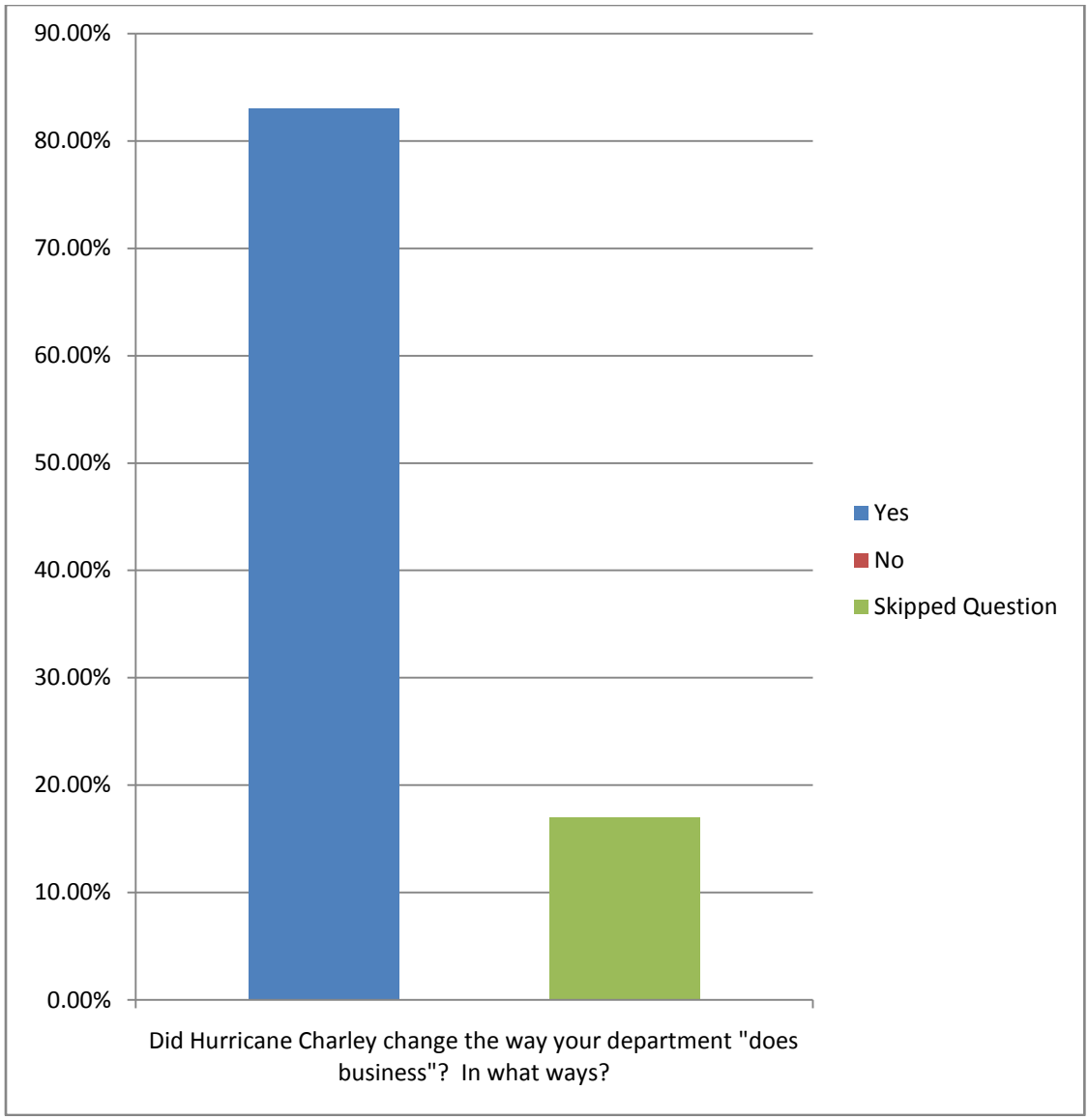

Figure 14: Changes resulting from Hurricane Charley

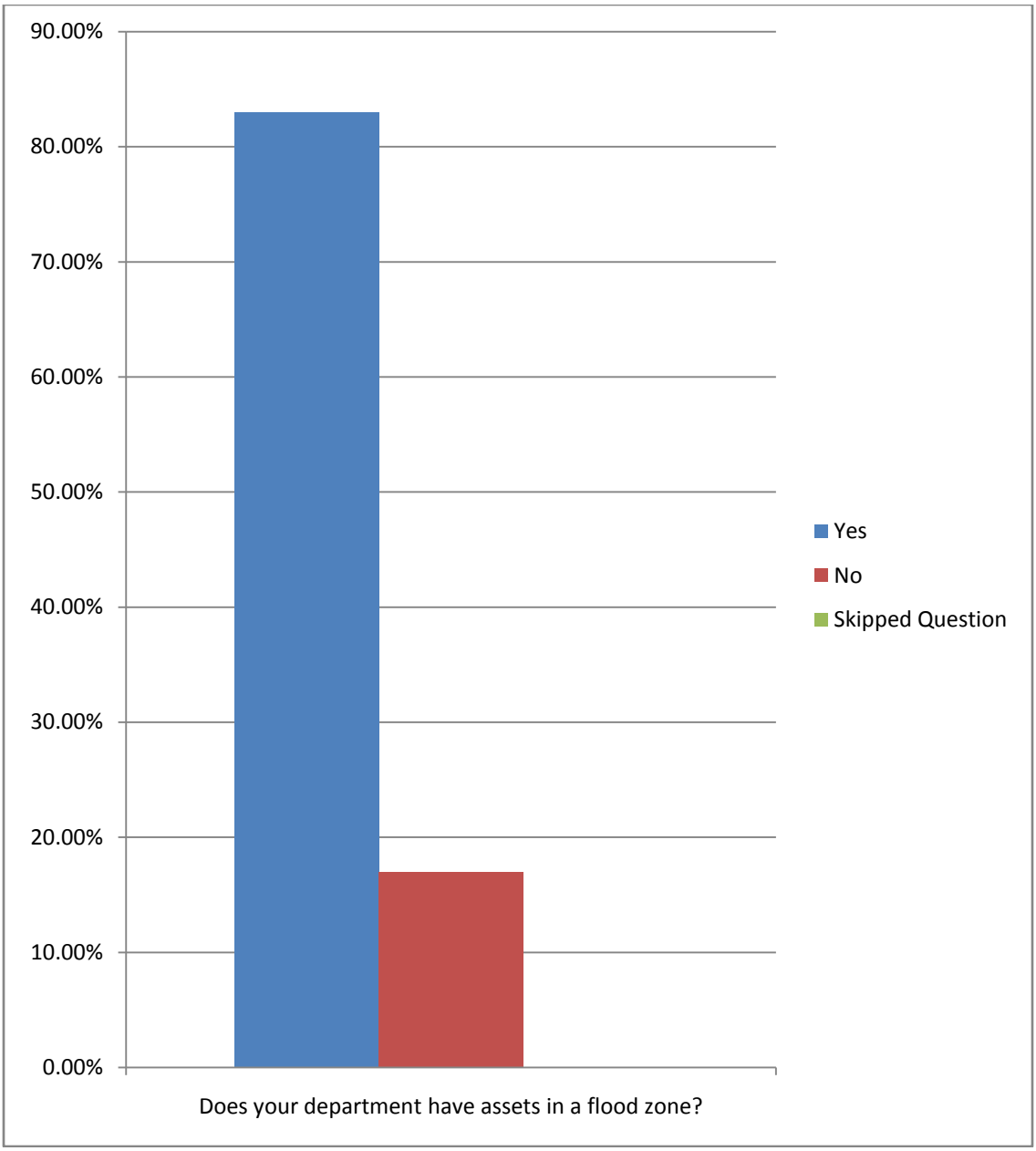

Figure 15: City assets in flood zones

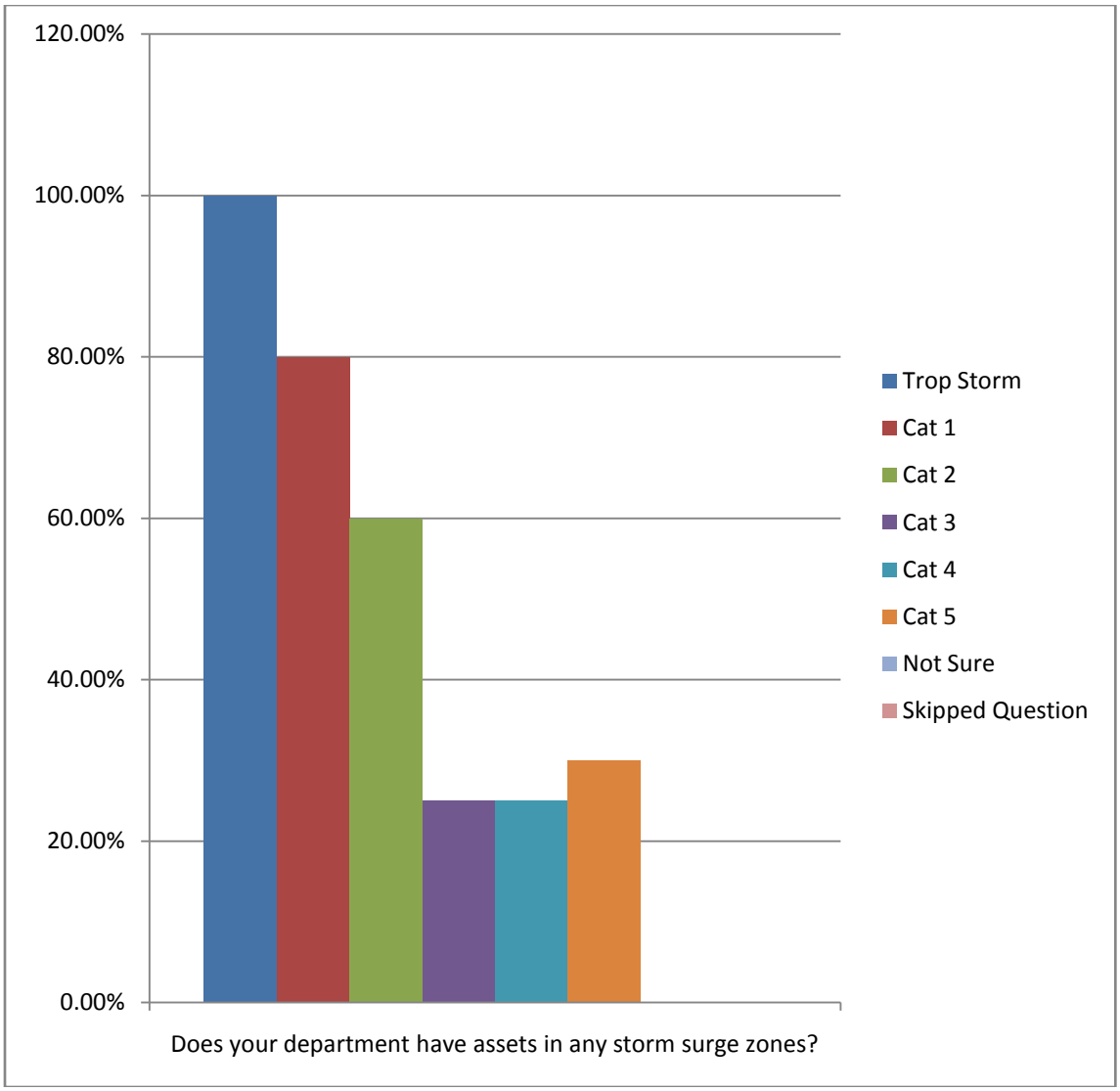

Figure 16: City assets in storm surge zones

(% is the % of departments with assets in that zone)

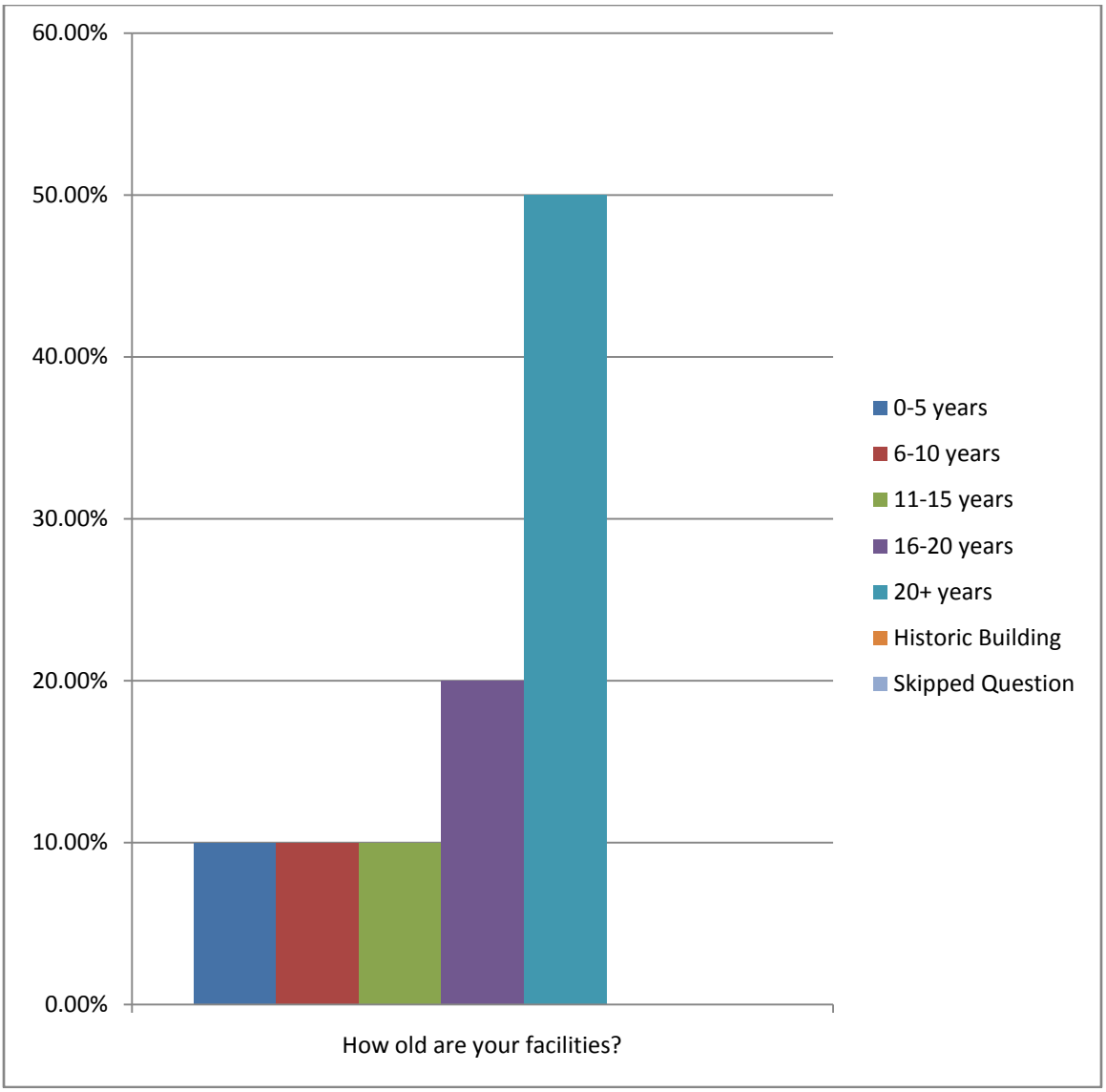

Figure 17: Age of facilities

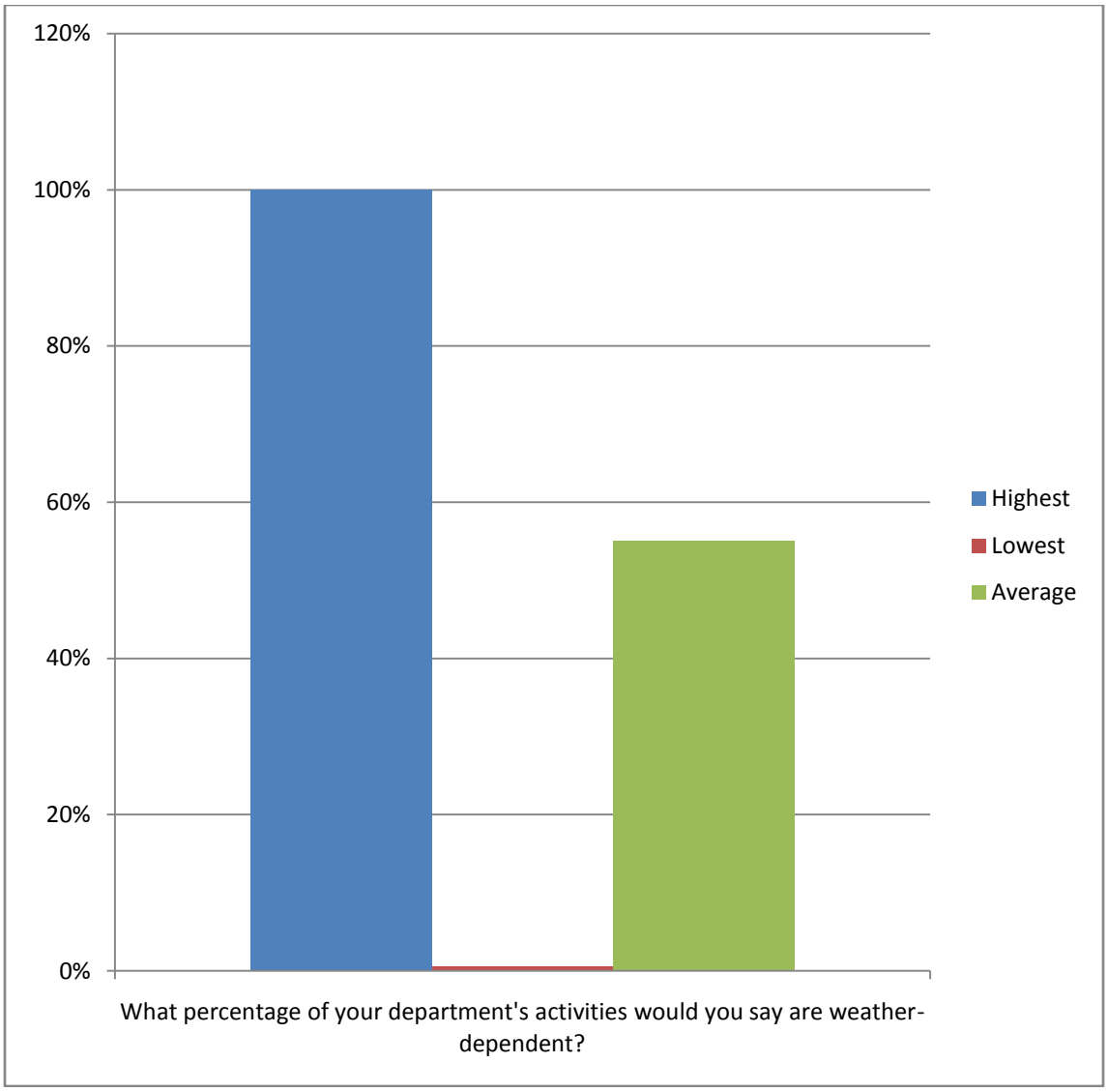

Figure 18: Weather dependence of city activities

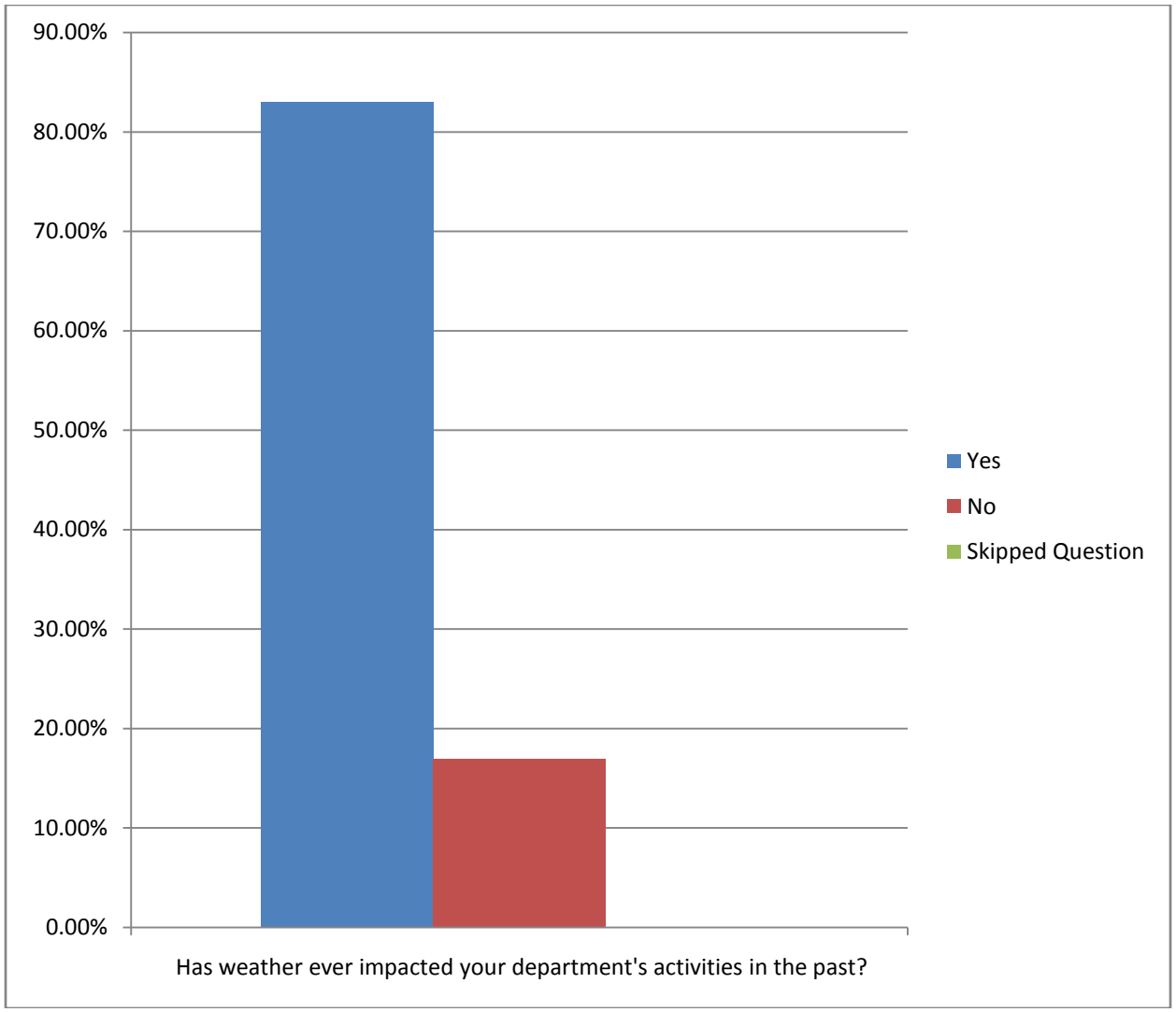

Figure 19: Impacts of weather on city activities

Finally, participants were asked if measures that could be taken to minimize and/or mitigate for certain climate change effects were utilized in their departments. These measures mainly serve to reduce greenhouse gas emissions and reduce energy usage.

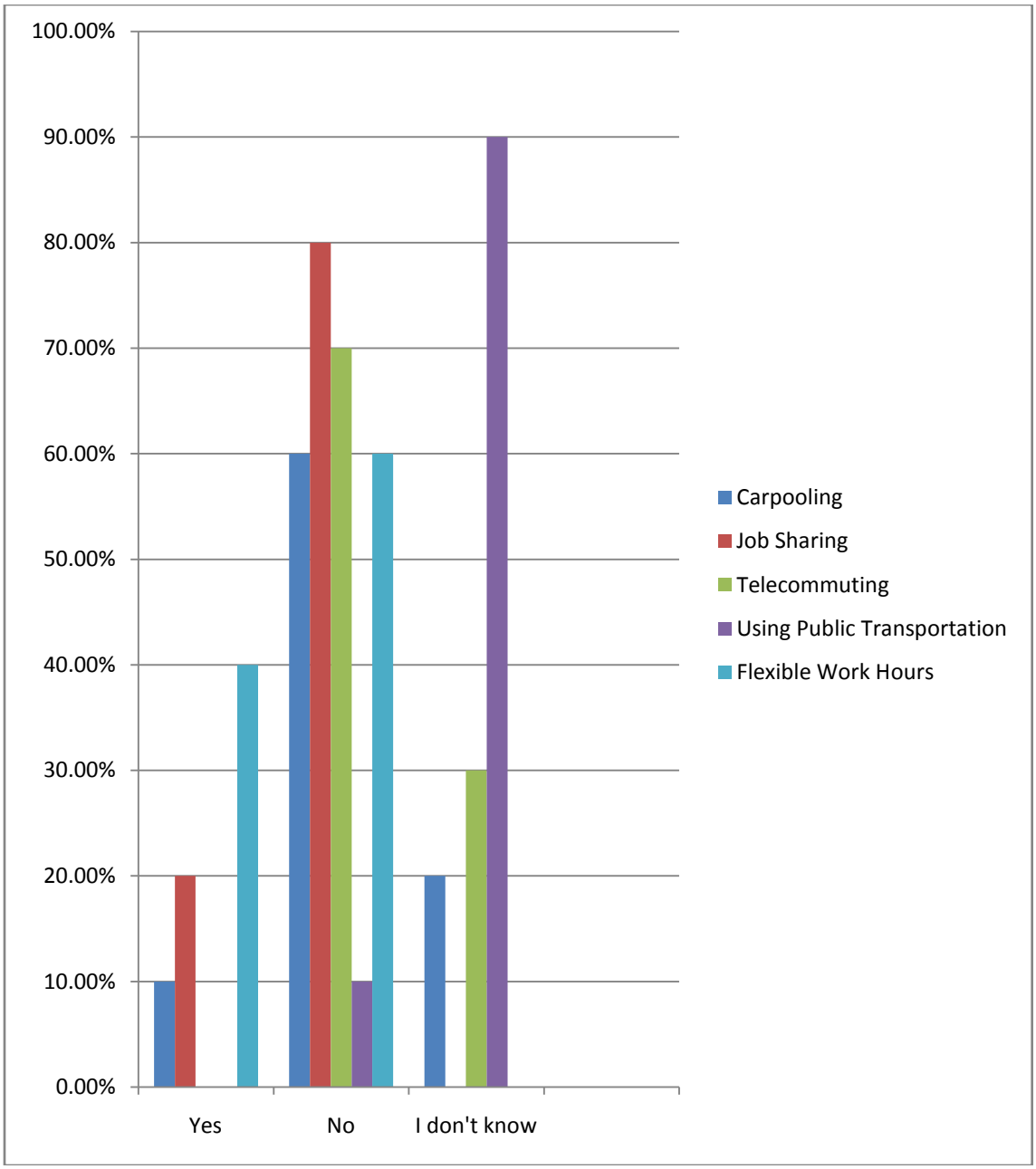

Figure 20: Participation in minimization and/or mitigation activities

All the respondents considered inaction and not planning and implementing actions to address climate change effects to be the worst thing The City of Cape Coral could do to prepare for potential climate change over the next 25 years.

Subsequently, SWFRPC staff met with The City of Cape Coral staff in six departments to conduct interviews regarding climate change resilience in The City of Cape Coral. Departments

contacted included Community Development, Emergency Management, Parks & Recreation, Public Works, and Utilities. The following is the three questions asked in the interviews:

1) What do you think the major vulnerabilities are for the City of Cape Coral currently and in the near future?

2) What do you see as the climate change vulnerabilities for the City of Cape Coral?

3) What adaptations do you think the City of Cape Coral should undertake to address the climate change vulnerabilities you have identified? What adaptations do you think the City of Cape Coral should undertake to address the climate change vulnerabilities you have identified?

Figure 21: Talking points for senior staff interviews

The City of Cape Coral interviewee-identified vulnerabilities by category

Buildings and City Infrastructure
Impacts from tropical storms and hurricanes
Sea level rise in general
Storm surge and sea level rise overtopping salinity barrier weirs.
Impacts to roads from increased high precipitation rain events.
Increased cost of building materials not just air conditioning.
A harsher climate will create the need for more frequent replacement of materials
Increased cost of infrastructure repair and maintenance
Increased cost of maintaining facilities including roadways from hotter temperatures and impacts to asphalt
More frequent flooding events with associated structural damage
More frequent storm events with associated structural wind and storm surge damage
Higher costs of new construction and elevation of roads
Current average elevations for facilities are 8 feet ground floor elevation.
Coastal Protections
Impacts from tropical storms and hurricanes
Impacts to the Yacht Club beach and the demand for beach renourishment
More frequent storm events with associated erosion
Coastal Economies
Declining property values impacting the City's ability to maintain infrastructure and provide adequate services
If it is warmer and the land becomes inundated, people may choose other locations to vacation/live – impact on tourism/tax base.

Increased cost of doing business
Increased impact on human resources – hotter temperatures will increase the cost of workers' compensation and may require compensation to be reevaluated for those employees working in harsher strenuous environments.
The City of Cape Coral's sporting events may be impacted by more frequent storm events and hotter temperatures. Sporting event organizers may choose to locate events according to the reputation or perception of an area.
More extreme temperatures will increase the cost burden to low income residents.
More storms translates into more impact and a drain on financial resources
Normal, everyday work may take more hours to perform
Perception of vulnerability can have real economic consequences. Hotter temperatures can influence this perception.
Loss of swale rain storage, infiltration, and water quality treatment as streets are changed into an urban configuration
Emergency and Hazard Planning
Impacts from tropical storms and hurricanes
Lack of shelter space for tropical storms and hurricane events
Residents may experience communication problems during and following storm events
Health and Human Services
Increased health cost resulting f0r those living without air conditioning or unable to pay utility bills
Increased impact on the economically disadvantaged
More people may seek out financial assistance from the government to weatherize their homes
Possible modification of work hours due to hotter temperatures.
Utility assistance requests may rise if the weather becomes more extreme.
Over heating of public at recreational facilities
Increased lightning storms and strikes on people
EMS may have a harder time serving in low lying areas and may not be able to access flooded areas
Residents may experience increased response times for emergency services
Land Use Planning and Growth Management
Possible reduction of immigration to the City and a possible increase in out emigration out of the City.
Urban, Suburban and Rural Landscape
Increased impact on Stormwater Management Systems
More frequent storms will increase the burden on the City departments
Water and Wastewater
More regular and longer droughts
Could experience strains on freshwater aquifers

Surface water management issues
Salt water intrusion from both lateral and subsurface sources.
Having enough freshwater in freshwater canals for irrigation and water source for fire-protection
Level of flow-through in freshwater canals and canals become stagnant
Sea level rise at the separation weirs. It will overtop the control elevation
Loss of swales as streets are changed into an urban configuration
Waste Management
Impacts from tropical storms and hurricanes
Large amounts of construction debris post hurricanes
Economic Development
Higher utility bills
More frequent adverse working conditions for outdoor workers
Natural Systems and Resources
Very limited space for mangrove swamps and salt marshes to migrate landward as sea level rises
Loss of endangered species habitats for burrowing owls and gopher tortoise
Changes to the day to day hydroperiod, base flows water budget, wetland impacts, water bodies and the volume, timing and distribution of flows.
Concerns regarding excess Lake Okeechobee flows
Could experience impacts to landscaping and plants
Could impact canal life, river life, sea life and the estuary
Destruction of ecological systems which could severely impact our tourism industry
Education and Outreach
Could impact nearly every area of how the City functions impacting the budget and demanding more interdepartmental and intergovernmental coordination
Potential for increased variability of weather – more rainfall during rainy season and longer periods of drought

Table 2. The City of Cape Coral interviewee-identified vulnerabilities by category

Note: If no suggestion was made for a category, that category is not included on this table.

Description of Specific Implementation Actions

Buildings and City Infrastructure
Elevation increases for future critical facilities including fire stations, city public building infrastructure to 15 feet ground floor elevation.
No new construction of critical facilities in the Hurricane High Hazard Zone. When existing

critical facilities reach the end of useful life
All rebuilds should have at least 1 foot increase in base floor elevation. Three feet would be better.
Automatically shutting down the power to buildings after hours.
Building to LEED certification standards.
Consideration of solar path and incorporating structural shading of doors and windows.
Continually explore increased energy-efficient materials and systems with a reasonable return on investment.
Daylighting for new facilities.
May have to build or modify structures where they can function in areas with higher surface waters.
Need to limit the placement of city facilities and infrastructure in flood prone and storm surge areas. This can be problematic since the facilities and infrastructure should be community-based.
New facilities should not only be energy efficiency but water efficient.
Program for hardening structures.
Building and development codes should be reviewed in light of vulnerabilities/to address strategies.
Coastal Protections
Beach loss and potential renourishment at Yacht Club
Land acquisition for storm buffers
Emergency and Hazard Planning
Careful consideration of location/ relocation of critical facilities.
Observation of Coastal High Hazard Zone and not allowing inappropriate building seaward of the coastal construction control line.
The City may consider placing some requirements on residential housing developments to reserve land for post-disaster housing.
Health and Human Services
Locating healthcare facilities out of vulnerability zones.
Land Use Planning and Growth Management
Adopt standards that take climate change scenarios into consideration
Comprehensive Plan – update to reflect changing climate and sea level conditions.
Develop policy analysis regarding land use regulations in relationship to future sea level rise and storm surges.
Actively reduce automobile dependency in the City.
Consider transit oriented development.
Promote increased density and a reduction in the amount of impervious surface.
Reduce density in Coastal High Hazard Area.
The City of Cape Coral should work very closely with adjacent governments

planning/community development to address climate change
Development of a Solar Strategy for inclusion in the comprehensive plan.
Water and Wastewater
Update drought management plans to reflect more regular droughts
Investigate methods to reduce/prevent salt water intrusion from both lateral and subsurface sources.
Develop additional sources to have enough freshwater in freshwater canals for irrigation and water source for fire-protection
Increase flow-through in freshwater canals by connections and headwater restorations
Plan for improvements to increase the height of the separation weirs.
Design/re-design drainage systems to create vegetated swales in all City road configurations
Careful consideration in the placement of facilities to avoid hazard areas.
Increase the use of rain barrels and other rain collection systems.
Use native plants and reduced irrigation for City facilities.
Waste Management
Recycling cleaning fluids and waste stream from the fleet maintenance department.
Recycling and hazardous waste collection days and encouraging green incentives.
Reduce travel, increase use of webinars, teleconferencing, etc.
Natural Systems and Resources
Use Conservation 20/20 funds to acquire buffer and corridor conservation lands within the City.
Installation of filter marshes to treat water quality.
Keeping fertilizers, yard clippings and pet waste out of surface water bodies.
Restoration of flow ways and increasing surface water storage.
Utilize environmental BMPs, the Florida Yards program and land stewardship strategies.
Renewable, Green Energy
Emphasis on biomass, reducing greenhouse gas emissions, providing economic stimulus dollars for renewables
Encourage LEED® standards for new construction..
Encouraging the Green Lodging Certification
Green purchasing policies for office supplies and other materials.
Purchasing hybrid vehicles, electric vehicles, and other more efficient fleet vehicles.
Education and Outreach
Encourage behavior change in employee trips (carpooling, transit, bicycling, walking, teleworking, four day work weeks, reduction of VMTs, etc)
Key staff/human resources are critical to developing strategies to address these issues.
Offsite (from tropical storms and hurricanes) data storage and protection.
Public Information is an important tool to help avoid and/or reduce impacts associated with climate change.
Outreach to the community to make them aware of the importance of climate change issues.

Table 3. The City of Cape Coral interviewee identified resiliency strategies by category

Note: If no suggested was made for a category, that category is not included on this table.

Specific Adaptations by Group

The following is a discussion of adaptation strategies that can be used to help implement the goals of the resilient plan.

Buildings and City Infrastructure (Facilities and Operations)

The goal of energy-efficient (green) buildings is to reduce their impact on the environment. By reducing energy impacts, the green building design can reduce the local climate effects of urban heat islands, desertification from inefficient water use, increase groundwater recharge, reduce the level of stormwater pollution and coastal nutrification and minimize greenhouse gas production for the purposes of building operation, maintenance and utility provisions.

Green building practices apply to construction, renovation, operation, maintenance, and demolition. Green building techniques include thermally-efficient roofs, walls, and windows; building shape and orientation; thermal mass and daylighting strategies that reduce cooling loads; smaller heating, ventilation, and air conditioning systems and efficient electrical lighting strategies that capitalize on daylighting; water efficient supply and waste fixtures; and interior designs providing visual access to the outdoors and access to daylight. The concept also features interior finishes and installation methods having lower volatile organic compound emissions; landscaping strategies that require little or no irrigation, groundwater replenishment and on-site stormwater management; and siting to minimize stress on natural systems either by building on previously contaminated sites or avoiding ecologically sensitive areas. Benefits of green building include improved air and water quality, reduced solid wastes, conserved natural resources, decreased operating costs and enhanced profits, and reduced strain on local infrastructure.

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience for Buildings and City Infrastructure (Facilities and Operations)

Local government strategies to create more energy efficient buildings (both existing and new) and operations can begin with a number of steps.

Note: This and all following tables related to climate change resiliency strategies are not ranked by any form of prioritization. Strategies discovered in the course of staff interviews to already be in use by The City of Cape Coral to some extent are indicated with this symbol. They are included to recognize these accomplishments and to encourage expansion of those policies and practices. Not all strategies being used by The City of Cape Coral may be accounted for. Key words are shown in bold italics. Some strategies are applicable in more than one area of interest. These strategies are repeated where applicable.

Energy Efficiency
Add energy efficiency as a dominant criterion in ***purchasing*** policies, including requiring the purchase of ENERGY STAR appliances. Calculate the cost/benefit of equipment price to include the energy cost of operation. EPA provides guiding principles and standards for Environmentally Preferable Purchasing (www.epa.gov/opptintr/epp). It also maintains a database of environmental products and services, along with guidelines, contract language, standards, and specifications for over 600 products and services (yosemite1.epa.gov). The Green Seal Standard and Certification (www.greenseal.org) has been issuing product standards and certifications since 1991.
Automatically shut down the ***power*** to buildings after hours.
Build and retrofit to meet ***LEED***® (Leadership in Energy and Environmental Design) certification standards.
Conduct ***energy audits*** to understand current conditions and the potential cost savings from altering public buildings and implementing energy efficiency retrofits to existing ones. Audits should include both the structural and operational efficiencies (for example, lighting, cooling, water use). An energy tracking and management system should be established to monitor progress over time and make course corrections as needed.
Consideration of solar path and incorporating ***structural shading*** of doors and windows.
Increase the use of ***daylighting*** for new facilities.
Encourage and support appropriate staff to become ***LEED® Accredited Professionals***
Establish procedures to turn off and unplug ***office equipmen***t when not in use, since idle office equipment continues to use energy.
Improve water pumping efficiency including disperse ***solar powered systems.***
Install energy-efficient ***exit sign lighting.***
Install green or reflective ***roofing***.
Install ***room occupancy light sensors,*** particularly for rooms with sporadic occupancy.
Institute ***lights-out-at-night*** and lights-out-when-not-in-use policies.
Limit the placement of city facilities and infrastructure in flood prone and storm surge areas. This can be problematic since the facilities and infrastructure should be proximate to the population.
Reduce electricity transmission and distribution through clustering of facilities within a site.

Require installation of ***energy-efficient vending machines***.
Retain an ***Energy Service Company (ESCO)*** to analyze the potential cost savings from altering an existing building. An ESCO develops, installs, and finances projects designed to improve the energy efficiency and maintenance costs for facilities over a seven-to-20 year time period.
Technology infrastructure reduces the need for driving the fleet of automobiles to property locations for valuations, meter reading, etc.
Use ***energy efficient lighting*** (for example, replace conventional incandescent bulbs with more efficient compact fluorescent bulbs).
Use EPA's ***combined heat and power (CHP) program*** (www.epa.gov/chp) that produces both electricity and steam for heating and cooling from a single power plant located near consumers. CHP systems recover heat that is normally wasted at power plants and funnels the heat into surrounding buildings, thereby reducing energy costs and GHG emissions.
Water Efficiency
If irrigation is essential for "signature" exotic species such as royal palms, royal Poinciana, orange trees, mango trees, utilize ***micro-irrigation and low flow pumps***.
New facilities should not only be energy efficiency but ***water efficient***.
Storm / Sea Level Rise Hardening
May have to build or modify structures to be able to function in areas with ***higher surface water levels***.
PACE program for hardening structures.
Perform heating, cooling, and ventilation system ***retrofits*** (for example, boilers, fans, pumps, coolers, belts).

Table 4. Resiliency strategies to address city buildings and infrastructure

Adopt more stringent residential and commercial ***energy code requirements***
Promote ***green building*** initiatives and retrofits.
Promote the use of ***green roofs*** (www.epa.gov/nps/roofcover.pdf) through incentives or requiring developers to construct LEED® certified or ENERGY STAR homes.
Create a fund to ***finance energy-efficient housing*** projects that lower overall energy costs for

residents.
Do not approve new utility facilities that utilize oil or coal as the fuel source for energy generation.
Encourage utilities to install ***energy efficient co-generation*** power production facilities.
Establish ***incentives*** including reduced fees, licenses, and/or property taxes to promote more energy efficient practices.
Offer ***weatherization assistance*** programs for lower-income residents.
Promote energy conservation and green building through ***education campaigns*** targeted at residents and businesses.
Promote ***LEED® Design for Neighborhood Development*** (LEED® ND).
Promote participation in a local ***green business*** program.
Promote through ***incentives*** the purchase of **ENERGY STAR** appliances.
Work with the Lee County school board to incorporate green building practices into ***school renovations and construction***.
Work with the Lee County school board to locate schools with ***good walking connections*** to user neighborhoods.
Work with the Lee County school board, Lee County MPO and transportation planning staff to implement a "***Safe Routes to School" program.***
Work with utilities to implement district heating and cooling and time-of-use or peak demand ***energy pricing.***

Table 5. Policy and program-related resiliency strategies

Resources for Buildings and City Infrastructure (Facilities and Operations) Resilience

In Florida, the principal resource organizations on energy efficient, green building practices are the six Florida USGBC chapters and the Florida Green Building Coalition (floridagreenbuildings.org), a nonprofit organization dedicated to improving the built environment and that also hosts a state conference called Green Trends (www.greentrend.org). The coalition offers a number of designations for green homes, green development, and green cities and counties (floridagreenbuilding.org/standard/govs). It has also teamed with the Florida Homebuilders Association to promote affordable green buildings (www.fhba.com). An additional resource is the Southeast Rebuild Collaborative (www.southeastrebuild.org), a joint

effort of the state energy offices of Alabama, Florida, Georgia, Mississippi, and South Carolina to promote energy efficiency to individuals, school districts, state and local governments, colleges and universities, vendors, trade organizations, and other allies in the member states.

Three other national organizations that serve as resources on green building are the American Institute of Architects (AIA), the American Society of Landscape Architects (ASLA), and the American Planning Association (APA). The AIA offers a green building on-line toolkit, developed in partnership with the USCM (www.aia.org/static/state_local_resources/adv_sustainability).

The AIA adopted a 2030 Challenge position statement that calls for the immediate energy reduction of all new and renovated buildings to half the national average for that building type. Increased reductions of 10 percent are required every five years so that all buildings designed by the year 2030 will be carbon-neutral (they will use no fossil fuel energy). In June 2006, the U.S. Conference of Mayors unanimously adopted the 2030 Challenge.

The ASLA (www.asla.org) recently released a new performance report on green roofs and offers a live green roof web cam, and the APA sponsors a Green Communities Program (www.planning.org/yourcommunity/greencommunities.htm), which offers grants for green affordable housing. That program is presented in conjunction with the Enterprise Foundation (www.enterprisecommunity.org/programs/green%5Fcommunities).

Other Florida resource organizations include the Florida Solar Energy Center (www.fsec.ucf.edu), created by the state of Florida to conduct research in advanced energy technologies, and Eco-$mart, Inc. (www.ecosmartinc.com), a Florida House Institute for Sustainable Development initiative to bridge the gap between understanding and applying sustainable development principles. Additional national resource organizations include the Building Codes Assistance Project (www.bcap-energy.org), which assists states and local jurisdictions in the advancement of energy-efficient building energy codes; Building Green (www.buildinggreen.com); Capital E, which published *Greening America's Schools: Costs and Benefits*, a summary of green schools developed across the nation (www.cap-e.com/ewebeditpro/items/O59F9819.pdf); the Congress for the New Urbanism (www.cnu.org) that worked with the USGBC to develop the LEED® Design for Neighborhood Development standards; the Green Mechanical Council (www.greenmech.org); and the National Association of Energy Service Companies (www.naesco.org).

Coastal Protections

The following discussion depends significantly on the contributions Titus (1998), Trescott and Walker (2009), and Volk (2008a).

Coastal erosion is responsible for hundreds of millions of dollars of property damage each year; the threat of erosion, that is, merely being located in an erosion-prone area, significantly lowers property values as well. Both beach nourishment (the addition of sand to the eroded shore) and shoreline stabilization (in the form of seawalls, riprap, revetments and other structures) can help waterfront property owners protect the sales value of individual properties. However, when analyzed at the scale of a community, the implications of the two approaches are quite different.

Completed beach nourishment increases property values for both waterfront properties and for non-waterfront properties a few rows inland. Thus the total benefits to the community may be substantially greater than estimated for waterfront properties alone, as is typically the case. In contrast, shoreline stabilization appears to lower property values a few rows inland. Thus, while it is beneficial for each individual waterfront property owner to stabilize his own shoreline, non-waterfront property owners lose value as a result of the actions of their waterfront neighbors. Moreover, as more and more waterfront property owners rely on shoreline stabilization, waterfront property values eventually decline as well. The first few property owners to stabilize their shoreline achieve significant benefits, but as more and more of their neighbors follow suit, property values drop to about where they started (Kriesel and Friedman 2002).

Many options that maintain sediment transport are reactionary, in that they seek to reverse changes that have already occurred or changes that will continue to occur. Because sediment transport is based on a constant cycle of gains and losses, all of these options require maintenance. However, when combined with other actions, these options may work to prevent loss of coastal habitats and enable marshes and mangroves to accrete at a rate consistent with sea level rise (Martinich 2008).

Options to maintain sediment transport include either trapping sediment that would otherwise migrate or reintroducing sediment into systems. Constructing groin structures traps sand and prevents it from traveling down shore. Adding sand to beaches with beach nourishment projects that extend the shoreline or create dunes, and replacing sand in water bodies following storms allows for sediment transport to continue and reverses losses due to erosion (Martinich 2008).

Possible responses to sea level rise include building walls to hold back the sea, allowing the sea to advance while adapting to it, and raising the land and/or structures (e.g., by replenishing beach sand and/or elevating houses and infrastructure). Each of these responses is costly, either in out-of-pocket expenses or in lost land and structures. For example, the cumulative cost of enough sand replenishment to protect Florida's coast from a 20-inch rise in sea level by 2100 is estimated at $1.7 to $8.8 billion (USEPA 1997).

The effects of sea level rise in The City of Cape Coral will be to increase the level of risk and expense borne by property owners, particularly if property owners choose to remain in place utilizing the expensive strategy of armoring the shoreline and filling land to keep up with storm surge and the increasing average tide height. The likelihood that the City will respond in a way that reduces these effects is complicated by factors including City population increases, coastal property values, increased density in coastal development, the value of coastal tourism, demand for individual coastal access, and the level of insurance subsidization.

The three primary options for development responses to sea level rise and storm surge effects are ***protection*** (armoring, filling, diking), ***managed retreat*** which is better described as ***planned relocation***, and structural ***accommodation*** methods (such as elevation of infrastructure). Each method possesses advantages and disadvantages (TCRPC 2005). To date, The City of Cape Coral has only employed protection methods, with variable success to address sea level rise and shoreline issues.

One of the major problems in evaluating the different options to address flooding from storm surges, sea level rise and the combination of the two is that the names utilized to describe the activities have psychologically loaded contexts. The term **"**protection**"** that can represent expensive and complex engineering solutions has a heroic and active connotation of man vs. nature, triumph over adversity. In contrast, the terms "managed retreat" and "accommodation" have passive and negative connotations associated with defeat, particularly for those that seek active, physically tangible solutions to problems.

It was the determination of the study *Summary of Research on Strategies for Adaptation to Sea Level Rise in Florida* by Michael Volk of the University of Florida, that a variety of strategies will be necessary for adaptation, particularly along protected shorelines. These strategies may be categorized based on the existing and projected land use and on the natural coastal ecology. Volk's (2008) strategies are broken down based on high or low energy shorelines, and developed or undeveloped land use. The general recommendation from that study was for managed retreat from the shoreline.

Volk's conclusions are that ecologically and financially sustainable shoreline protection is probably not possible, particularly on high energy shorelines. Protection of any shoreline will only be feasible up to a certain amount of sea level rise, after which the financial costs will be too great to justify protection. As an alternative to shoreline protection, managed retreat policies could be implemented and shorelines could generally be allowed to retreat naturally. There may however be cases where shoreline protection is deemed appropriate, such as in the case of historic downtown Cape Coral.

Shoreline hardening (Protection)

Shoreline stabilizing or hardening techniques (Protection) refers, such as seawalls and beach nourishment, that attempt to maintain a static shoreline position. It also includes diking and filling to keep pace with sea level. Protection may be financially sustainable in the short term because it does not require relocation or discontinuation of property use. If the structural method is a relatively small proportion of the total infrastructure investment both in terms of effort and costs, including maintenance, then it is more easily selected. However, in the long term protection is likely to prove to be financially unsustainable. Recurrent property damage will likely increase due to the effects of sea level rise coupled with more severe storms and storm surges. Protective structure maintenance and construction costs will increase. The concentration of public resources on protection of shoreline infrastructure will require an unbalanced use of public funding sources repetitively on the same parcels. Armoring, filling and diking all damage the recreational and fisheries values of coastlines by causing shoreline ecosystem loss. Protection will likely be ecologically unsustainable because it tends to damage coastal ecosystems, alter shoreline processes such as sediment flows, and prohibit ecosystem translocation (Titus 1991 et al.).

Under some circumstances, where shorelines are well-developed, shoreline armoring and other protection measures may be necessary. The historic downtown district of Fort Myers, where The City of Cape Coral has invested significant infrastructure is an example of an area where some passive protection strategies could be employed. Buildings can be raised either by lifting them

with jacks and adding fill beneath, or by filling in ground-level floors and adding additional stories at the top. Raising a building by just one eight to ten foot story would compensate for the maximum amount of sea level rise predicted to occur by 2200. New structures could be designed to have the additional height in the initial design.

While adverse impacts should first be avoided and then minimized, sometimes some loss of ecological function and/or public access to the shoreline is unavoidable. Mitigation can be required to compensate for these lost uses and functional values. Depending on the type of loss, mitigation can take the form of restoring another impaired shoreline, preserving a shoreline of significant ecological value, or enhancing or creating another public access site. Similar to established wetland mitigation banks, shoreline mitigation banks could also be created to facilitate selection and prioritization of mitigation projects. Property owners could pay into a mitigation bank which is then used to fund regional shoreline restoration and beach renourishment efforts.

In highly developed areas where a hardened structure is already present and is the only feasible alternative, mitigation allows for positive environmental/societal benefits to be gained to offset any adverse environmental or public access impacts that occur at the site.

However, mitigated systems are rarely as good as the unaltered natural systems they are meant to replace. Good scientific data and project monitoring is needed to ensure that the mitigation will be comparable to the functions and uses lost. Mitigation may not be environmentally or socially relevant if the mitigation project is geographically removed from the project area (NOAA 2009).

Strategies for shoreline protection were examined for high and low energy developed shorelines as well as for critical conservation lands by Volk (2008). It was determined that ecologically and financially sustainable protection of high energy developed shorelines is not possible, due to the dynamic nature of shoreline processes.

Seawalls or other hard stabilizing structures along these shorelines will destroy shoreline ecosystems, require continued maintenance, and will cease to be feasible after some level of rise (15 feet for example). Beach nourishment used along shorelines will also have negative ecological effects, and will likely become more financially unsustainable as sea levels rise. Sustainable protection of low energy developed shorelines was determined to have a higher level of feasibility than protection of high energy shorelines due to decreased wave and erosive energy. It may be possible to maintain functional shoreline ecosystems while still maintaining a ‘static’ protected shoreline. For this to happen, ecosystems must still be allowed to retreat upland from rising seas. Ecosystem retreat inland from the existing shoreline is likely not possible if the existing shoreline position is to be maintained.

A second option is to establish ecosystems seaward of the existing shoreline, which can retreat up to the existing shoreline position. With this option, shoreline ecosystems may exist while maintaining an essentially static shoreline. The goals of a strategy such as this would be to maintain the same level of protection as would be gained through construction of a traditional protective structure such as a dike, to reestablish, maintain, and facilitate the adaptation of functional shoreline ecosystems, and to spread shoreline protection costs spread over a long

period of time in keeping with rate of sea level rise. Several important issues created by this strategy, which could preclude its use, are sediment sources, takings of sovereign submerged lands, source of funding, and upland drainage. It should be noted that drainage of uplands will be an issue with any strategy protecting lands lower than the mean high tide.

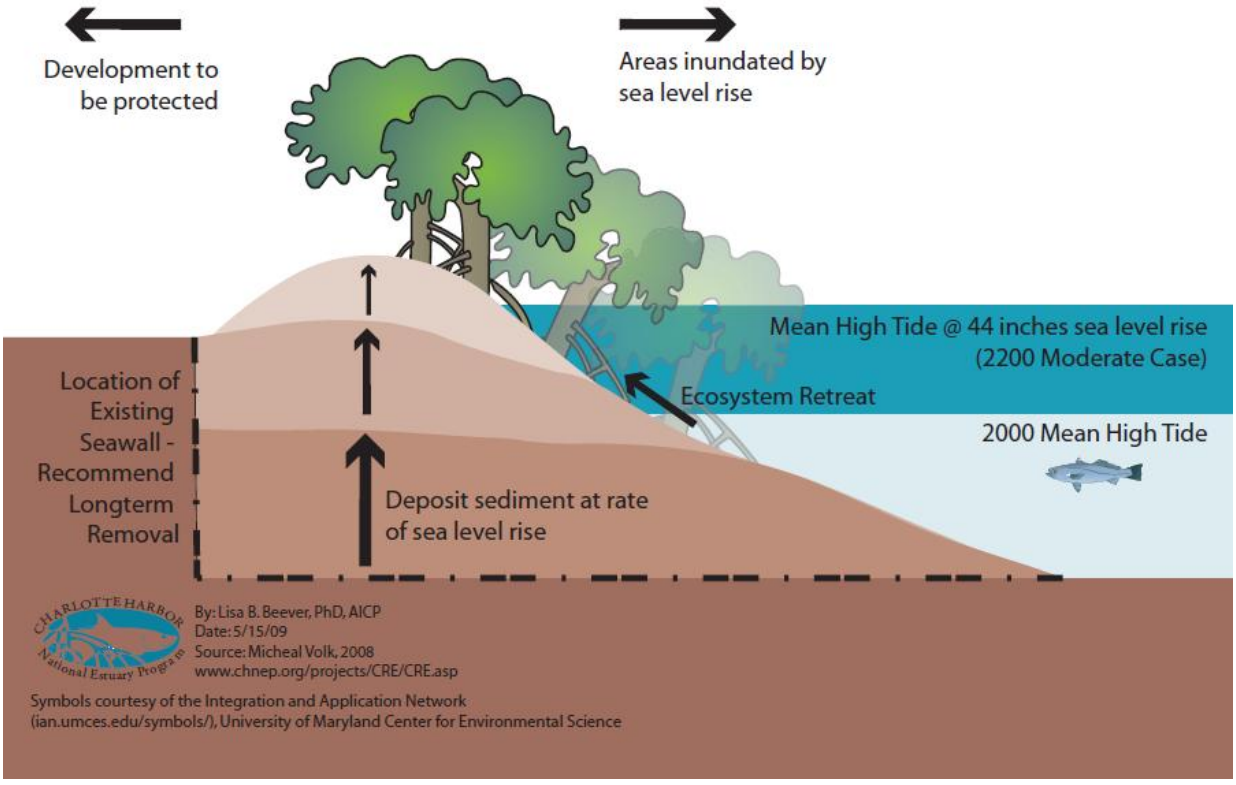

Figure 22: A method of gradual filling of areas in front of shoreline protection.

Designed to keep pace with sea level rise. *Based upon Volk 2008.*

Planned Relocation (Managed Retreat)

Planned Relocation or managed retreat or refers to moving development and infrastructure out of harm's way in a planned and controlled manner over time using techniques such as long-range infrastructure planning, property abandonment, structure relocation, and hazard avoidance. Planned relocation is ecologically sustainable because it allows natural ecosystem processes and shoreline relocation to occur while protecting the public financial and infrastructure investment. It is financially sustainable because it avoids the long-term costs associated with *protection*, particularly if it is based on long-range planning. There are however a number of issues related to *planned relocation* including dry land property loss, in-migration land use conflicts, the possibility of 'takings' arguments and litigation, the ability to overcome existing external financial incentives for coastal development, potential tourism and tax base impacts, and the potential short-term costs.

Protection of conservation lands is not generally recommended (Volk 2008; Titus 1991 et al., SWFRPC 2005). Rather, facilitation of ecosystem adaptation and migration should occur. However, there may be cases where the criticality of conservation lands is such that it justifies short term protection. Figures 23-26 illustrates conceptually how this could occur. Water flow and disturbance of the existing tidal ecosystems are issues created by this strategy.

The primary elements of a *planned relocation* strategy could be as follows.

First, The City of Cape Coral would conduct comprehensive shoreline assessments to determine the unique characteristics of the specific shoreline, suitability analyses to determine which lands should be protected or where shoreline retreat should be allowed, and hazard projections to determine the area first in line to be inundated based on erosion, sea level rise, and storm surge estimates.

Second, rolling easements or similar policies that allow shoreline retreat and disallow coastal protection or hardening could be implemented. Rolling easements are a special type of easement purchased from property owners along the shoreline to prevent them from holding back the sea but which allow any other type of use and activity on the land. As the sea advances, the easement automatically moves or "rolls" landward. Because shoreline stabilization structures cannot be erected, sediment transport remains undisturbed and wetlands and other important tidal habitat can migrate naturally. Similarly, there will always be dry or intertidal land for the public to walk along, preserving lateral public access to the shore. This step does not need to be implemented all at the same time and easements could be acquired in order of priority related to level and timing of exposure to coastal flooding.

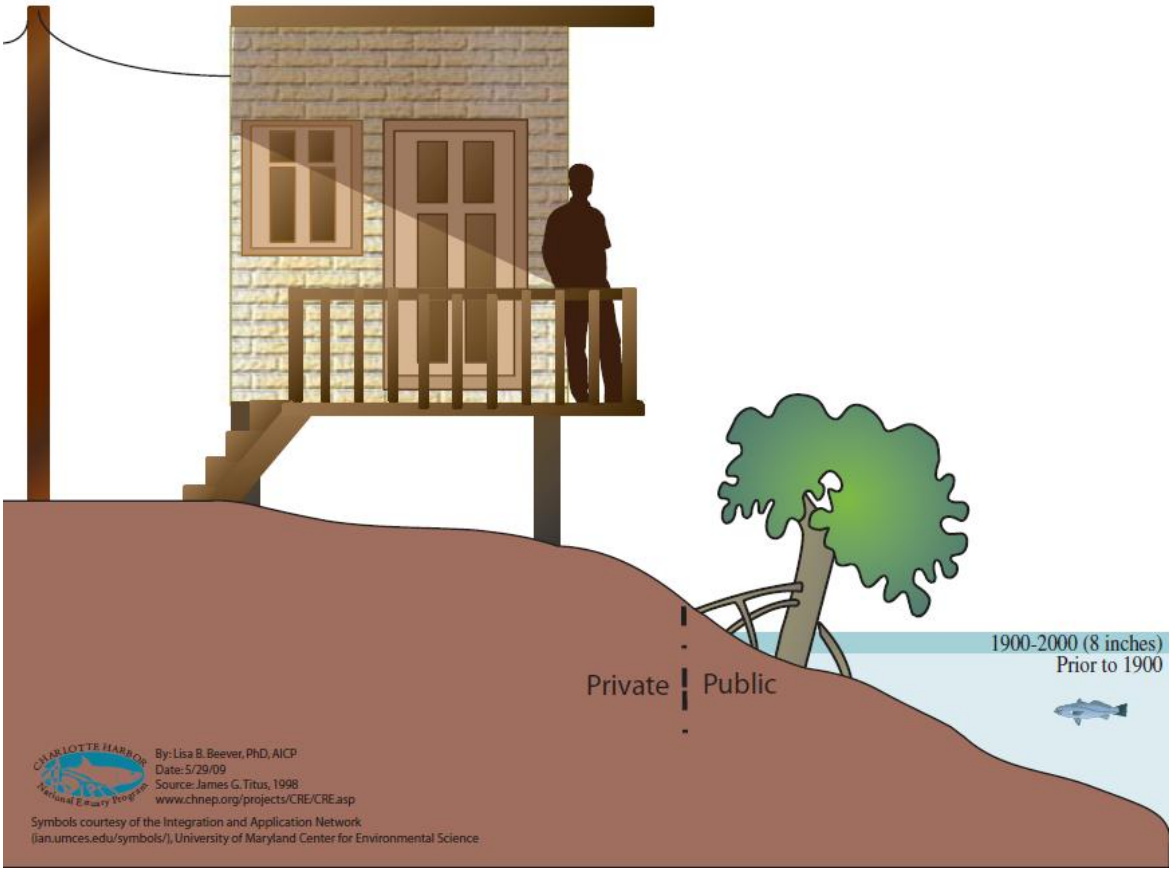

Figure 23: Rolling easement step 1 Year 2017.

Easement established at current shoreline. *CHNEP 2009 Based on Titus 1998.*

Unlike setbacks, which prohibit development near the shore and can often result in "takings" claims if a property is deemed undevelopable due to the setback line; rolling easements place no restrictions on development. They allow the landowner to build anywhere on their property with the understanding that they will not be able to prevent shoreline erosion by armoring the shore, or the public from walking along the shore—no matter how close the shoreline gets to their structure. If erosion threatens the structure, the owner will have to relocate the building or allow it to succumb to the encroaching sea.

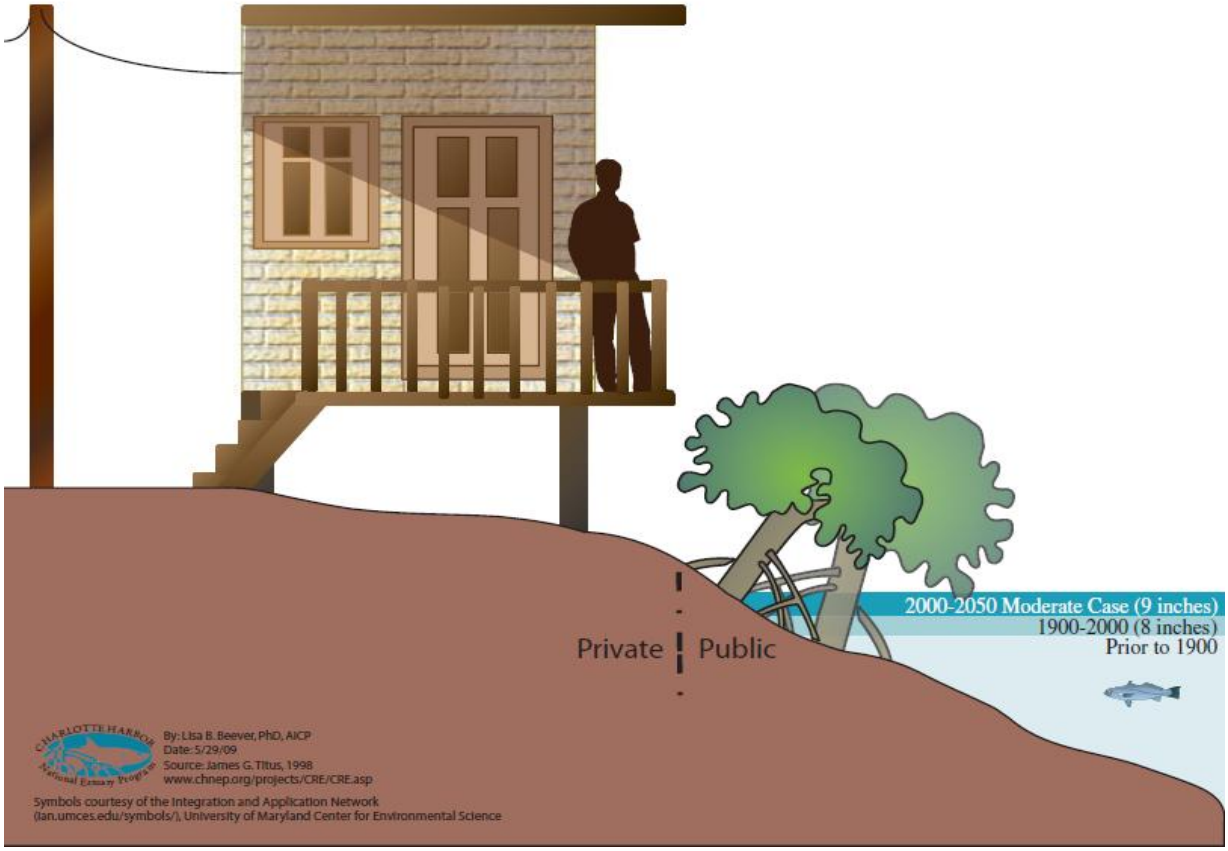

Figure 24: Rolling easement step 2 Year 2057.

Moderate case 12 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated. *CHNEP 2009 Based on Titus 2008.*

Under the Public Trust Doctrine, the public has the right to access tidal lands for fishing and recreation. Therefore, for most states, tidal land is public land. Even for "low-tide" states where private ownership is permitted up to the low-tide line, the public still has the right to access the intertidal zone. For the purposes of a rolling easement, eventually, as the shore continues to erode, the structure that was once on private property, will be sitting on public land. At this point, the private owner could decide to relocate the structure inland. Alternately, the property owner could allow the structure to remain until it becomes unsafe and pay rent to the state for use of public land.

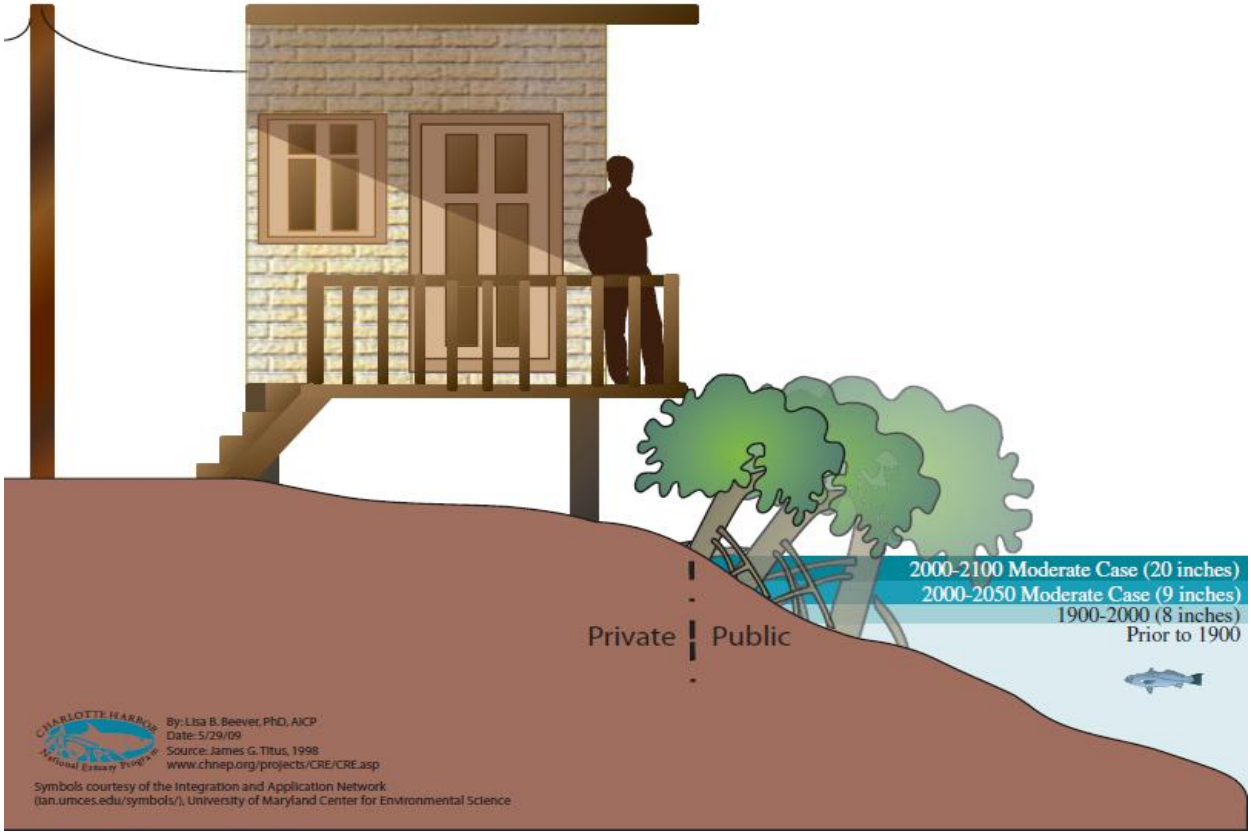

Figure 25: Rolling easement step 3 Year 2100.

Moderate case 20 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated. *CHNEP 2009 Based on Titus 2008***.**

Because there are no restrictions to land use, rolling easements have minimal impacts on property values, usually reducing property values by one percent or less (Titus 1998). "Takings" claims are also limited because it could be decades or more before erosion impacts are felt. In the meantime, the landowner would have full use of their property. To circumvent any potential "takings" claim, the government could purchase the easement from the property owner. More detailed examples about the cost advantages and disadvantages of rolling easements can be found in Titus (1998).

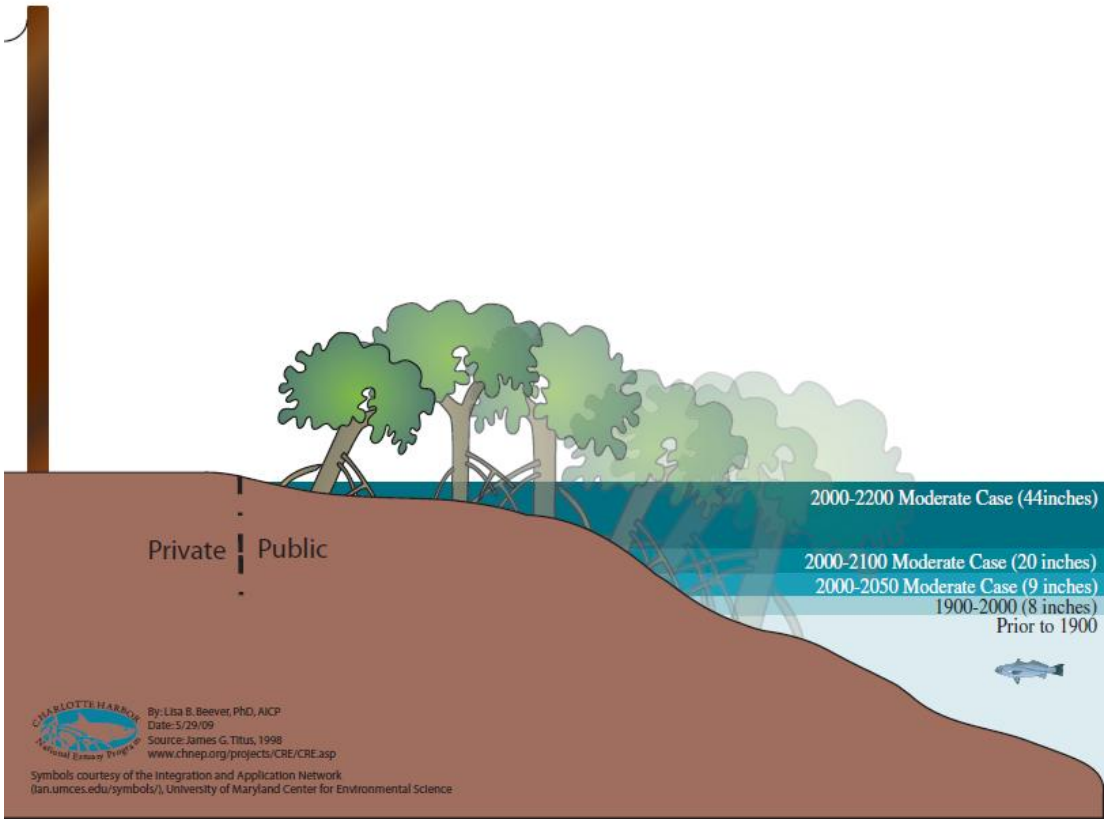

Figure 26: Rolling easement step 4 Year 2200.

Moderate case 20 inches sea level rise. Mangroves and marsh move inland. Former mangroves become inundated. Residence moved to new location or abandoned and removed. *CHNEP 2009 Based on Titus 2008.*

In addition, because landowners are aware that their structure may one day need to be relocated, rolling easements can encourage the building of smaller, and more mobile structures that can be relocated easily.

Rolling easements can even be used where the shoreline is hardened to allow for continued lateral public access to the shore. As the beach disappears at the base of the hard stabilization structure, the rolling easement steps over the structure, enabling the public to walk along the landward side of the armored shore—an area that used to be private property. Without a rolling easement to enable public access, once the sea advances to the toe of the bulkhead or riprap, the public would be barred from walking along the shore since the dry upland falls into private ownership. The rising water levels would have drowned all access to tidal beach on public trust land.

Although rolling easements, like erosion control easements, can be useful shoreline management tools by themselves, and an effective way to implement managed retreat

policies they are typically more effective if used in coordination with other approaches including setbacks and other building along the shore.

Among the benefits of rolling easements is that they help minimize activities that could enhance erosion problems without prohibiting development altogether. Often property owners can receive tax benefits for placing a conservation easement on their property. Rolling easements can help maintain natural shoreline processes. There are minimal "takings" issues as compared to setbacks. Rolling easements do not require as much scientific data as some other shoreline management approaches such as setbacks. Rolling easements are typically less costly than setbacks as well.

Among the drawbacks of rolling easements is that they are not as effective for shorelines that are already significantly developed. Property owners may be hesitant to place easements on their property because the restrictions may decrease or be perceived to decrease the resale value of their property. Property boundaries typically do not align with drift cell boundaries or other environmentally relevant scales. Therefore, placing an easement along the shoreline to prohibit shoreline armoring or limit development in one area but not for another site in the same drift cell could exacerbate erosion rates down drift from the hardened/developed shoreline, negating any benefits a conservation easement could have. Enforcing rolling easements could be difficult.

Third, the City may designate a special overlay district in areas likely to be inundated based on hazard projections. Unique design guidelines should be implemented in these areas. Public financing in these areas should be minimized, particularly for new infrastructure. Within this area likely to be inundated, the City should create an along-shore buffer or easement for ecosystem retreat, management, and restoration. Property purchases, purchase of development rights, setbacks or deed restrictions, development disincentives, and sale incentives are some ways to create this easement. The City will need to plan for removal of inundated structures, infrastructure, and identify strategies for mitigation of hazards related to inundated structures. Creative reuse will be essential; for example, the reuse of building foundations as marine habitat could be appropriate.

Finally, the City will need to continue to integrate good waterfront design principles, and adapt existing useable infrastructure for new evolving waterfront. Communities that allow retreat must realize that the waterfront will be constantly evolving, and must allow for this change within land-use plans and waterfront projects.

Adaptation (Accommodation)

Adaptation or Accommodation refers to strategies that allow for the use of vulnerable lands to continue, but that do not attempt to prevent flooding or inundation with shoreline protection. Examples include relocation friendly construction, short-term land uses, and inundation friendly uses. Accommodation adaptations, if not part of a long-range plan for planned relocation, can have the same negative financial and ecological impacts as protection.

Strategies for accommodation are addressed in Volk (2008) through draft guidelines for construction and land use in areas likely to be inundated. Accommodation is recommended as part of an overall managed retreat strategy, and would occur in areas likely to be inundated where retreat is ultimately planned. It is important to adopt special guidelines for these areas first because suitable land uses within these areas will be better able to respond and adapt to coastal hazards, minimizing financial loss and hazards to coastal populations. These guidelines must be adopted for the use of areas likely to be inundated in order to minimize negative ecological effects and hazards to development, and proactive human action will likely be necessary to facilitate ecosystem adaptation to sea level rise. Two of the most important elements to this are discontinuing coastal hardening and providing lands for ecosystem retreat.

Second, suitable land use within these areas may help to facilitate ecosystem adaptation and maintain functional shoreline ecology. The key concepts behind the guidelines discussed by Volk (2008) are the support of land uses that are water dependent, temporary, adaptable, or evolve as sea levels rise, that are financially sustainable investments with consideration of sea level rise, that allow natural shoreline and ecosystem processes to continue, and that integrate good waterfront design principles.

In The City of Cape Coral, the largely undeveloped areas adjacent to the coast are uncommon. Some areas where planned relocation is the best strategy contain areas of conservation land such as the western spreader canals flanking the State Park and on a more limited scale Four-Mile Cove, and Glovers Bight/ Rotary Park. In these areas, ecosystem retreat would enable the migration of the extensive mangrove forests and salt marshes, which form an important protective barrier against storm surge and tropical storm-related winds.

Ecosystem retreat inland from the existing shoreline is likely not possible if the existing shoreline position is to be maintained. A second option is to establish ecosystems seaward of the existing shoreline, which can retreat up to the existing shoreline position. With this option, shoreline ecosystems may exist while maintaining an essentially static shoreline. The goals of a strategy such as this would be to maintain the same level of protection as would be gained through construction of a traditional protective structure such as a dike, to reestablish, maintain, and facilitate the adaptation of functional shoreline ecosystems, and to spread shoreline protection costs spread over a long period of time in keeping with rate of sea level rise. Several important issues created by this strategy, which could preclude its use, include sediment sources, takings of sovereign submerged lands, source of funding, and upland drainage. It should be noted that drainage of uplands will be an issue with any strategy protecting lands lower than the mean high tide. Protection from inundation of conservation lands is not generally recommended (Titus 1991 et al.). Rather, facilitation of ecosystem adaptation should occur. However, there may be cases where the criticality of historical or conservation lands is such that it justifies short-term protection. Water flow and disturbance of the existing tidal ecosystems are issues created by this strategy.

Strategies for accommodation are addressed in the TCRPC study through draft guidelines for construction and land use in areas likely to be inundated. Accommodation is recommended as part of an overall managed retreat strategy, and would occur in areas likely to be inundated where retreat is ultimately planned. It is important to adopt special guidelines for these areas first

because suitable land uses within these areas will be better able to respond and adapt to coastal hazards, minimizing financial loss and hazards to coastal populations. Second, suitable land use within these areas may help to facilitate ecosystem adaptation and maintain functional shoreline ecology. The key concepts behind the guidelines discussed are the support of land uses that are water dependent, temporary, adaptable, or evolve as sea levels rise; that are financially sustainable investments give consideration of sea level rise; that allow natural shoreline and ecosystem processes to continue; and that integrate good waterfront design principles.

The conclusions of the TCRPC (2008) study are that ecologically and financially sustainable shoreline protection is probably not possible, particularly on high energy shorelines. Protection of any shoreline will only be feasible up to a certain amount of sea level rise, after which the financial costs will be too great to justify protection. As an alternative to shoreline protection, managed retreat policies should be implemented and shorelines should generally be allowed to retreat naturally. There may however be cases where shoreline protection is deemed appropriate, such as in the case of historic St. Augustine, Florida. Accommodation, if used, should be part of a greater strategy for retreat. Guidelines must be adopted for the use of areas likely to be inundated in order to minimize negative ecological effects and hazards to development, and proactive human action will likely be necessary to facilitate ecosystem adaptation to sea level rise. Two of the most important elements to this are discontinuing coastal hardening and providing lands for ecosystem retreat.

Although the southwest Florida region does not have an explicit sea level rise response policy, policies designed to address other issues with similar consequences define an implicit response for many parts of the region. Trends in land use, construction practices, economic growth, environmental sensibilities, and consumer preferences also contribute to the momentum that defines the region's likely response to sea level rise (Titus 1991 et al.).

Federal Policies and Programs

The federal government has several major policies that directly and indirectly affect the likelihood that shores will be protected from erosion, inundation, and increased flooding as sea level rises. We will first examine some policies that encourage retreat, and that encourage shore protection.

Federal Policies that Encourage Shore Protection

The federal wetland program explicitly allows shoreline armoring, while having no explicit policies to *prevent* shoreline armoring. The federal government has long provided subsidies for jetties that stabilize harbor entrances, and beach nourishment along intensely developed shores. In areas like Miami Beach, seawalls did—and probably still would—protect development from eroding shores, so the subsidy for beach nourishment fundamentally influences the type of shore protection. Along more moderately developed shores in this region, the absence of shore protection would probably result in seawalls designed for a modest storm; but a major storm would destroy the seawall, and permanently erode the shore 50 to 100 feet inland. In these areas, the availability of federal beach nourishment funds enables the shore to continue to be protected.

Numerous federal policies appear to encourage or enable relatively dense development in the coastal zone. Federal flood insurance decreases the risk to the owner of coastal construction. Improved building codes resulting from flood insurance regulations enable homes to continue standing in the waters of the Gulf of Mexico after storm-generated erosion, making retreat unnecessary, provided that the beach returns (either naturally or from a beach nourishment project). Federal subsidies for sewage treatment plants make it possible to more densely develop coastal areas where a proliferation of septic tanks would severely pollute coastal bays.

Federal Policies that Encourage a Retreat from the Shore

The federal government influences shore protection as a landowner, a regulator, and a subsidizer (Titus 2000). As a coastal land owner, the federal government has made several very large parcels of land in southwest Florida unavailable to development by acquisition for conservation purposes. Because undeveloped lands are much less likely to be protected than developed areas, federal ownership itself often makes shore protection unlikely, even where there is no specific policy on whether to protect the shore or retreat. Several conservation-oriented landowning agencies consciously allow wetlands and beaches to migrate inland. Everglades National Park and Big Cypress National Preserve all follow the National Park Service general policy of allowing natural processes to work their will. The most noteworthy example of the National Park Service's commitment to allowing shores to retreat was the recent relocation of Hatteras Light in North Carolina, which was moved over one thousand feet inland on a special-purpose railroad track at a cost of over $10 million. National Wildlife Refuges generally allow wetlands to migrate inland within their boundaries, which would apply to the refuges at Ding Darling on Sanibel Island, Matlacha Pass, Pine Island, and Caloosahatchee National Wildlife Refuges all in The City of Cape Coral.

Even agencies that regularly protect some shores may foster shore retreat to some extent. Military bases armor shores to protect buildings and naval port facilities; but military bases often have substantial undeveloped buffer areas where natural shores are preserved.

The federal government does not generally regulate the use of privately owned uplands; so it does not directly discourage development in the coastal zone. However, Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act require landowners to obtain permits to fill wetlands. Regulations interpreting the requirements of these statutes often discourage or prohibit fill and other beach nourishment activities along bay shores. Although bulkheads and stone revetments are generally allowed in this region, they are technically fill and require a permit if below mean high water. Although these structures can be built inland of mean high water, eventually they sit within the ebb and flow of the tides as sea levels rise and shores erode; therefore replacement or repair might require filling in the "waters of the United States" and hence require a permit.

The Coastal Barrier Resources Act (CoBRA) prohibits federal subsidies and flood insurance to specific designated portions of barrier islands, barrier spits, and other coastal areas (Titus 2000).

In other parts of the state, CoBRA areas with easier access have been developed, but the unavailability of federal subsidies makes beach nourishment unlikely. Lack of federal subsidies

for sewage treatment has limited the density in still other areas. The unavailability of flood insurance and federally backed mortgages also discourages development.

Even though the other parts of the Federal Flood Insurance Program encourage shore protection, the program does have a component that also encourages retreat. Specifically, the repetitive loss program (a repetitive loss consists of two flood insurance claims on the subject property) offers a 50/50 federal/local match to buy the parcel for preservation. Otherwise a repetitive loss owner can match 50% of the cost to raise the structure to prevent further flooding which is a form of encouraging shore protection.

Florida State Policies and Programs

Similar to the federal policies, no state policies specifically address the issue of sea level rise, but many policies are already in place to deal with consequences. These policies are included in the Coastal Construction Control Line Program, the Beach Erosion Control Program, the Coastal Building Zone, Strategic Beach Management Plans and Environmental Resource Permits.

Florida Policies that Encourage Shore Protection

The Florida Beach and Shore Preservation Act was enacted by Florida's legislature to preserve and protect Florida's beach and dune system. Beaches and dunes are the first line of defense against storms, acting as a buffer between the sea and coastal development. One of the programs authorized by the Beach and Shore Preservation Act to be an essential element in the protection effort is the Coastal Construction Control Line (CCCL) Program (Beach and Shore Preservation Act, Florida Statutes Chapter 161).

The CCCL Program was designed to protect Florida's beach and dune system from irresponsible construction that could weaken, damage, or destroy the health of the dune system. Structures that are built too close to the sea can inhibit the beach and dune system from its natural recovery processes and can cause localized erosion. Improperly constructed structures are a threat to other nearby coastal structures, should they be destroyed by storms. The CCCL Program gives the state the jurisdiction to apply stringent siting and design criteria to construction projects seaward of the control line. The CCCL is not a setback line, but is rather a demarcation line of the state's authority.

The CCCL is marked at the landward limit of coastal areas that are subject to the effects of a 100-year storm surge. While wind and flooding may intrude further inland than the 100-year storm surge area, effects landward of the CCCL are considerably less than seaward of it. Seaward of the CCCL, the State prohibits the construction or siting of structures that would cause a significant adverse impact to the beach and dune system, result in the destabilization of the system or would destroy marine turtle habitat. To meet these requirements, structures are required to be located a sufficient distance from the beach and frontal dune and must also be sited in a way that does not remove or destroy natural vegetation. The CCCL also requires all structures to be constructed to withstand the wind and water effects of a 100-year storm surge event. This involves creating structures that meet the American Society of Civil Engineering 7-88 Section 6 wind design standard for 110 mph winds (115 mph for the Florida Keys). Water design standards include a foundation engineered to withstand a 100-year storm event, including

the effects of surge, waves and scouring. There is no prohibition of rebuilding under the CCCL Program. Due to the effects of erosion, the CCCL Program discourages the construction of rigid coastal armoring (seawalls) and instead encourages property owners' use of other protection methods, such as foundation modification, structure relocation and dune restoration.

Another similar endeavor to regulate coastal construction is the Coastal Building Zone (CBZ). The CBZ was established as part of the Coastal Protection Act of 1985 to protect coastal areas and to protect life and property. The CBZ is similar to the Coastal Construction Control Line program in that it is a regulatory jurisdiction, rather than a setback line. The CBZ envelopes land from the seasonal high water line to 1500 feet landward of the CCCL. In those areas fronting on the ocean but not included within an established CCCL, the Coastal Building Zone includes the land area seaward of the most landward V-Zone line, as established by the National Flood Insurance Program's (NFIP) flood maps. The V-Zone is an area likely to experience a wave greater than three feet high with storm surge, or areas within the 100-year storm event used by the CCCL program. Local governments, rather than the state, enforce the Coastal Building Zone as a part of their building codes.

Within the CBZ, new construction is required to meet the Standard Building Code 1997 wind design standard of 110 mph (115 mph for the Florida Keys). As for water standards, structures are required to meet NFIP requirements or local flood ordinance requirements, whichever are stricter. Foundations must also be designed to withstand a 100-year storm surge. CBZ construction standards are less stringent than CCCL standards. This is due to the fact that NFIP flood maps have lower base flood elevations for 100-year storm events than do CCCL studies.

Another State effort to protect Florida's beaches, authorized by the Beach and Shore Preservation Act, is the Beach Erosion Control Program (BECP). The BECP is the primary program that implements the Florida Department of Environmental Protection's beach management recommendations. The BECP was created to coordinate the efforts of local, state, and federal governments in protecting, preserving and restoring Florida's coastal resources. One of the activities of this program is the offering of financial assistance to counties, local governments and other special districts for shore protection and preservation efforts. The BECP will provide up to 50 percent of project costs. The mix between federal, state and local funds is different for each project.

Beach management activities eligible for funding from the BECP include beach restoration and nourishment activities, project design and engineering studies, environmental studies and monitoring, inlet management planning, inlet sand transfer, dune restoration and protection activities, and other beach erosion prevention related activities.

Another endeavor of the BECP is the development and maintenance of a Strategic Beach Management Plan (SBMP) for Florida. The SBMP is a multiyear repair and maintenance strategy to carry out the proper state responsibilities of a comprehensive, long-range, statewide program of beach erosion control; beach preservation, restoration, and nourishment; and storm and hurricane protection. The SBMP is divided into specific beach management plans for Florida's coastal regions.

Like the Federal Wetland Program, a State of Florida Environmental Resource Permit (ERP) is authorized by Part IV of Chapter 373, Florida Statutes, to regulate activities involving the alteration of surface water flows. This includes new activities in uplands that generate stormwater runoff from upland construction, as well as dredging and filling in wetlands and other surface waters. ERP applications are processed by either the Department of Environmental Protection or one of the state's water management districts. The South and Southwest Florida Water Management Districts cover parts of this region.

State Policies that Encourage a Retreat from the Shore

Florida also has one of the largest land and water (including wetlands) acquisition programs in the country, called "Florida Forever" (FF). The funding from this program is used for restoration, conservation, recreation, water resource development, historical preservation, and capital improvements on acquired conservation lands. Land acquisition through this program is almost exclusively voluntary, as the state wishes to avoid using its power of eminent domain. The funding for this program comes from $3 billion in bond issues over a 10-year period, which is being paid back from an excise tax. Florida Forever funds are distributed annually to various governmental agencies for land and water acquisition: Department of Environmental Protection (38%), Water Management Districts (35%), Florida Communities Trust (24%), Department of Agriculture/Forestry (1.5%), and the Fish and Wildlife Conservation Commission (1.5%). Since the program began in 1999, Florida Forever funds have been used to protect over 270,000 acres of natural floodplains, nearly 500,000 acres of significant water bodies, over 24,000 acres of fragile coastline, and over 520,000 acres of functional wetlands (FNAI 2008).

Similar to and developed at about the time as the first federal CoBRA designations, the Florida Legislature passed the Coastal Infrastructure Policy law in Chapter 380.27(1 & 2), F.S. that states the following:

(1) No state funds shall be used for the purpose of constructing bridges or causeways to coastal barrier islands, as defined in s. 161.54(2), which are not accessible by bridges or causeways on October 1, 1985.

(2) After a local government has an approved coastal management element pursuant to s. 163.3178, no state funds which are un-obligated at the time the element is approved shall be expended for the purpose of planning, designing, excavating for, preparing foundations for, or constructing projects which increase the capacity of infrastructure unless such expenditure is consistent with the approved coastal management element.

The State Comprehensive Plan, under Section 8 Coastal and Marine Resources, contains the following policies that encourage retreat:

1. Accelerate public acquisition of coastal and beachfront land where necessary to protect coastal and marine resources or to meet projected public demand.

3. Avoid the expenditure of state funds that subsidize development in high-hazard coastal areas.

4. Protect coastal resources, marine resources, and dune systems from the adverse effects of development.

9. Prohibit development and other activities which disturb coastal dune systems, and ensure and promote the restoration of coastal dune systems that are damaged.

As part of Local Government Comprehensive Planning, Chapter 163 F.S. titled Intergovernmental Programs, Part II Growth Policy; County and Municipal Planning; Land Development Regulation and specifically the Coastal Management law in Chapter 163.3178(1) F.S. could encourage both shore protection and retreat depending on how local governments implement this law relative to natural disaster planning as follows:

(1) The Legislature recognizes there is significant interest in the resources of the coastal zone of the state. Further, the Legislature recognizes that, in the event of a natural disaster, the state may provide financial assistance to local governments for the reconstruction of roads, sewer systems, and other public facilities. Therefore, it is the intent of the Legislature that local government comprehensive plans restrict development activities where such activities would damage or destroy coastal resources, and that such plans protect human life and limit public expenditures in areas that are subject to destruction by natural disaster.

The Coastal High Hazard Area, as defined in the Coastal Management Law Chapter 163.3178(2) (h), is equivalent to the Category 1 hurricane storm surge zone. To provide direction on implementing the Coastal Management Law, the Florida Department of Community Affairs adopted rules in Chapter 9J5.012 (3) (b) Florida Administrative Code. The following sections apply to encouraging retreat or shore protection:

(3) Requirements for Coastal Management Goals, Objectives, and Policies.

(b) The element shall contain one or more specific objectives for each goal statement which address the requirements of paragraph 163.3177(6) (g) and Section 163.3178, F.S., and which:

1. Protect, conserve, or enhance remaining coastal wetlands, living marine resources, coastal barriers, and wildlife habitat;
4. Protect beaches or dunes, establish construction standards which minimize the impacts of man-made structures on beach or dune systems, and restore altered beaches or dunes;
5. Limit public expenditures that subsidize development permitted in coastal high-hazard areas subsequent to the element's adoption except for restoration or enhancement of natural resources;
6. Direct population concentrations away from known or predicted coastal high-hazard areas;

(c) The element shall contain one or more policies for each objective and shall identify regulatory or management techniques for:

1. Limiting the specific impacts and cumulative impacts of development or redevelopment upon wetlands, water quality, water quantity, wildlife habitat, living marine resources, and beach and dune systems;
2. Restoration or enhancement of disturbed or degraded natural resources including beaches and dunes, estuaries, wetlands, and drainage systems; and programs to mitigate future disruptions or degradations;
3. General hazard mitigation including regulation of building practices, floodplains, beach and dune alteration, stormwater management, sanitary sewer and septic tanks, and land use to reduce the exposure of human life and public and private property to natural hazards;
4. Hurricane evacuation including methods to relieve deficiencies identified in the hurricane evacuation analysis, and procedures for integration into the regional or local evacuation plan;
5. Post-disaster redevelopment including policies to: distinguish between immediate repair and cleanup actions needed to protect public health and safety and long-term repair and redevelopment activities; address the removal, relocation, or structural modification of damaged infrastructure as determined appropriate by the local government but consistent with federal funding provisions and unsafe structures; limiting redevelopment in areas of repeated damage;
7. Designating coastal high-hazard areas and limiting development in these areas;
8. The relocation, mitigation or replacement, as deemed appropriate by the local government, of infrastructure presently within the coastal high-hazard area when state funding is anticipated to be needed.
10. Providing, continuing, and replacing adequate physical public access to beaches and shorelines; enforcing public access to beaches renourished at public expense; enforcing the public access requirements of the Coastal Zone Protection Act of 1985; and providing transportation or parking facilities for beach and shoreline access.

Local Policies and Programs

In Florida each local government is required to complete a comprehensive land use plan, which may have policies that encourage either retreat or shore protection. Normally, these policies would be in the Coastal Management Element which was discussed above in terms of state requirements.

Approaches for maintaining shorelines in the face of sea level rise include protection and retreat. Each of these approaches, or some combination of them, may be appropriate depending on the characteristics of a particular location (e.g., shore protection costs, property values, the environmental importance of habitat, the feasibility of protecting shores without harming the habitat). Note that the strategies presented include both shoreline hardening/armoring and

removing armoring to create living shorelines. These different and seemingly conflicting options are each appropriate in different situations. Protection options can include hardening the shoreline through measures such as bulkheads, seawalls, revetments, breakwaters, sills, and creating or reinforcing headlands. Shoreline protection can also be achieved through ”softening” measures, which develop living shorelines through beach nourishment, planting dune grasses, marsh creation, and planting submerged aquatic vegetation (SAV). Planned retreat (or wetland migration) is an alternative to shoreline protection in the face of natural forces such as coastal erosion or sea level rise (Martinich 2008).

With two simplifying assumptions, it is possible to estimate the value of real estate at risk from sea level rise. First, Stanton and Ackerman (2007) assumed that the value of real estate will grow uniformly in all parts of the state, in proportion to gross state product (GSP), throughout this century. Second, they assume that the fraction of the state’s residential property at risk is proportional to the extent of sea level rise. Then, starting from the calculation of $130 billion of residential real estate, as of 2000, that would be vulnerable to 27 inches of sea level rise, it is possible to project the effects of both scenarios (business-as-usual and rapid stabilization) through 2100. The cost of inaction — that is, the annual increase in the value of residential real estate at risk of inundation — rises from $11 billion in 2025 to $56 billion in 2100, or almost 1 percent of GSP. And sea levels will continue to rise beyond 2100.

No one expects coastal property owners to wait passively for these damages to occur; those who can afford to do so will undoubtedly seek to protect their properties. But all the available methods for protection against sea level rise are problematical and expensive. It is difficult to imagine any of them being used on a large enough scale to shelter all of Florida from the rising seas of the 21st century, under the worst case (Stanton and Ackerman 2007).

Elevating homes and other structures is one way to reduce the risk of flooding, if not hurricane-induced wind damage. A FEMA estimate of the cost of elevating a frame-construction house on a slab-on-grade foundation by two feet is $58 per square foot, after adjustment for inflation, with an added cost of $0.93 per square foot for each additional foot of elevation (FEMA 1998). A house with a 1,000 square foot footprint would thus cost $58,000 to elevate by two feet. It is not clear whether building elevation is applicable to multistory structures; at the least, it is sure to be more expensive and difficult (Stanton and Ackerman 2007).

Another strategy for protecting real estate from climate change is to build seawalls to hold back rising waters. There are a number of ecological costs associated with building walls to hold back the sea, including accelerated beach erosion and disruption of nesting and breeding grounds for important species, such as sea turtles, and preventing the migration of displaced wetland species (NOAA 2000). In order to prevent flooding to developed areas, some parts of the coast would require the installation of new seawalls. Estimates for building or retrofitting seawalls range widely from $300 to $4,000 per linear foot (Yohe et al. 1999; U.S. Army Corps of Engineers 2000; Kirshen et al. 2004; Dean 2007b; Stanton and Ackerman 2007).

Specific costs for coastal armoring for southwest Florida are listed below in Appendix A. Costs do not include labor for installation. For future analyses these could be updated for current costs.

The United States Geological Survey (USGS) has created an index to rate the vulnerability of U.S. shoreline to sea level rise, taking into consideration tides and erosion, as well as elevation (USGS 2000). According to their assessment, out of 4,000 miles of total Florida shoreline, 1,250 miles are in the "high" vulnerability category and 460 miles are in the "very high" category. If just these 1,700 miles of shoreline were protected with seawalls, and construction costs averaged $1,000 per linear foot (or a bit over $5 million per mile), the total cost would be just under $9 billion. The 4,000 total miles of shoreline assumed by USGS, however, do not take into account Florida's many channels and inlets, which make the actual coastline much longer. (Conversely, other estimates of the length of Florida's coastline range down to 1,350 or fewer miles; the varying estimates reflect the different resolutions at which the measurements are made.). The actual coastline length, when these features are accounted for, is 22,000 miles (Stanton and Ackerman 2007). If seawalls were needed for 42 % of Florida's actual coastline (the share of very high and high vulnerability coastline under the USGS definition), or 9,200 miles, the cost would be $49 billion. In other words, constructing seawalls sufficient for statewide protection would be an engineering mega project, several times the size of the long-term Everglades restoration effort (Stanton and Ackerman 2007).

Yet another approach involves beach nourishment, bringing in sand as needed to replenish and raise coastal beaches (which as noted above can have major environmental impacts). A large-scale analysis of the costs of protecting the U.S. coastline from sea level rise, conducted by USEPA in 1989, relied heavily on restoring and building up beaches (Titus et al. 1991). The study projected that most of the sand would need to be dredged up from more than five miles offshore. It estimated the cost of sand to protect Florida against 39 inches of sea level rise (a level reached in 2087 in the worst case) would be between $6 billion and $30 billion in 2006 dollars, depending on assumptions about the quantity and cost of sand. As with statewide seawall construction, beach nourishment on this scale would be a mammoth engineering project, with uncertain environmental impacts of its own. In short, while adaptation, including measures to protect the most valuable real estate, will undoubtedly reduce sea level rise damages, there is no single, believable technology or strategy for protecting the vulnerable areas throughout the state (Stanton and Ackerman 2007).

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience against Coastal Erosion and Sea Level Rise

The existing scientific literature has identified actions that can better adapt human economies to sea level rise and associated geomorphic changes **(**Ebi et al. 2007; Fiedler et al. 2001; Lee County Visitor and Convention Bureau 2008; Peterson et al. 2007; Titus 1998; USCCSP 2008; USNOAA 2008; USEPA CRE 2008). (Note: This and all following tables related to climate change resiliency strategies are not ranked by any form of prioritization. Strategies found by staff interview to already be in use by The City of Cape Coral to any extent are indicated with this symbol. They are included to encourage expansion of those policies and practices. Not all strategies being used by The City of Cape Coral may be accounted for. Key words are shown in

bold italics. Some strategies are applicable in more than one area of interest. These strategies are repeated where applicable.)

These include:

Address climate change impacts in plans for ***working waterfronts***.
Strengthen building codes in coastal areas to provide additional protection for properties from wind and storm surges.
Adopt ***soft defense strategies***, such as establishing aquatic vegetation beds, using natural or artificial breakwaters, and beach nourishment, where appropriate (for example, shorelines that are more undeveloped and where a seawall would inhibit wetland migration and damage natural defense systems).
Allow coastal wetlands to migrate inland in areas explicitly indicated.
Allow shoreline ***hardening*** where appropriate.
Allow ***beach nourishment*** where appropriate.
Change building codes to promote ***energy efficient building***.
Change the ***placement and design of infrastructure*** (for example, for water supply, wastewater treatment, power plants and other utilities, and transportation).
Connect landscapes with ***corridors***.
Conserve land in coastal areas by removing or limiting development potential through acquisition, conservation easements, and the purchase and transfer of development rights.
Consider sea level rise in ***infrastructure planning***.
Consider sea level rise in ***site design***.
Constrain locations for certain high risk infrastructure.
Create a regional ***sediment management plan***.
Create more ***energy- and cost-effective communities*** through community design and green building.
Create ***natural buffers*** against sea level rise.
Design new ***coastal drainage systems***.
Develop and adopt ***building design criteria*** to deal with the consequences of possible sea level rise.
Ensure appropriate ***foundations*** for buildings.
Establish or broaden ***use containment areas*** to allocate and cap water withdrawal.
Improve land use and management.
Explicitly indicate in the City of Cape Coral Comprehensive Plans which areas will retain natural shorelines.

Identify, protect and adapt protections of ***ecologically important areas/critical habitat.***
Implement ***stormwater management*** processes that more closely mimic nature by retaining rainfall close to its source so that it can be filtered, stored, and allowed to evaporate.
Incorporate ***Low Impact Development*** (LID) principles.
Incorporate ***LEED*** standards into building codes.
Incorporate wetland protection into ***infrastructure planning*** data.
Increase ***shoreline setbacks*** and exchange/purchase/acquisition.
Increase use of ***alternative and renewable energy***.
Land exchange programs.
Encourage use of ***living shorelines*** in residential, commercial and institutional properties.
Manage realignment of infrastructure.
Prepare for ***more frequent storm events*** with associated erosion.
Encourage ***natural breakwaters*** where appropriate.
Partner with utility companies to ***educate the public*** on energy efficiency and expand and increase incentives to homeowners (free/low cost loans for photovoltaic systems, net metering, and solar panels).
Prevent or limit ***groundwater extraction*** from shallow aquifers to protect coast from subsidence and saltwater intrusion.
Prohibit development or engineering "solutions" to block ***migration of wetlands***.
Prohibit ***development subsidies*** (federal flood insurance and infrastructure development grants) to estuarine and coastal shores at high risk.
Promote ***green building alternatives*** through education, green-lending, taxing incentives, and building and design standards.
Promote ***green roof technology*** through building codes.
Promote ***wetland accretion*** by introducing sediment and prohibiting hard shore protection.
Protect barrier islands that shelter beaches.
Protect ***water quality*** for fisheries and reefs.
Protect and restore ***natural defenses*** such as salt marshes, sand dunes, and natural vegetation.
Provide ***alternative transportation.***
Purchase ***upland development rights*** or property rights.
Redefine ***flood hazard zones***.
Reduce carbon emissions.
Regulate ***fertilizer application and use.***

Regulate pumping near shorelines, especially for flood control.
Remove hard protection or other barriers to shoreline retreat and replace shoreline armoring with ***living shoreline protections***.
Replicate habitat types in multiple locations to ***spread risks.***
Restrict/prohibit development in erosion/flood/damage prone areas.
Relocate structures away from vulnerable/affected shoreline.
Retrofit roads and bridges, which may involve rebuilding roads and bridges at higher elevations and developing engineering techniques that allow them to float or withstand flooding.
Use adaptive ***stormwater management***.
Use ***integrated coastal zone management***.
Use natural and artificial breakwaters to ***reduce wave energy.***
Wetland conservation/restoration accounting for climate change and human engineering such as canals, floodgates, levees, etc.

Table 6. Resiliency strategies to address coastal erosion and sea level rise

A hypothetical comparison of relative costs of various sea-level rise adaptations

The relative costs of different approaches to sea level rise can vary significantly.

In an example of rolling easements, Volk (2008) reports that as of 2005, Worcester County in Maryland secured $7.25 million from the Maryland Rural Legacy Program and contributed $400,000 in local funds to purchase rolling conservation easements for 6,000 acres of land (representing eight miles of shoreline) within the Worcester County Bays Rural Legacy Area. The county continues to work with land owners within the Coastal Bays Rural Legacy Area to encourage others to place conservation easements on their property as well.

This Rolling Easement total cost is $7.65 million for 6,000 acres of land (representing eight miles of shoreline) that in 2005 dollars is $1,275/acre or $1,045,752/mile of shoreline. This would be $1,310,445.59 per mile of shoreline in 2017 dollars. In estimating the shorelines of The City of Cape Coral, SWFRPC GIS measured the total length of all major tidal manmade canals including all shorelines in the city as 440 miles. So a rolling easement for the entire using this estimation the cost of a rolling easement for the entire The City of Cape Coral shoreline in 2017 land values could be $576,596,059.60. If only the natural perimeter shoreline of 40 miles on the Caloosahatchee River, and the western spreaders is placed in easement then in 2017 land values it could be $52,417,823.60.

The costs of a total shoreline treatment of the city boundary (set at the mean tide line and including the man-made canals) with a complete 6 foot vertical concrete bulkhead set above

MHWL along all public and private properties would be $1,126,333,824 for the bulk head alone. Based on SFWMD elevation data, a 6 foot back fill of the currently developed areas of the city would add 307,200 acre/feet (495,615,262 cubic yards) of fill. At $22.56 a cubic yard, this would cost $11,181,080,310.72 in materials. Estimated construction costs for the bulkhead installation with normal salaries would be approximately $4,533,981,801.81. This would be a total of $16,841,395,937 in 2017 dollars for complete currently developed City protection with backfill to an approximately 6 foot elevation above the current mean tide line.

Utilizing the method of gradual sand filling to keep pace with sea level rise the current estimate for careful sand placement would be in the neighborhood of $2,144,232.53 for each mile of shoreline. At the manmade waterfront there would need to be a concomitant raising of bulkheads if the standard navigable depth of canals were to be maintained. Examining only the outer shoreline (40 miles) the cost for the method of keeping pace with sea level rise would be $85,769,301.2

Elevating the existing infrastructure in place would include increasing the height of buildings that are historical or are too valuable to rebuild, and replacing buildings that have exceeded their useful life with new construction that would be elevated to the new standards. As a unified area of structures achieves elevation, then the roadway network and utilities would need to be brought up to the new height. Based upon house elevation flood hazard mitigation performed in Sarasota County for a house in the Myakka River flood plain the total cost was $170,000 (FEMA 2003). House elevation costs listed for post Hurricane Katrina recovery are in the neighborhood of $150,000. With a total of 78,948 buildings in storm surge zones and potential sea level rise inundation, the total cost of elevation of only the structures would be approximately $13,421,160,000

Construction of perimeter earthen dikes that are generally waterproof with a seepage management system would be $324,289,334.38 to $361,256,240.51 in fill material along if all manmade canals are left open to tide. If canals are blocked, and separated from the tide then the fill material dike cost can go as low as $9,872,527.42 if the total wetlands are left waterward of the dike. If the dike is armored the increased cost would be from $813,478,959.29 (canals closed) to $29,766,882,606.45 (canals open). In this method the area behind the dike would not be elevated but major pumps would be needed to address discharge of storm waters, dike seepage, and drainage. Pumps of sufficient scale to maintain a relatively dry city would range in cost from $7 to $20 million (SFWMD 2006, Wood 2006) which would be $175,000,000 to $625,000,000 depending on design, power sources and portability. Presuming a minimum of 25 major pumps for the City's basins the costs of an armored dike system with pumps would range from $998,351,486.71 to $3,340,952,764.37 for a interior dike with the canals cut-off from direct navigation access to $9,484,524,792.70 to $30,753,138,846.96 for an exterior coastline with embayments and the canals open to navigation access. Of course this does not account for the costs accrued when the dike(s) fails.

Table 7. A hypothetical comparison of relative costs of various sea-level rise adaptations for The City of Cape Coral.

Alternative	**Rolling Easements**	**Bulkhead with fill to 4 feet (2/3 Galveston Solution)**	**Gradual Sand Filling to keep pace (Volk 2008)**	**Elevating Infrastructure (Venice Solution)**	**Armored Dike 25 major pumps (New Orleans Solution)**
Cost Estimate (Billions of Dollars)	$0.05 to $0.57	$16.84	$0.08	$13,42	$0.94 (canals cut off) to $30.75 (canals open)

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience for Land Development and Building

The same qualities that render The City of Cape Coral desirable for tourists make it desirable to move to here permanently. In fact, many residents saw the area first as tourists. In addition to the vulnerabilities found in tourism, water availability, increased intensity of storms, increased and vulnerability of low lying development will affect the future health of the construction industry.

Much of the land platted for residential development was created on the coast from dredged low-lying areas. Many of these areas are vulnerable to the impacts of sea level rise. Additional land that had been slated for development within the most vulnerable zones associated with Charlotte Harbor was acquired and managed for environmental purposes, improving the overall resiliency of area.

The land-sale development that began in the 1950s dramatically and permanently changed the character and use of southwest Florida and cast the form of future development. Thousands of acres of land were subdivided over the next three decades. Pastures and croplands were drained and cleared, taking productive land out of use. Coastal lowlands were dredged and filled to create developable home sites by the tens of thousands. Canals were dug and streets were paved years in advance of when the land would actually be needed for housing. Even though some of this land was platted and sold almost 40 years ago, today a large percentage of it remains sparsely populated.

Land and home values increased rapidly through the end of the last century and peaked in 2007. Construction employed tens of thousands of people in Florida. (Table 11.20 UFBEBR 2008). The economy in Cape Coral is based on health care services, retail, and real estate/construction. The City's Economic Development Office promotes and incentivizes business relocation to Cape Coral. In 2016 the city's top five employers were the Lee Memorial Hospital, Lee County School System, Publix Supermarkets, City of Cape Coral and Wal-Mart

Per capita income in 2006 for The City of Cape Coral was $40,113. Economic sectors generating the most non-farm total earnings for The City of Cape Coral residents in 2006 were construction and retail trade (Table 5.00 Florida County Perspective 2008).

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience in Emergency and Hazard Planning

Although climate change may not specifically be identified in emergency preparedness plans, it is an issue that's being addressed simply because of its nature. The all-hazards emergency management community plans for all types of emergencies, whether manmade or natural. Changing climate and weather patterns automatically lend themselves to increased planning and new mitigation actions. Although scientists and planners have advice for how the changing climate can be included in emergency preparedness, the field is continuing to evolve as more information becomes available and agencies begin developing best practices.

Planning for climate change can mean looking at current natural hazards and anticipating which of them will become more extreme in the future. One of the barriers to the new planning considerations is that the future being planned for isn't likely to be next year, but many years from now. Emergency management also has traditionally been response-based, which can hinder how agencies include climate change in their planning.

Throughout the history of settlement in Florida, extreme weather events—particularly in the form of hurricanes—have played a major role in shaping culture, commerce, and community development. As a result, Florida's state government has developed one of the more robust emergency preparedness and response infrastructures in the nation. This was particularly evident in the depth of aid provided by Florida to Mississippi during the 2006 hurricane season in the aftermath of Hurricane Katrina.

Current science supports increased intensity and duration for storms that form in the Atlantic and the Gulf of Mexico. When coupled with rising sea levels, future hurricane events may yield greater storm surge effects to put coastal communities at greater risk for damage than is the case today. In addition, there could be more intense rain events, droughts, wildfires, and heat emergencies.

Extreme weather in The City of Cape Coral could:
• Overtax the emergency response systems and funding for flood response,

• Result in major storms and power outages,

• Affect buildings or transportation routes, and

• Cause drought-related fires.

Hurricanes, as Florida's typical extreme weather event, may no longer be the only major threat to Floridians. An analysis of predictable climate change impacts would include projections for other intense rain events, increased droughts, wildfires, heat, and public health emergencies. Additionally, given the many fronts that climate change is expected to present to the City of Cape Coral's emergency infrastructure, there is the possibility that several of these impacts might occur simultaneously. Delayed emergency response could become more common.

Florida's current emergency preparedness and response functions are a coordinated effort between federal, state, and local governmental agencies, as well as nongovernmental organizations (NGOs). The objective of Florida's future emergency preparedness and response functions has been to build on the excellence gained through past experience to ensure sufficient capacity and efficacy in protecting public health and welfare in more severe storm events with increased incidence of storm surge and the associated coastal damage. As the impact of sea level Rise (SLR) and higher storm surges becomes more evident, development patterns must be constrained to increase the resiliency of coastal communities and to protect those communities.

The City of Cape Coral must be prepared to address the synergistic effects of multiple climate stressors on its emergency response infrastructure and, prior to such occurrences, must devise an approach to deal with this by building on existing skills in emergency preparedness and

environmental response. Policy makers in particular need information and data on changes in risks from climate change and need to know where to get such information.

Coastal communities and ecosystems are at particular risk from increased storm surge and increased hurricane intensity. The majority of The City of Cape Coral's population lives in the coastal zone or low elevation areas. Likewise, the vast majority of the City's existing building stock is situated near the coast. While many coastal ecosystems have adapted to periodic extreme weather, system resiliency in some cases may be undermined because of the loss of habitat, pressures from invasive exotic species, or other incidences that prevent post-hurricane recovery. Aside from risk to the human population from hurricane events, increases in temperatures may cause certain water- and vector-borne diseases normally associated with more southern climates to migrate to Florida. Increased flooding and infrastructure damages resulting from increased heat and flooding could aggravate these risks.

Many of the impacts that climate change is projected to bring are already familiar to The City of Cape Coral, Consequently, programs to address impacts such as increased intensity of hurricanes and major storm events, storm surge and erosion, saltwater intrusion, and the availability of potable drinking water supplies have been implemented. Additionally, The City of Cape Coral's excellent emergency response infrastructure has proven itself under many scenarios, and the planning mechanisms that are part of that infrastructure are in place to deal with a large variety of catastrophic events. However, it is uncertain to what extent these programs and infrastructure will be affected by future impacts associate with climate change, or to what extent additional financial resources will be needed to meet these future conditions.

Florida's Energy and Climate Change Action Plan has identified an **Adaptation (ADP) Planning Framework for Florida. The Goals and Strategies include:**

Goal 1: Ensure sufficient response capability among regional, state, and local first responders to potential increases in extreme weather events.

Goal 2: Increase the resiliency of coastal communities to storm surge.

Goal 3: Assess the role of ecosystems such as coastal wetlands and beaches and dunes in reducing risks from extreme events.

Goal 4: Plan for other extreme events (e.g., flooding, wildfire, and heat waves).

Goal 5: Develop a process for early detection, evaluation, and handling of extreme events resulting from climate change. Effectively distribute such information to key emergency preparedness and response personnel.

Goal 6: Invest in emergency response and mitigation strategies for extreme environmental events likely to be exacerbated by climate change.

Strategies:

Encourage the search for practical and effective solutions to ensure that existing and future built environment in Florida will remain habitable, providing ***viable shelter*** for the full range of human activity and ensuring continuity of critical and essential functions in the aftermath of

impact by climate change–exacerbated hazards.
Establish educational and professional ***licensing requirements*** to ensure that key professional sectors become practitioners of adaptation in support of planning, building design, and construction activities.
Foster an environment of ***communicating and sharing knowledge*** about adaptation to climate change and the adaptation/protection of the built environment among the scientific community, lawmakers, various professional sectors (practitioners), and the general public.
Make ***the practice of adapting*** the built environment to the impact of climate change an integral component of comprehensive planning, building codes, life-safety codes, emergency management, land development and zoning regulations, water management, flood control, coastal management, and community development.
Make the practice of adapting the built environment to the impact of climate change a ***preferred objective*** of building design, siting, and construction research funded by public monies in Florida.
Promote an environment for ***connecting scientific research with practical applications*** that will contribute to the adaptation of the built environment to the impact of climate change.
Promote an environment to ***connect science with decision making*** regarding climate change and the need to adapt the built environment to its impacts.
Reduce the potential for damage to the built environment from the impact of natural hazards, especially from those hazards caused or exacerbated by climate change, make this a high priority for all levels of government and the private sector in Florida.
Develop and maintain a ***local climate change adaptation plan***, to provide a framework for assessing vulnerability, identifying risks, defining and quantifying the value of the built environment that is at risk (see attachment on Quantifying Value at Risk), and identifying and implementing effective adaptation measures at each jurisdictional level (i.e., state, county, municipality, and individual facility).
Work cooperatively to ***identify and evaluate transportation infrastructure at risk*** and to coordinate adaptation efforts for infrastructure immediately landward of coastal high hazard areas or to provide emergency evacuation routes for coastal populations.

Table 8. Resiliency strategies to address emergency and hazard planning

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience in Health and Human Services

The City of Cape Coral must be prepared for an increased incidence of heat-related illness in large sectors of the public, particularly given the large population of senior citizens. As temperatures rise and the climate becomes more tropical, water- and vector-borne diseases now associated with more equatorial climes might become commonplace in The City of Cape Coral. This situation will be aggravated by increased flooding events and their associated impacts on certain portions of the public infrastructure such as sewage systems, hospitals, and nursing homes.

Consider the impact of sea-level rise or flooding and storm surges and more frequent and intense tropical storms in ***local emergency evacuation plans***.
Conduct a needs assessment and cost-benefit analysis of implementing an ***emergency heat warning system***.
Conduct community wide assessments to identify the homes occupied by ***disabled persons and seniors***; assess the safety, energy and water use efficiency of these homes, and modify or retrofit homes, if needed. Modifications could include installing: access/mobility enhancing features and other physical safety improvements (e.g., smoke alarms and walkway lighting); weatherproofing; energy efficient appliances; shade cover including planting trees.
Conduct ***health assessments of proposed mitigation and adaptation strategies***, including impacts on vulnerable populations and communities and assessment of cumulative health impacts; conduct health assessments of land use and transportation proposals that could impact health, greenhouse gas emissions, and community resilience for climate change.
Consider climate change as part of planning efforts directed at attaining the health based ambient ***air quality standards***.
Develop climate change ***communication tools, techniques, and messages*** that promote active public and individual discourse, engagement, and positive actions.
Develop integrated and comprehensive approaches to ***respond to economic and physical dislocations and shifts*** that provide support and structures to either mitigate the impacts of these shifts or stabilize neighborhoods and communities as quickly as possible after dislocations.
Develop ***real-time surveillance and reporting*** of deaths, and collect supplemental information from coroners and explore partnering with the health care providers' system for syndromic surveillance opportunities.
Develop ***regional definitions for heat alerts/warnings*** which are based on public health thresholds for heat morbidity.
Disseminate ***information specific to vulnerable populations*** (e.g., outdoor workers and residents

in urban heat islands or people with chronic illness regarding heat, immigrants with literacy/language needs).
Disseminate ***information to address specific risks*** associated with climate change (e.g. to prevent heat illness in communities and in workplaces, vector borne, or food-borne disease, etc.).
Educational materials should be available in ***multiple languages*** to reach wider audiences.
Elevate structures above the minimum threshold for the 100-year storm.
Empower and engage communities for action to mitigate and adapt to climate change.
Engage vulnerable communities and at-risk populations.
Ensure public health participation in and preparation for discussions about proposed mitigation and adaptation strategies and in land use and transportation planning processes.
Ensure that health care providers are educated about climate change and health impacts thereof, including diagnosis and treatment of climate-related illness and recognition of emerging trends.
Expand "safe routes to school" and "green tools for schools" to promote increased physical activity, enhance school performance, and improve health and safety of children in and around school.
Expand training and education of health and social services systems/providers to identify and treat ***mental health problems*** and integrate mental health into systems and services deployed post disaster and in the wake of economic and other dislocating or disruptive climate related changes.
Formally engage the full community in planning and preparing for an ***effective disaster response***, as well as climate change mitigation and adaptation. It is especially critical that efforts are made to engage the most vulnerable segments of the community in this planning. This could help to fortify community mental health in advance of a disaster or the changes required for mitigation or adaptation.
Identify ***"heat island" areas*** of the community and increase ground cover and shade by creating or expanding urban forests, community gardens, parks, and native vegetation-covered, open spaces.
Identify and provide research to develop and continually refine ***comprehensive strategies to minimize the impacts*** of climate change on human health.
Identify specific groups at risk for ***heat-related illness***, including the elderly and outdoor workers (farm workers, construction).
Improve ***coordination of health-risk communication*** strategies and integrate climate change in

other efforts (e.g. PH preparedness).
Increase access to ***air conditioning***, particularly in areas where it is currently not common and in population groups that lack access. Consider expanding existing programs that help low income people pay for residential heating to include residential cooling as well. (Note that air conditioning use may increase greenhouse gas emissions and health problems related to fossil fuel combustion.)
Increase public awareness and understanding of climate change impacts on human health, the need to prepare for these changes, and the likelihood that adaptation and preparedness efforts will be overwhelmed without also taking urgent and strong actions to prevent dangerous climate change.
Increasing community ***bike/walkability and expanding public transit*** – measures that will also improve health through increased physical activity and possibly reduced injury rates. ✸
Increasing ***preparedness and response to outbreaks of diseases*** that may become more prevalent with warmer temperatures.
Initiatives like the California Green Chemistry Initiative that support ***reduced use of toxic materials*** and use of alternatives that maintain product performance but reduce environmental and health effects will be central to any strategy to build community resilience.
Integrate climate change mitigation and adaptation; encourage adaptation strategies that maximize health co-benefits, minimize unintended consequences, and simultaneously mitigate climate change.
Maintaining strict regulation of ***air pollutants*** will be an important support to community resilience. Some pollutant levels will be altered by changing temperatures and locations. Furthermore, some of the regulated air pollutants may act as green house gases and therefore require more stringent regulation. New controls for green house gases that are not presently regulated as pollutants will be required.
Outreach to businesses and private sector.
Outreach to clinicians and health sector.
Prepare to reduce and respond to ***heat stress***, which increases the incidence of heart attacks and other emergency room visits.
Primary prevention: preventing the occurrence of illness and injury through reduction of exposure to risk factors. Primary prevention in climate change is through reduction of greenhouse gas emissions to reduce the severity of climate change impacts (for example the amount of global warming) over time; some experts have called this "primordial" prevention (McMichael, 2000). ✸
Promote ***healthy and resilient populations***, communities, and human environments, including

reduction of existing health and environmental inequities, to increase preparedness for unavoidable climate change and ability to reduce greenhouse gas emissions.
Promote increased ***access to health care***, to ensure adequate access for individuals who suffer health consequences related to climate change.
Promote sustainable ***local food systems***: a sustainable food system provides healthy, accessible, and affordable food while maintaining healthy ecosystems with minimal negative impact on the environment. http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1361 Local food systems help reduce the length of the supply chain between producer and consumer, as well as the amount of inputs needed to produce food, including fertilizers, transportation, and storage, all of which should help reduce costs. From an emissions perspective, food miles make up a very significant proportion of all vehicular transport which also contribute to congestion, demand for new roadways, and fuel consumption.
Provide and maintain ***resources*** required to implement comprehensive strategies to minimize the impacts of climate change on human health and well-being.
Reduce health inequities and ensure health promotion and protection for vulnerable populations and communities.
Reduce climate-change related exposures – for example by shading buildings to reduce heat exposure – are another example of primary prevention.
Reducing exposures to ***combustion products*** (e.g. through actions such as CARB regulations on diesel trucks, increased car fuel efficiency, etc.)
Review and, as appropriate, revise ***occupational health and safety standards*** to identify occupations at risk due to climate change or climate mitigation and adaptation strategies: for example, agricultural and construction workers exposed to heat, solar installation workers at high risk of falls (similar to roofers), forest fire fighters, solar panel manufacturing workers, etc.
Review and expand existing ***vector control programs*** as necessary.
Secondary prevention: early detection and slowing the onset or progression of illness. For example, identification of people that might be particularly sensitive to heat and provision of advice and cooling and hydration stations.
Strengthen surveillance for temperature-related mortality and adverse health effects of air pollution exposure and wildfires, as well as infectious diseases related to water, vector, and food borne pathogens.
Tertiary prevention is the treatment and management of illness and disability that could not be prevented, such as provision of appropriate health care to those who suffer heat illness in order to prevent severe heat stroke, or management of heat stroke to prevent neurological damage.
Urgently expand dissemination of climate change health impact information including impacts,

co-benefits of mitigation strategies, and preparedness strategies

Table 9. Resiliency strategies to address health and human services

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience Land Use Planning and Growth Management and the Urban, Suburban and Rural Landscape

Land use and climate change in Florida are deterministically linked issues. Past and current projections of development within The City of Cape Coral are not consistent with either the goals of sustainable development or maximizing the opportunity for climate mitigation and adaptation through land management.

Adaptation options that protect coastal land and development focus on land use planning and management, land exchange and acquisition programs, and changes to infrastructure. Some adaptation options aim to protect the land itself, while others are aimed at protecting existing development (e.g., homes and businesses) and infrastructure (e.g., sewage systems, roads). Land use management involves using integrated approaches to coastal zone management as well as land use planning. Land exchange and acquisition programs allow for coastal land to be freed up for preservation uses. Changes to infrastructure can include limiting where hazardous and polluting structures can be built (including landfills and chemical facilities) as well as changing engineering structures that affect water bodies and will be impacted by climate change (Martinich 2008).

Land use planning and management, as well as changes in infrastructure, would be appropriate adaptation options for programs that are looking to implement anticipatory changes. These options require working with various key stakeholders and a have a longer timeline for implementation. Land exchange and acquisition programs would be viable options for estuaries that have a management goal of acquiring more land in order to protect currently threatened areas (Martinich 2008).

One way for decision makers to more completely understand the impacts of land use changes is to analyze choices using Cost of Community Services studies.

Cost of Community Services

Cost of Community Services (COCS) studies use a case study approach to determine the fiscal contribution of existing local land uses. It is a subset of the much larger field of fiscal analysis. COCS studies have emerged as an inexpensive and reliable tool to measure direct fiscal relationships (American Farmland Trust 2007).Their particular niche is to evaluate working and open lands on equal ground with residential, commercial and industrial land uses.

COCS studies are a snapshot in time of costs versus revenues for each type of land use. They do not predict future costs or revenues or the impact of future growth. They do provide a baseline of current information to help local officials and citizens make informed land use and policy decisions. In a COCS study, researchers organize financial records to assign the cost of municipal services to working and open lands, as well as to residential, commercial and industrial development. Researchers meet with local sponsors to define the scope of the project and identify land use categories to study. For example, working lands may include farm, forest and/or ranch lands. Residential development includes all housing, including rentals, but if there is a migrant agricultural work force, temporary housing for these workers would be considered part of agricultural land use. Often in rural communities, commercial and industrial land uses are combined. COCS study findings are displayed as a set of ratios that compare annual revenues to annual expenditures for a community's unique mix of land uses (American Farmland Trust 2007).

COCS studies involve three basic steps:

1. Collect data on local revenues and expenditures.

2. Group revenues and expenditures and allocate them to the community's major landuse categories.

3. Analyze the data and calculate revenue-to-expenditure ratios for each land use category.

The process is straightforward, but ensuring reliable figures requires local oversight. The most complicated task is interpreting existing records to reflect COCS land use categories. Allocating revenues and expenses requires a significant amount of research, including extensive interviews with financial officers and public administrators.

Communities often evaluate the impact of growth on local budgets by conducting or commissioning fiscal impact analyses. Fiscal impact studies project public costs and revenues from different land development patterns. They generally show that residential development is a net fiscal loss for communities and recommend commercial and industrial development as a strategy to balance local budgets. Rural towns and counties that would benefit from fiscal impact analysis may not have the expertise or resources to conduct a study. Also, fiscal impact analyses rarely consider the contribution of working and other open lands, which's very important to rural economies.

American Farmland Trust (AFT) developed COCS studies in the mid-1980s to provide communities with a straightforward and inexpensive way to measure the contribution of agricultural lands to the local tax base. Since then, COCS studies have been conducted in at least 128 communities in the United States.

Southwest Florida has paid a high price for unplanned growth. Scattered development frequently causes traffic congestion, air and water pollution, loss of open space and increased demand for costly public services. This is why it is important for citizens and local leaders to understand the

relationships between residential and commercial growth, agricultural land use, conservation and their community's bottom line.

COCS studies help address three claims that are commonly made in rural or suburban communities facing growth pressures:

"1. Open lands—including productive farms and forests—are an interim land use that should be developed to their 'highest and best use'."

"2. Agricultural land gets an unfair tax break when it is assessed at its current use value for farming or ranching instead of at its potential use value for residential or commercial development."

"3. Residential development will lower property taxes by increasing the tax base."

While it is true that an acre of land with a new house generates more total revenue than an acre of hay or corn, this tells us little about a community's bottom line. In areas where agriculture and/or forestry are major industries, it is especially important to consider the real property tax contribution of privately owned working lands. Working and other open lands may generate less revenue than residential, commercial or industrial properties, but they require little public infrastructure and few services.

COCS studies conducted over the last 20 years show working lands generate more public revenues than they receive back in public services. Their impact on community coffers is similar to that of other commercial and industrial land uses. On average, because residential land uses do not cover their costs, they must be subsidized by other community land uses. Converting agricultural land to residential land use should not be seen as a way to balance local budgets.

The findings of COCS studies are consistent with those of conventional fiscal impact analyses, which document the high cost of residential development and recommend commercial and industrial development to help balance local budgets. What is unique about COCS studies is that they show that agricultural land is similar to other commercial and industrial uses. In every community studied, farmland has generated a fiscal surplus to help offset the shortfall created by residential demand for public services. This is true even when the land is assessed at its current, agricultural use. As more communities invest in agriculture this tendency may change. For example, if a community establishes a purchase of agricultural conservation easement program, working and open lands may generate a net negative.

Communities need reliable information to help them see the full picture of their land uses. COCS studies are an inexpensive way to evaluate the net contribution of working and open lands. They can help local leaders discard the notion that natural resources must be converted to other uses to ensure fiscal stability. They also dispel the myths that residential development leads to lower taxes that differential assessment programs give landowners an "unfair" tax break, and that farmland is an interim land use just waiting around for development (American Farmland Trust 2007).

In COCS studies in Florida the ratios of public revenues gained to public costs are 1: 1.39 for residential including farm houses; 1: 0.36 for commercial and industrial; and 1: 0.42 for agricultural and natural lands (Dorfman 2004).

In urban areas, a critical element of reducing GHG emissions involves the protection of green space and vegetation because they absorb urban heat caused by heat islands, sequester carbon, reduce flooding, and clean stormwater runoff. Trees also provide shade from the sun.

The fact that Florida's increase in vehicle miles of travel more than doubled the rate of population growth underscores the land use planning-climate change connection and the fact that most Floridians depend on a car to get to where they want to go. The predominant pattern of growth in the state (low density, disconnected development pushing into rural areas and away from urban areas) not only encourages more driving, but also requires it. That has led to longer commutes for daily activities, more time stuck in traffic (meaning higher carbon emissions), less green space to sequester carbon, and higher energy consumption. Those outcomes, coupled with limited opportunities for biking, walking, and transit due to the low density form of development, have only magnified Florida's GHG emissions (and explain why 40 percent of those emissions are attributable to transportation). The strategies outlined below illustrate steps that local governments and communities can take to start reshaping land use patterns, thereby reducing the number of miles Floridians drive each day and the state's GHG emissions.

Adopt an ***urban growth boundary*** or other measures to contain growth within a designated urban area.
Allocating land for long-term potential population migrations.
Careful consideration of location of existing and future ***critical facilities***.
Consider climate change impacts in all nine of Florida's required ***comprehensive plan elements***, particularly those addressing Coastal Management and Capital Improvement.
Create an Employee Assisted Housing Program to encourage employees to ***live closer to work***.
Designate ***priority growth areas*** outside of high hazard zones for targeting infrastructure investments and other types of funding.
Development of a ***Solar Strategy*** for inclusion in the comprehensive plan.
Enacting ***land use policies*** (for example, overlay zones), to minimize development in coastal hazard areas (locating it away from coastal hazards and retreating or relocating public facilities and infrastructure) and low lying interior areas.
Establish an ***assessment of GHG emissions*** as a part of the development review and environmental impact assessment processes.
Establish targets for ***reducing vehicle miles of travel*** in comprehensive plans and in metropolitan

planning organization plans.
Establish ***zoning*** (for example, Agricultural Zoning and Conservation Design) and incentive programs (e.g., a purchase or transfer of development rights program) to protect agriculture and natural systems.
Identifying adaptation projects in a community's ***hazard mitigation plan***.
Incorporating sea-level rise scenarios in modeling of the ***30-year erosion line*** used for the Coastal Construction Control Line and revising land suitability criteria to prevent development of vulnerable land.
Policy analysis regarding land use regulations.
Actively ***reduce automobile dependency*** in the City.
Consider ***transit oriented development*** and fight urban sprawl.
Incentivize development and redevelopment within the urban area.
Promote increased density and a reduction in the amount of ***impervious surface***.
Reduce existing density in ***coastal high hazard area***.
Site public facilities next to one another to reduce travel time and ***maximize building use***.
Target expenditures through the Capital Improvement Plan to existing neighborhoods and town centers to ***limit sprawl*** on the edge of the City.
Use local zoning and land development regulations to require and/or provide ***incentives*** for compact mixed-use, walkable, and transit-oriented development, brownfield and greyfield redevelopment, and infill development. Incentives might include density bonuses or impact fee reductions or waivers.
Use ***scenario planning*** to understand the impacts of alternative growth patterns on how far people have to drive (vehicle miles of travel).
Identify climate change adaptation policies that can be ***implemented without funding***.

Table 10. Resiliency strategies to address land use planning

For more information on energy-efficient land use planning practices that create more compact walkable, less car-dependent communities and preserve farmland and natural systems, go to the American Farmland Trust (www.farmland.org), American Planning Association (www.planning.org), the Congress for the New Urbanism (www.cnu.org), the Conservation Fund (www.conservationfund.org), the Lincoln Institute of Land Policy (www.lincolninsti.edu), the Local Government Commission (www.lgc.org), the Nature Conservancy (www.nature.org), the Trust for Public Lands (www.tpl.org), Smart Growth America (www.smartgrowthamerica.org), the Smart Growth Network (www.smartgrowth.org) and its

Getting to Smart Growth: 100 Policies for Implementation (www.smartgrowth.org/pdf/gettosg.pdf), and the U.S. Green Building Council (www.usgbc.org). In Florida, resource organizations include the Department of Community Affairs (www.dca.state.fl.us), the Department of Environmental Protection (www.dep.state.fl.us), 1000 Friends of Florida (www.1000fof.org), and Florida's regional planning councils (listed at www.nefrpc.org/links.htm).

Acquire/protect ***critical habitat*** areas
Adopt building design criteria that consider ***more severe hurricanes.***
Adopt building design criteria that consider ***sea level rise.***
Change building codes to ***promote energy efficient building.***
Consider climate change in ***infrastructure planning.***
Consider climate effects in choice of ***building materials.***
Consider sea level rise in ***site design.***
Constrain locations for certain high risk infrastructure.
Control building with ***zoning and permitting.***
Create more energy- & cost-effective communities through ***community design and green building.***
Don't allow development or engineering solutions to block migration of wetlands
Ensure that master plans explicitly indicate which areas will ***retain natural shorelines***.
Establish a ***Transfer of Development Rights Program*** to move density from open space areas to be protected to areas suitable for development.
Establish ***rolling easements***.
Improve ***land use management***.
Provide Infill incentives.
Maintain and restore ***parks***.
Plant native shade ***trees*** around local government buildings and in and around parking lots and garages.
Preserve ***open space*** and create greenways.
Promote ***green roofs*** through building codes.
Provide ***alternative transportation.***
Reduce/eliminate development in ***sensitive areas/coast***.
Start an Urban Forest or ***Plant-A-Tree*** program.
Strict ***enforcement*** of existing codes.
Set Urban growth boundaries.
Use ***integrated coastal zone management*** in land planning.

Subsidize retrofitting buildings for energy efficiency.
Purchase upland development rights/property rights.
Increase use of ***alternative and renewable energy***.
Identify conflicting policies between programs.
Reduce local ***GHG emissions***.
Integrate ***carrying capacity principles*** into comprehensive planning.
Elevate land surfaces.
Establish living shorelines.
Increase shoreline setbacks.
Adopt ***building design criteria*** that consider all adaptation requirements.
Redefine and update ***flood hazard zones***.
Use ***LID*** standards in building.
Use ***flexible planning***.
Ensure appropriate ***foundations*** for buildings.
Plan for regional ***relocation & displacement***.
Remove unnecessary/inundated infrastructure.

Table 11. Resiliency strategies to address to address urban, suburban, and rural land use

Two useful documents related to the multiple values of trees to urban areas are:

- *Summary Report of Calculated Public Tree Values and Benefits for Historic Springfield District and Mandarin Road: The City of Jacksonville, Florida* prepared in 2001 by the city's Urban Forester. The report documents the public values of trees using the U.S. Forest Service's STRATUM (Street Resource Analysis Tool for Urban Forest Managers) Benefit Model. The results quantify the following benefits of trees in two test neighborhoods: energy savings avoided and sequestered carbon dioxide, air quality, stormwater reduction, and aesthetic, property value, social, and economic benefits. The conclusion: a per tree cost of $12.52 and a total benefit of $56.52 means a net per tree benefit of $44.00.
- *Urban Ecosystem Analysis: City of Jacksonville, Florida*, a study by American Forests in conjunction with the state of Florida and the City of Jacksonville. The study highlights the ecosystem services that Jacksonville's urban tree canopy (their natural capital) provides. According to the report, the city's urban tree canopy saves money on managing air and water quality, helps meet environmental regulations, and fulfills city environmental protection goals. The Urban Ecosystems Analysis enables city decision-makers to calculate the value of their green infrastructure and apply that information to their planning and investment decisions.

Florida resource organizations on urban landscape programs include the Florida Urban Forest Council [www.fufc.org], which works with communities and state, local, and professional

organizations to promote urban and community forestry initiatives, and the Florida Division of Forestry [www.fl-dof.com] and its Florida Tree USA Program [www.fl-dof.com/forest_management/cfa_urban_tree_city.html], which offers grants to local governments. Additional Florida resources include the University of Florida IFAS [http://edis.ifas.ufl.edu/mg249]; Audubon of Florida [www.audubonofflorida.org]; the Florida Chapter of the Nature Conservancy [www.nature.org]; and the Florida Chapter of the Trust for Public Lands [www.tpl.org]. At the national level, resource organizations include American Forests [www.americanforests.org]; American Society of Landscape Architects [www.asla.org], Community Trees [www.communitytrees.org]; Keep America Beautiful [www.kab.org]; the Local Government Environmental Assistance Network [www.lgean.org]; the Alliance for Community Trees [actrees.org/site]; the National Arbor Day Foundation [www.nationaltreetrust.org], and, in Florida, [www.nationaltreetrust.org/states/?state=FL]; the National Association of Conservation Districts [www.nacdnet.org]; and the Urban and Community Forestry Program [www.fs.fed.us/ucf], a program of the U.S. Department of Agriculture Forest Service.

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience Water and Wastewater

An often overlooked consumer of energy is the municipal potable water service. The vast majority of The City of Cape Coral's fresh water comes from ground water. In the city, there is one potable water provider; City of Cape Coral Utilities. , The following map shows service areas for water utilities located within The City of Cape Coral and the portion of Charlotte County in the South Florida Water Management District.

Utility	2005	2010	2015	2020	2025	2030
Burnt Store	1,485	1,798	2,177	2,636	3,192	3,862
Cape Coral	113,221	136,694	165,034	199,249	240,558	290,717
Greater Pine Island	12,259	13,877	15,708	17,781	20,127	22,795
Lee County Utilities	216,343	233,637	252,314	272,484	294,267	317,567
Self-Supplied (DSS)	68,566	64,517	60,707	57,122	53,749	40,088
Cape Coral Total	413,879	452,533	497,955	551,292	613,918	677,059
LWC Planning Area Total	910,375	994,777	1,090,633	1,209,052	1,349,288	1,506,233

Table 12. Public water supply and domestic self-supply projections of population.

Source: LWCWSP 2012, SFWMD.

Strategies related to water and wastewater focuses on energy costs and efficiencies. Local governments can take actions to:

Acquire land for flood/water supply.
Acquire land for ***recharge.***
Reduce local GHG emissions.
Build ***climate-friendly landscaping*** into codes and educate homeowners.
Capture ***digester gases*** from wastewater reclamation plants and use them to produce electricity.
Change ordinances that require vegetation such as non-native turf grass.
Channel water from impervious to pervious areas.
Charge more for certain potable water uses.
Charge more for treated water (similar to Sarasota).
Use and encourage use of ***cisterns/rain barrels***.
Water Use Conservation
Water Conservation education
Consider climate change in ***water supply planning.***
Control ***fertilizer*** use.
Control ***invasive exotic*** species.
Create ***redundancy*** in water supply.
Desalinization
Maintain ***drinking water standards.***
Engage in ***drought preparedness planning.***
Encourage ***composting and mulching*** to reduce irrigation.
Identify ***alternative water sources***.
Identify conflicting policies between programs.
Improve water distribution systems and ***leak detection*** and management.

Improved system of ***retaining rainwater***.
Increase ***stormwater management capacity***.
Increase native tree cover to reduce evaporation from ground.
Install ***rainfall sensors*** to reduce automatic irrigation.
Minimize impervious surfaces to increase recharge.
Use of ***reclaimed water for irrigation***.
Minimize use of potable water for irrigation.
Protect groundwater sources.
Reduce runoff into streams and canals.
Reinforce existing infrastructure.
Evaluate re-pricing water on a ***sliding scale***.
Require City use of ***climate-friendly landscaping***.
Reservoir(s)
Use ***native plants*** in landscaping.

Table 13. Resiliency strategies to address water and wastewater

A number of water planning resource organizations are listed in the Water Resource chapter. Other sources of information about water and wastewater management include the EPA through its Energy Star Program [http://energystar.gov/index.cfm?c=government.bus_government_local] and its Office of Wastewater Management [www.epa.gov/owm]; the Florida Department of Environmental Protection's Office of Wastewater Management [www.dep.state.fl.us/mainpage/programs/wastewater.htm]; the Florida Water Environment Association [www.fwea.org]; and the Water Environment Federation [www.wef.org/Home].

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience in Waste Management

The collection, transportation and ultimate disposal of municipal household waste can be very energy intensive. Land use and transportation facilities are a very important factor in the cost of garbage collection. More dense urban environments may allow collection fleets to travel fewer miles to reach the collection capacity of the vehicle. Less dense land use patterns require

collection vehicles to travel larger distances to fill vehicles to capacity. Landfill and/or incineration facility location can also influence the energy consumed and thus the cost of transporting municipal waste. These types of facilities are often unwanted land uses subject to local residents' opposition and thus are often located in areas removed from concentrated human populations.

Considering the greenhouse gas emissions required to collect and transport solid waste, it is important to offer strategies to reduce municipal waste and adapt to changing climactic conditions. Consumers should be aware that the many relatively small components of the national solid waste stream add up to millions of tons. One of the easiest and most effective strategies to reduce greenhouse gases produced from rubbish collection and transport is the promotion of a reduction in the amount of waste stream that must be collected. This can be accomplished in a number of ways and must be examined from the perspective of the full life cycle of products, materials and lawn vegetation/plants that ultimately produce waste. First, consumers should actively seek to minimize product packaging. This includes the packaging of the packaging (i.e. plastic and paper bags consumers use to "contain" materials purchased). Second, consumers should consider the life expectancy of a product prior to purchase. The longer the product lasts, the longer it stays out of the waste stream. Third, consumers should evaluate if products could be reused for other activities. Fourth, consumers should consider separating wastes by type. Food/agricultural wastes, landscape trimmings and yard wastes can easily be composted at the point of consumption (for residential consumers). Composting at the point of consumption can greatly reduce the amount of material that is collected and transported to either a landfill or waste to energy plant. The reduction in material generated can increase the number of garbage producers serviced per truck and thus reduce greenhouse gas emissions generated by the collection fleet.

Consideration should also be given to one time projects such as home construction, remodeling, replacement of building systems and materials, some fabrication and the wastes associated with those activities. Steps should be taken to reduce the waste stream generated from construction activities. The US Green Building Council's Leadership in Energy and Environmental Design (LEED©) certification framework encourages the reuse of building materials, use of recycled materials and the reduction and diversion of waste materials from the solid waste stream that is to be collected by waste haulers.

One time projects such as reroofs can contribute significantly to the waste stream. According to the Asphalt Roofing Manufacturers Association, over 12.5 billion square feet of asphalt shingle products are manufactured annually. That is enough to roof more than 5 million homes. Four out of five homes are roofed with asphalt shingles. http://www.asphaltroofing.org/resources_faq.html. If we assume all 12.5 billion square feet of asphalt shingles are produced for reroofing work and the project includes a complete tear off of the existing finished roofing materials and underlayment and that each 100 square feet of asphalt roofing material weighs 240 pounds, then the estimated national waste stream generated by reroofing work would be 30,000,000,000 pounds (12.5 billion/100 square feet*240 pounds per 100 square feet). This is an enormous annual burden on our solid waste disposal facilities.

Another consideration beyond the greenhouse gases emitted from the collection, transportation and processing of waste is the embodied-energy of materials. This concept acknowledges that it takes energy to harvest/extract raw materials for production, process transport and install and/or consume materials. If products consume less raw materials (less packaging or longer duration of use) or are reused then there is less energy input in the creation of additional products.
Lee County's current solid waste collection system is separated into three parts 1) non-recyclable household waste 2) recyclable household waste and 3) yard (vegetative) waste. These are collected from source producers (such as individual households) and transported to the waste-to-energy plant located at 10500 Buckingham Road. At the facility, non-recyclable materials and yard waste are incinerated to generate electricity. The single stream recyclable materials are separated into their individual components. Components such as milk jugs, laundry bottles, steel cans, aluminum cans, cardboard and paper are separated and compressed into bundles. These bundles are sold on the open market to help offset the cost of waste collection.

In the 2009 fiscal year, the County's waste-to-energy plant generated approximately 355,000 megawatts of electricity. Of this, 60,000 megawatts were consumed by the facility and 295,000 megawatts were feed into the grid and sold to electric utility rate payers. The combustion of household waste reduces the volume of material that needs to be land filled by 90 percent. The combustion of waste also reduces the production of gases with high global warming potentials, such as methane. These gases are produced from the anaerobic decomposition of organic materials such as food waste. The combustion of these wastes at the waste to energy facility eliminates this process and the high global warming potential gases that are produced in the process.

Waste management tools to conserve energy and reduce GHG emissions focus mainly on reducing, recycling, and reusing waste. Reduction (often called waste prevention or source reduction) programs address consuming and throwing away less – that is, they prevent the generation of waste. Strategies include purchasing durable, long-lasting goods; seeking products and packaging that are as free of toxins as possible; and redesigning and purchasing products that use less raw material in production, have a longer life, or can be reused.

Reuse programs promote selling, repairing, or donating products to charity and community groups. Reusing products can be better than recycling because the item does not need to be reprocessed before it can be used again. "Up-cycling" is a growing trend in which materials that have been used for their primary purpose are made into something else and are repurposed. Examples include items like wallets and purses made from durable plastic wrappers that are cleaned and sewn together, or clothing and home décor items made from cloth grain and flour sacks. EPA estimates that, nationwide, curbside recycling programs, along with drop-off and buy-back centers, resulted in a diversion of about 32 percent of the nation's solid waste in 2005

. Composting, another form of recycling, involves the controlled biological decomposition of organic matter, such as food and yard wastes, into humus that can be used in vegetable and flower gardens, landscaping, and many other applications. The City of Cape Coral currently collects all yard waste from residences and converts it to mulch, which is then provided free of charge to residents at several locations. Use of mulch in residential landscaping, in turn, helps hold moisture in soil, reducing the need for irrigation.

Buy supplies made with ***recycled content***.
Consider ***leasing programs*** to ensure reuse and recycling.
Donate used equipment, along with magazines and publications, to schools or other organizations.
Educate businesses and residents on waste reduction, reuse, and recycling strategies and their benefits.
Enact ***purchasing guidelines*** that emphasize materials and products with recycled content.
Establish a ***Recycle on the Go*** program (an EPA initiative [www.epa.gov/epaoswer/non-hw/payt/]). The program involves placing recycling containers where large numbers of people gather, such as parks, stadiums, transportation hubs, special event venues, and shopping centers.
Establish an ***internal program to recycle*** paper, plastic, metal, and other products, including printer ink cartridges.
Expand ***community recycling*** programs. For example, establish a large trash pick-up day and extend recycling to include organic and yard debris collection and composting.
For waste that must be land-filled, ***capture the resulting methane*** and utilize it as a clean, renewable source of energy.
Implement and educate the public on ***penalties for non-compliance*** with recycling programs.
Purchase and use ***refillable pens***.
Require that city fleet facilities implement or improve ***recycling programs for tires, batteries, brakes, solvents, and oils***.
Require that debris collected through trimming trees and cutting grass on public property (parks, medians, around government buildings) be ***composted and reused as mulch***.
Require use of ***durable coffee mugs, plates, and utensils*** in by the City in offices and at meetings.
Set ***recycling goals*** and monitor results.
Set up a ***paint collection program*** and donate the paint to a local charity for distribution to needy families.
Use ***two-sided printing and copying***.

Table 14. Resiliency strategies to address waste management

In Florida, the Department of Environmental Protection, through its Division of Waste Management [www.dep.state.fl.us], offers information and technical assistance on recycling programs. Division programs include the Recovered Materials Dealers Certification Program, the Construction and Demolition Debris Facilities Reporting Program, and the Green Lodging Program that requires lodging facility improvement in the areas of communication, water conservation, energy efficiency, waste reduction, and clean air practices. Financial programs to encourage recycling include the Innovative Recycling and Waste Reduction Grants Program, a loan program for businesses that engage in recycling; and a Recycling and Reuse Business Assistance Center [www.dep.state.fl.us]. The EPA also offers information about programs to reduce, reuse, and recycle wastes [www.dep.state.fl.us/mainpage/programs/waste.htm] and sponsors a number of waste management programs – the Landfill Methane Outreach Program [www.epa.gov/lmop], WasteWise [www.epa.gov/epaoswer/non-hw/reduce/wstewise/climate], and the Responsible Appliance Disposal Program [www.epa.gov/ozone/snap/emissions/radp.html].

Addition resources on waste reduction, reuse, and recycling include Florida's America Recycles [www.dep.state.fl.us], the International City/County Management Association [www.icma.org], the Local Government Commission [www.lgc.org], the National Recycling Coalition [www.nrc-recycle.org], Recycle Florida Today [www.recyclefloridatoday.org], the Southern Waste Information Exchange [www.wastexchange.org], and the University of Florida TREEO Center [www.treeo.ufl.edu/sw].

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience in Economic Development

Local and regional economic development organizations can offer industry recruitment incentives and entrepreneurial assistance programs to attract businesses involved in the emerging clean energy technology sector:

- Help businesses take advantage of the tax refund incentive that Enterprise Florida (the state's primary economic development organization: www.eflorida.com) offers to attract new and expanding businesses in selected targeted industries. Alternative energy is among the targeted industries in the Emerging Technologies cluster. Described below under Renewable, Green Energy, the Florida Energy Office also offers state incentives for the use of renewable energy.
- Encourage developers to utilize the Florida Community Loan Fund (www.greencommunitiesonline.org/about/programs/florida.asp), a joint initiative of the Florida Green Building Council (floridagreenbuilding.org) and Enterprise Partners, Inc., through its Green Communities Initiative (www.greencommunitiesonline.org). The two have joined forces to invest more than $2.7 million to help build or renovate at least 200 affordable green homes in Florida that promote health, conserve energy and natural resources, and provide easy access to jobs, schools, and services. Incentives include more

than $2.5 million in discounted green loans to developers of affordable residential or supportive housing; $200,000 in grants to help cover costs associated with building green; technical assistance at no cost through the Florida Solar Energy Center (www.fsec.ucf.edu); and competitively priced equity through the Low-Income Housing Tax Credit.

- Work with the farming community, landowners, and conservation organizations to establish a green payment program that compensates farmers for environmental services provided by their land, thereby providing another source of income. Those services can include carbon sequestration, whereby energy companies begin to purchase carbon credits in the open market, paying farmers to help mitigate climate change by planting grasses or trees or using no-till planting techniques that leave the soil largely undisturbed and trap carbon in the ground instead of releasing it into the atmosphere. Forest land is also an important part of the carbon trading market. The Florida Forestry Association (www.floridaforest.org), which helps landowners market carbon sequestration to buyers seeking to reduce their greenhouse gas emissions, estimates that Florida's forests sequester 5.9 million tons of carbon annually.

Additional resource organizations for attracting green technology business include Ceres [www.ceres.org], a national network of investors, environmental organizations, and other public interest groups working with companies and investors to address sustainability challenges such as global climate change, and Capital E [www.cap-e.com], which provides consulting, technology assessment and deployment, and advisory services to firms and investors in the clean energy industry. The American Farmland Trust [ecosystemmarketplace.com] provides information on green payments and agriculture's role in reaching climate change goals, including offsetting carbons, growing biofuels, and generating alternative energy such as wind and solar power.

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience for Natural Systems and Resources

Adopt protections of ***critical biogeochemical zones***.
Measures to ***reduce local GHG emissions.***
Allow ***coastal wetlands*** to migrate inland.
Collect data on and map ***existing conditions***.
Conservation ***land acquisition***.
Controls/ restrictions on growth.
Develop ***GIS-based decision-making/visualization tools***.

Developing programs that ***facilitate species migration*** (for example, planting foods and providing shelter for birds whose habitat is covered with water).
Establish and use ***land exchange*** programs.
Establish ***early warning sites*** and gather baseline data.
Establish funds for land purchase.
Establish ***living shorelines***.
Establish ***migration routes*** for wildlife.
Establish ***seed banks***. for use by residents
Establish ***strong laws*** to protect habitat.
Explicitly indicate in Comprehensive Plan which areas will retain natural shorelines.
Fertilizer regulation.
Habitat protection/retention
Improve ***site planning controls.***
Incorporate wetland protection into ***infrastructure planning.***
Incorporate wetland protection into ***transportation planning.***
Restore mangroves in front of bulkheads.
Minimize habitat alteration.
Prohibit new ***bulkheads***.
Promote ***catch and release*** fishing.
Regulate import of ***exotics***.
Remove invasive species and ***restore native*** species.
Seagrass protection and restoration.
Use of CLIP, FNAI, etc. to ***prioritize land purchases***.
Use more climate-resilient landscaping.

Table 15. Resiliency strategies and actions to address natural systems and resources

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience using Renewable, Green Energy

Renewable, green energy sources come from natural sources such as the wind, sun, tides, and geothermal heat that are constantly being replenished and will not run out. Examples include electricity generated from solar power, wind power, hydrogen, hydropower, and biomass (the organic matter that makes up plants). Biomass and biofuels can also be used to power transportation. Renewable energy sources are in contrast to energy from fossil fuels, such as coal, oil, and natural gas, which draw on nonrenewable sources that will diminish over time and cannot be re-created. According to the National Renewal Energy Laboratory, most renewable energy comes directly or indirectly from the sun in the form of solar energy that can serve a variety of uses, including heating, cooling, and lighting homes and other buildings, hot water heating, and commercial and industrial uses.

Conduct ***education programs*** on the benefits of alternative fuel vehicles.
Create ***financial incentives*** for greater use of renewable energy in new construction and in existing buildings.
Generate electricity from landfill or wastewater methane or refuse.
Install ***solar thermal and solar photovoltaic*** systems (systems that use semiconductor materials to convert sunlight to electricity) in government facilities.
Launch ***green power*** programs for citizens and businesses.
Require the purchase of ***energy from renewable, green sources***; purchase renewable energy certificates (a shorter term action). Green energy certificates (also known as green tags or tradable renewable certificates) represent the environmental attributes of power generated from renewable electric plants.
Require use of ***alternative fuels in city fleets***.

Table 16. Resiliency strategies and actions to address renewable, green energy

In Florida, a principal resource for information about renewable fuel sources is the Florida Energy Office (www.dep.state.fl.us/energy), the state's primary center for energy policy. In addition to developing and implementing Florida's energy policy, the Energy Office coordinates all federal energy programs delegated to the state. Under the state's Energy Future program, the office is also focusing on advancing clean energy sources, energy conservation, and efficiency through the promotion of hydrogen power, solar energy, bio-based fuels, and clean vehicles. As a part of this focus, the Energy Office maintains a Directory of Biofuels (biodiesel and ethanol)

Retailers in Florida and offers a number of financial incentives to businesses, organizations, and residents seeking to use renewable energy technologies (www.dep.state.fl.us/energy/incentives.htm). Those incentives include a Solar Energy Systems Rebate Program, a Renewable Energy Technologies Grant Program, a Renewable Energy Technologies Tax Incentives Program, and the Florida Farm to Fuel Grant Program.

The Department of Agriculture and Consumer Services, through its Florida Farm to Fuel Program (www.floridafarmtofuel.com), is assisting Florida farmers and ranchers with the production of biofuel crops to help reduce the nation's dependency on foreign oil. The department is partnering with the Florida Department of Financial Services to explore how Florida's economy could be affected by climate change and the state's opportunities to expand renewable energy sources (www.floridaclimatechange.com). The Department of Agriculture and Consumer Services also sponsors an annual Farm to Fuel Summit (www.floridafarmtofuel.com/summit_2007.htm).

At the national level, the EPA and the U.S. Department of Energy provide information on renewable, green power. EPA programs include the Green Power Partnership (www.epa.gov/greenpower), which encourages organizations to buy green power in order to decrease the environmental impacts associated with conventional electricity use and the Landfill Methane Outreach Program (www.epa.gov/lmop). EPA also offers fact sheets on biofuels (www.epa.gov/SmartwayLogistics/growandgo/info.htm) and Renewable Energy Pollution Prevention (www.epa.gov/solar), a web site addressing the pollution prevention benefits of using renewable energy and ways to obtain electricity from green power marketers and utilities. The Department of Energy's Green Power Network (www.eere.energy.gov/greenpower), operated and maintained by the National Renewable Energy Laboratory (www.nrel.gov/learning), provides news and information on green power markets and related activities. The Clean Cities Program (www.eere.energy.gov/cleancities), another Department of Energy initiative, works with a network of volunteer coalitions that develop public/private partnerships to promote alternative fuels and vehicles, fuel blends, fuel economy, hybrid vehicles, and idle reduction. Organizations providing green power in each state are listed at www.eere.energy.gov/greenpower/buying/buying_power.shtml.

Additional renewable, green energy resource organizations in Florida include the Florida Center for Renewable Chemicals and Fuels [http://fcrc.ifas.ufl.edu], the Florida Energy Commission [www.floridaenergycommission.gov], the Florida Hydrogen Initiative [www.h2florida.org], the Florida State Chapter of the Energy Services Coalition [www.escperform.org/chapters/FL/resources.htm], the Florida Solar Energy Center [www.fsec.ucf.edu], and the University of Florida Institute of Food and Agricultural Sciences Living Green programs [http://livinggreen.ifas.ufl.edu/energy/renewable_energy.html]. Additional resource organizations are the Alternative Fuels Data Center [www.afdc.doe.gov], the American Solar Energy Society [www.ases.org], Apollo [www.apolloalliance.org], Electric Drive Transportation Association [www.electricdrive.org], Fuel Economy [www.fueleconomy.gov], Renewable Choice Energy [www.renewablechoice.com], the Renewal Energy Policy Project [www.repp.org], and the U.S. Federation of Public Interest Research Groups [www.uspirg.org/issues/new-energy-future].)

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience in Transportation

As the contributor of 40 percent of Florida's GHG emissions, the state's transportation sector needs to address mobility and local government fleet emissions as reduction strategies. Transportation-related strategies that should be used in combination to reduce GHG emissions include reducing vehicle miles of travel (VMT) and trip frequency, increasing vehicle efficiency, and using biofuels (providing a net reduction in GHG can be achieved). Due to land development patterns in Cape Coral, per capita VMT is higher than many other urbanized areas. While improved vehicle efficiency, increased use of hybrid and electric vehicles, and technological advances are expected to help reduce the rate of growth of VMT, modifying land use development patterns to reduce sprawl and facilitate proximate complementary land uses, combined with increased availability of local and long-distance mass transit services, will be needed to achieve a reduction in VMT while maintaining economic sustainability.

Mobility issues in Florida are directly linked to land use planning – where development is located and the proximity of daily needs (shopping, job centers, and schools) relative to where people live. The more removed and separated those uses are, the further and more often people have to drive each day, thus making the use of alternative forms of transportation less likely. This means that to reduce GHG emissions, communities can make a big difference by changing local zoning and planning regulations and establishing incentive programs to enable and promote the creation of more walkable, mixed-use, and compact developments that support transit, walking and cycling, and that reduce the need to drive to take care of daily needs. Those strategies should be coupled with others calling for interconnected streets that provide additional and more direct routes.

Building regionally integrated transit systems will be an important part of sustaining economic vitality in Florida's metropolitan regions, enhancing the economy of the entire state. Clustering development around transit stations or stops improves the efficiency of a transit system, allowing for higher-quality service, which, with supportive planning and development policies, increases property values.

Compact development is walkable and cyclable. It encompasses residential and commercial development and can be adapted to urban, suburban, and even rural settings. Single-family houses, townhomes, and apartments all have a place in compact development. Compact development means neighborhoods or employment centers with most of all of the following:

- concentrations of population and/or employment;
- medium to high densities appropriate to context;
- a mix of uses;
- interconnected streets;
- creative approaches to parking, including "park once" strategies;
- pedestrian-, bicycle-, and transit-friendly design; and
- access and proximity to transit.

Transit tied to land use also provides environmental benefits. Developing around transit service will help protect urban areas from underdevelopment, and rural and environmentally sensitive areas from overdevelopment. By reducing driving, developing around transit can also have significant climate change benefits. Compact development patterns with transit service can reduce carbon emissions from 20 to 40 percent in comparison to auto-only development patterns.

Climate change will directly affect transportation primarily through increases in severe types of weather and climate extremes. Climate warming over the next 50 to 100 years will be manifested by increases in very hot days and heat waves, increases in average temperatures, rising sea levels coupled with storm surges and land subsidence, more frequent intense precipitation events, and increases in the intensity of strong hurricanes. The impacts will vary by mode of transportation and region, but they will be widespread and costly in both human and economic terms and will require significant changes in the planning, design, construction, operation, and maintenance of transportation systems (Transportation Research Board 2008).

Transportation professionals should acknowledge the challenges posed by climate change and incorporate current scientific knowledge into the planning, design, construction, operation, and maintenance of transportation systems. Every mode of transportation and every part of The City of Cape Coral will be affected as climate change poses new and often unfamiliar challenges to infrastructure providers (Transportation Research Board 2008).

"Special Report 290: Potential Impacts of Climate Change on U.S. Transportation"—the report of a study conducted by a committee of experts under the auspices of the Transportation Research Board and the Division on Earth and Life Studies of the National Research Council—makes the case that focusing on the problem now should help avoid costly future investments and disruptions to operations (Transportation Research Board 2008).

One response to the threat of inundated transportation infrastructure is simply to elevate it to keep pace with the sea level rise. While elevation may be less expensive than letting rising waters wash out entire highways, it is expensive. One estimate put the average cost of elevating roads at $2 million per mile (Dean 2007b). Approximately 862 miles of roadway in The City of Cape Coral are at or below 3 feet of elevation, including 44 miles of primary highways and 36 miles of named state routes. The cost of rebuilding and elevating just these roads can sum to over $495,590,000. This estimated total of road miles does not take into account the miles of city streets in The City of Cape Coral's vulnerable areas that would need to be elevated, nor does it consider the many additional miles and lanes of roads that will likely be built as The City of Cape Coral's population increases over the next 50 to 100 years.

Elevating roads, however, may cause other problems. Streets are typically built lower than surrounding residential and commercial property so that water from the land can drain into the street. Elevating the roads can prevent this drainage and put flooding back onto the adjacent lands. In such cases, it becomes necessary to raise surrounding land along with the street, so that relative engineered heights are preserved (Titus 2002).

The past several decades of historical regional climate patterns commonly used by transportation planners to guide their operations and investments will no longer be a reliable guide for future plans. In particular, future climate will include new classes (in terms of magnitude and

frequency) of weather and climate extremes, such as record rainfall and record heat waves, not experienced in modern times (Transportation Research Board 2008). Decisions transportation professionals make today, particularly those related to the design and retrofitting of existing transportation infrastructure or the location and design of new infrastructure, will affect how well the system adapts to climate change far into the future (Transportation Research Board 2008).

Inventory Critical Infrastructure

Potentially, the greatest impact of climate change on The City of Cape Coral's transportation system will be flooding of coastal roads, bridge approaches and causeways because of a rise in sea level coupled with storm surge and exacerbated in some locations by land subsidence. The vulnerability of transportation infrastructure to climate change, however, will extend well beyond coastal areas. Railways, transit systems, and airport runways may also be flooded by interior precipitation-driven floods. Therefore, federal, state, and local governments, in collaboration with owners and operators of infrastructure such as airports, and private railroad and pipeline companies, should inventory critical transportation infrastructure to identify whether, when, and where projected climate changes in particular regions might be consequential (Transportation Research Board 2008).

Incorporate Climate Change into Investment Decisions

Public authorities and officials at various governmental levels, and executives of private companies are making short- and long-term investment decisions every day that have implications for how the transportation system will respond to climate change in the near- and long-terms. Transportation decision makers have an opportunity now to prepare for projected climate changes. State and local governments and private infrastructure providers should incorporate climate change into their long-term capital improvement plans, facility designs, maintenance practices, operations, and emergency response plans. Table 18 lays out a six step approach for determining appropriate investment priorities (Transportation Research Board 2008).

Decision Framework for Transportation Professionals to Use in Addressing the Impacts of Climate Change on Transportation Infrastructure
1. Assess how climate changes are likely to affect various part of the City and modes of transportation.
2. Inventory the transportation infrastructure essential to maintaining network performance in light of climate change projections to determine whether, when, and where their impacts could be consequential.
3. Analyze adaptation options to assess the trade-offs between making the infrastructure more robust and the costs involved. Consider monitoring as an option.
4. Determine investment priorities, taking into consideration criticality of the infrastructure components as well as opportunities for multiple benefits (e.g., congestion relief, removal of evacuation of route bottlenecks).
5. Develop and implement a program of adaptation strategies for the near and long-terms.
6. Periodically assess the effectiveness of adaptation strategies and repeat Steps 1 through 5.

Table 17. Decision framework for transportation professionals
For use in addressing the impacts of climate change on transportation infrastructure.
Transportation Research Board 2008

Adopt Strategic, Risk-Based Approaches to Decision Making

The significant costs of redesigning and retrofitting transportation infrastructure to adapt to the potential impacts of climate change suggest the need for more strategic, risk-based approaches to investment decisions. Transportation planners and engineers should incorporate more probabilistic investment analyses and design approaches that apply techniques for trading off the costs of making the infrastructure more robust against the economic costs of failure, and should communicate these trade-offs to policy makers who make investment decisions and authorize funding. One model is the California Seismic Retrofit Program, which uses a risk-based approach to analyze vulnerability to earthquakes and criticality of highway bridges to determine priorities for retrofitting and replacement (Transportation Research Board 2008).

Improve Communication

Transportation decision makers note that one of the most difficult aspects of addressing climate change is obtaining the relevant information in the form they need to plan and design. Transportation professionals often lack sufficiently detailed information about expected climate changes, and their timing, to take appropriate action. The National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Transportation (USDOT), the U.S. Geological Survey (USGS), and other relevant agencies are now working together to institute a process for better communication among transportation professionals, climate scientists, and those in other relevant scientific disciplines, and should establish a clearinghouse for transportation-relevant

climate change information. In addition, better decision support tools are needed to assist transportation decision makers. Ongoing and planned research at federal and state agencies, and universities that provides climate data and decision support tools should include the needs of transportation decision makers (Transportation Research Board 2008).

Integrate Evacuation Planning and Emergency Response into Transportation Operations

Projected increases in weather and climate extremes underscore the importance of emergency response plans in vulnerable locations and require that transportation providers work more closely with weather forecasters and emergency planners, and assume a greater role in evacuation planning and emergency response. Climate extremes, such as more intense storms and more intense precipitation, will require near-term operational responses from transportation providers and greater attention to emergency response in transportation operations and budgets. Transportation agencies and service providers should build on the experience in locations where transportation is well integrated into emergency response and evacuation plans (Transportation Research Board 2008).

Develop and Implement Monitoring Technologies

Monitoring transportation infrastructure conditions, particularly the impacts of weather and climate extremes, offers an alternative to preventive retrofitting or reconstruction of some facilities in advance of climate change. Greater use of sensors and other "smart" technologies would enable infrastructure providers to receive advance warning of potential failure due to water levels and currents, wave action, winds, and temperatures exceeding what the infrastructure was designed to withstand. Federal and academic research programs should encourage the development and implementation of these technologies (Transportation Research Board 2008).

Share Best Practices

As the climate changes, many U.S. locations will experience new climate-induced weather patterns. The geographic extent of Florida and its diversity of weather and climate conditions can provide a laboratory for best practices and information sharing as the climate changes. Drawing on existing technology transfer mechanisms, relevant transportation professional and research organizations should develop a mechanism to encourage sharing of best practices to address the potential impacts of climate change (Transportation Research Board 2008).

Reevaluate Design Standards

Environmental factors are integral to transportation infrastructure design. Climate change projections indicate that today's 100-year precipitation event is likely to occur every 50 years or perhaps even every 20 years by the end of this century. Reevaluating, developing, and regularly updating design standards for transportation infrastructure to address the impacts of climate change will require a broad-based research and testing program and a substantial implementation effort. The Transportation Research Board recommended in 2008 that USDOT take a

leadership role along with professional organizations in the forefront of civil engineering practice across all modes to initiate immediately a federally funded, multiagency research program. The program should focus on the reevaluation of existing design standards and the development of new standards as progress is made in understanding future climate conditions and the options available for addressing them. A research plan and cost proposal should be developed for submission to Congress for authorization and funding. Until new standards are developed, infrastructure rehabilitation projects in highly vulnerable locations should be rebuilt to higher standards (Transportation Research Board 2008). The City of Cape Coral could consider adding this recommendation to their legislative agenda.

Include Climate Change in Transportation and Land Use Planning

One of the most effective strategies for reducing the risks of climate change is to avoid placing people and infrastructure in vulnerable locations. Transportation planners are not currently required to consider climate change and its effects on infrastructure investments. Land use decisions are made primarily by local governments, that have displayed too limited a perspective to account for the broadly shared risks of climate change. Integration between transportation and land use planning is uncommon. The City of Cape Coral should require that climate change be included as a factor in the development of public-sector, long-range transportation plans; eliminate any perception that such plans be limited to 20 to 30 years; and require collaboration in plan development with agencies responsible for land use, environmental protection, and natural resource management to foster more integrated transportation–land use decision making (Transportation Research Board 2008).

Develop New Organizational Arrangements

The impacts of climate change do not follow modal, corporate, or jurisdictional boundaries, yet decision-making in the transportation sector is based on these boundaries. Current institutional arrangements for transportation planning and operations were not organized to address climate change and may not be adequate for the purpose. Some models of cross-jurisdictional cooperation exist. Among them are regional authorities for specific facilities; regional and multistate emergency response agreements; and state-mandated regional authorities, such as those responsible for air quality improvement. Similar arrangements could emerge to address the effects of sea level rise on coastal real estate and infrastructure, the effects of drought on shipping along inland waterways, and the effects of hurricanes in the Gulf Coast region. However, state or federal incentives may be required to ensure the development of such organizational arrangements at the regional or multistate level. Actions to prepare for climate change can be taken almost immediately. Some steps can be undertaken by local governments and private infrastructure providers. Others depend on federal and state action. In all cases, leadership and continuing commitment are essential (Transportation Research Board 2008).

Adopt and implement land use policies which ***facilitate mixed-use infill*** development.
Adopt Comprehensive Plan and Long Range Transportation Plan policies to limit investment in

public infrastructure which will be subject to extraordinary ***future maintenance costs***.
Adopt policies to direct public investments in transportation infrastructure to projects which result in ***energy savings***.
Allow additional density near transit as an incentive to use transit and encourage transit-oriented development.
Create high-occupancy vehicle lanes or other ***demand management practices*** such as lane reversals and road pricing (a charge applied for the use of a certain type of road or vehicle or for the use of a road at specific time of day, using for example, a toll, fuel tax, license fee, or congestion fee).
Develop and promote ***bus rapid transit***.
Educate employers and their employees on the benefits of programs that encourage taking alternative forms of transportation to work and reducing the number of drive-along commuting trips.
Encourage and provide ***incentives for companies to motivate employees*** to switch to public transportation, carpooling, biking, and telecommuting and find other ways to save energy and reduce GHG emissions on the way to and from work.
Encourage and provide ***incentives to employees who car- or van-pool***, use public transportation, or non-motorized transportation (walking or biking) to get to work. Incentives can include free bus passes and reserved parking at city buildings for employees who carpool.
Encourage the use of ***teleconferencing***.
Facilitate telecommuting and use of flex time to ***reduce the number of peak hour trips***.
Identify target areas for development which contribute to ***jobs-housing balance.***
Implement a community-wide ***trip reduction program***, including car-sharing.
Implement ***corridor planning*** approaches integrated with land use plans that encourage mixed land uses and alternate modes of transportation to reduce VMT.
Implement ***infrastructure programs*** to make bicycling (bike lanes, conveniently placed bike racks, and bike racks on city buses) and walking more convenient (for example, wider sidewalks and traffic calming).
Implement use of ***life cycle cost analyses*** in transportation planning and decision-making processes.
Improve traffic light synchronization and, although not related to mobility, install energy-efficient traffic lights (for example, advanced light-emitting diode [LED] technology that can reduce power consumption by 90 percent and last ten times longer than incandescent lighting).

Promote development of ***"Park Once" strategies*** for activity centers, malls, downtowns and neighborhoods.
Use ***municipal parking pricing*** to deter travel by car, particularly single-occupancy vehicles.

Table 18. Resiliency strategies to address transportation

Fleet Emissions

Actions local governments can take to reduce fleet emissions relate to both conservation and use of alternative fuels. Local governments have access to a wide variety of strategies to reduce fleet emissions, including retiring older, more inefficient and infrequently used vehicles (trucks and buses as well as cars) and purchasing smaller and more fuel-efficient vehicles. The City of Cape Coral has already made strides in this area, discouraging idle running of vehicles and using automatic cutoffs, and consideration of extended idling time as vehicle abuse. Adaptation of fleet vehicles to use alternative fuels is also being investigated.

Educate residents and businesses on the benefits of using fuel efficient vehicles.
Eliminate SUVs from local government use in all non-emergency applications; when SUVs are required, consider purchasing gas-electric vehicles.
Improve vehicle performance through ***enhanced maintenance***.
Install ***alternative fueling stations*** for government-owned vehicles.
Open local government alternative fueling stations to the public.
Promote the use of alternative fuel ***school buses and taxis***.
Provide ***electric plug-in stations*** at truck stops and marinas and ports.
Provide more bicycles and more fuel-efficient vehicles, such as scooters and full motorcycles, for ***law enforcement personnel***.
Retire older, less efficient, or infrequently used vehicles. When purchasing new vehicles, select ones that are smaller and more fuel-efficient (hybrid or alternative fuel). ***Minimum fuel efficiency standards*** should be part of vehicle purchasing programs.
Use ***car-sharing programs*** where possible instead of a large city fleet, thereby reducing the light-vehicle fleet.

Table 19. Resiliency strategies to address the city vehicle fleet

Two principal sources of information on transportation strategies to reduce GHG emissions are the U.S. Department of Energy and the EPA. The website entry to Department of Energy information is [www.doe.gov/energyefficiency/transportation.htm]. The department offers a number of programs, including its FreedomCAR, Fuel Initiative, Clean Cities Program, and Alternative Fuels Data Center. EPA's transportation-related programs to improve air quality and reduce GHG emissions are listed at [www.epa.gov/cleanenergy/stateandlocal/support.htm]. Those programs encourage the use of renewable fuels, efficient freight transport, diesel retrofit technologies, idling reduction, and alternatives to single occupancy travel. EPA's transportation initiatives include the *Best Workplaces for Commuters* program [www.bestworkplaces.org], which is a voluntary business-government program that provides national recognition and resource tools to employers offering commuter benefits such as free or low cost bus passes, strong telework programs, carpool matching, and vanpool subsidies. (In October 2007, the University of South Florida's Center for Urban Transportation Research [CUTR] assumed program management responsibilities for the Best Workplaces for CommutersSM program.) Other EPA programs are the National Clean Diesel Campaign, focused on reducing emissions from diesel fleets, and the SmartWay Transport Partnership that is working to improve the environmental performance of freight operations. EPA also publishes a Green Vehicle Guide that provides fuel economy and emissions information for new cars and light trucks. Additional resources are the Center for Clean Air Policy's Emissions Guidebook [www.ccap.org/guidebook] and the U.S Department of Transportation's Urban Partnership program [http://ops.fhwa.dot.gov/speeches/ntoc2007], which is aimed at reducing congestion on the nation's transportation systems. Metropolitan planning organizations participating in the program commit to pursuing the "Four Ts" – tolling, which involves broad applications of congestion pricing; transit; telecommuting; and technology.

The leading resource organizations with expertise on improving mobility and reducing vehicle miles of travel are listed in the Land Use Planning and Development and Transportation chapters. Additional information on strategies to reduce fleet emissions is available from DEP's Energy Office [www.dep.state.fl.us/energy] and many of the organizations listed above under Renewable, Green Energy.

What The City of Cape Coral Government Can Do to Increase Climate Change Resilience with Education and Outreach

A sustained, well organized education and outreach effort should serve as the basis for a successful mitigation and adaptation program. Starting with the chief executive, it is important for the City to demonstrate to employees that addressing climate change is an important part of the city's mission.

Education and outreach activities include the following:

Conduct a ***public education campaign*** about the benefits of reducing GHG emissions to the long-term livability of the community and the state, highlighting steps that residents can take as part of their daily routines.
Create out-of-area coalitions for ***mutual aid***.
Educate businesses on the environmental (work and community) and operating cost benefits of reducing energy output. Encourage them to take steps to reduce energy use, and provide technical assistance, "how-to" materials, and incentives (for example, utility incentive programs and joint purchasing of green products and services).
Educate homeowners associations regarding ***climate-friendly landscaping.***
Establish ***climate archives*** for baseline and tracking data.
Establish ***early warning sites*** and gather baseline data.
Establish programs that encourage employees to ***identify opportunities*** for emissions reduction and conservation. Promote voluntary programs and provide incentives.
Fund and perform ***long-term research.***
Funding for ***education programs at all levels.***
Hold ***public information workshops.***
Identify barriers to adaptation.
Identify ***conflicting policies*** between programs.
Increase public awareness.
Obtain ***state/federal grants/loans***.
Partner with community groups to sponsor or cosponsor professional events and activities that raise awareness of global warming and promote opportunities for climate protection.
Partner with utility companies to educate the public on energy efficiency.
Promote green building alternatives through education, taxing incentives, green lending.
Redirect revenues to these issues/***make funding for climate change adaptation a government priority***.
Sponsor or participate in ***public forums and debates*** that focus on climate protection (for example, addressing transportation and land use planning, taxation reform, and energy system planning).
Use government and community and civic newsletters, websites, brochures, and other media to ***inform and motivate the public***.
Use pure ***science***/proven information.
Work with schools to integrate energy efficiency into the ***curriculum***.

Table 20. Resiliency strategies to address education and outreach

Resource organizations on education and outreach programs as part of a climate change strategy include the International Council for Local Environmental Initiatives [www.iclei.org] and the U.S. Conference of Mayors [www.usmayors.org/climateprotection].

The American Association for the Advancement of Science [www.aaas.org] provides materials for schools, including its publication *Communicating and Learning About Climate Change: An Abbreviated Guide for Teaching Climate Change*, from Project 2061 at AAAS, and EPA has a free tool called Climate CHECK that teaches school-age children about climate change and how to assess emissions from their school [epa.gov/climatechange/wycd/school.html].

How Climate Change Resiliency Can be incorporated into the City of Cape Coral Comprehensive Plan

The current City of Cape Coral Comprehensive Plan does not have explicit language concerning planning for climate change or preparing the City for resilience to future climate changes including sea level rise.

It does designate a coastal high hazard zone as follows.

Policy 4.3.1: Cape Coral shall designate the coastal high hazard area as the sum of all of those areas which are within the storm surge flooding zone for a Category 1 hurricane as illustrated on Figure 4: *Coastal High Hazard Areas with Hurricane Evacuation Routes*, based on the *Southwest Florida Region, Statewide Regional Evacuation Study Program for Charlotte, Collier, Glades, Hendry, Lee and Sarasota Counties*, prepared by the Southwest Florida Regional Planning Council in 2010.

Policy 4.3.2: As of the adoption date of the City of Cape Coral 2030 Comprehensive Plan, new public expenditures within the Coastal High-Hazard Area shall be limited to those needed for public health and safety, recreation and open space uses, public land acquisition, and the enhancement and protection of natural resources.

Policy 4.3.3: The City shall not approve any future land use map amendment that would increase the maximum residential density within the coastal high-hazard area, unless one of the following criteria is met, in accordance with Section 163.3178(9), F.S.:

1. The proposed amendment would not exceed a 16-hour out-of-county hurricane evacuation time for a category 5 storm event, as measured on the Saffir-Simpson scale; or

2. A 12-hour evacuation time to shelter is maintained for a category 5 storm event as measured on the Saffir-Simpson scale and shelter space reasonably expected to accommodate the residents of the development contemplated by a proposed comprehensive plan amendment is available; or

3. Appropriate mitigation is provided that will satisfy the provisions of either of the previous two paragraphs. Appropriate mitigation shall include, without limitation, payment of money, contribution of land, and construction of hurricane shelters and transportation

facilities. Required mitigation may not exceed the amount required for a developer to accommodate impacts reasonably attributable to development. For future land use map amendments initiated by a developer, the City and the developer shall enter into a binding agreement to memorialize the mitigation plan prior to adoption of the amendment.

Draft Model Comprehensive Plan Language for the City of Cape Coral Comprehensive Plan update

As part of the Charlotte Harbor National Estuary Programs Climate Ready Estuaries regional strategy, the University of Florida Fredric G. Levin College of Law Coastal Development and Ecosystem Change Clinic worked to develop the legal and policy framework that reconciles coastal development with eroding beaches, sea level rise and other threats to the coastal environment in Florida in a project to develop draft Comprehensive Plan language for a coastal jurisdiction in southwest Florida.

The purpose of the UF project was to provide selected model comprehensive planning Goals, Objectives, and Policies (GOPs) to address sea-level rise adaptation in Southwest Florida. Adapting the results of the project for Cape Coral use, the following is recommended Comprehensive Plan language for the updating of the City of Cape Coral Comprehensive Plan.

Goal 1: [General] To develop the temporal and spatial context for sea-level rise adaptation planning in the City

- **Objective 1.1**: [**Spatial Overlay**] To identify the **Vulnerable Area** of the City where the protection, accommodation, and retreat strategies should be used.
    - **Policy 1.1.1:** The City shall use data and analysis to establish a sea level rise (SLR) adaptation overlay district encompassing all areas within the City that are vulnerable to SLR consisting of three coastal zones.
        - SLR Adaptation Overlay Protection Zone
        - SLR Adaptation Overlay Accommodation Zone
        - SLR Adaptation Overlay Relocation Zone
    - **Policy 1.1.2: [SLR Notice]** To require all sellers of real property within the SLR Overlay District to provide **notice** that such structures and properties are located in within the SLR Spatial Overlay
- **Objective 1.2**: [**Temporal**]: To expand planning horizons for sea-level rise adaptation to capture the anticipated impacts of SLR based on current SLR models
    - **Policy 1.2.1:** Utilize a 50 year planning horizon when considering the adoption of any protection, accommodation, and managed retreat strategy.

GOAL 2: [Protection.]To ensure adequate protection of the built environment through soft and hard shoreline stabilization that seeks to maintain a static shoreline position

Objective 2.1: [Inventories] To identify areas of the built environment vulnerable to sea level rise where shoreline stabilization strategies will be appropriate

- **Policy 2.1.1: [Protection Strategy]** By 20(15), the City shall develop a **comprehensive shoreline stabilization strategy** to address **protection of the built environment where** it has been determined to be **feasible and in the best interest of the City to protect economic investment and infrastructure**.
- **Policy 2.1.2: [Soft Stabilization Preferred**] The City shall require the **use of soft shoreline stabilization techniques** unless precluded by engineering or regulatory constraints.
- **Policy 2.1.3 [Public Interest**]: The City shall **prohibit further hardening** of shorelines **unless found to be in the public interest**.
- **Policy 2.1.4:** Based on projected rates of sea level rise within the SLR planning horizon the City shall **inventory** all **existing shoreline stabilization structures** and **determine** their **capacity to maintain functionality throughout the SLR planning horizon**.
- **Policy 2.1.5:** The City shall **inventory all public buildings and infrastructure** that are vulnerable to sea level rise within the SLR planning horizon and **determine whether such buildings and structure are suitable for protection through shoreline stabilization.**

GOAL 3: [**Accommodation**]: To **accommodate increasing sea levels** and the additional flooding that will result by **adapting the built environment** and **enhancing the resiliency of the natural environment** where it is economically and ecologically practicable to do so

- **Objective 3.1**: **[Built Environment]** To assure that all aspects of the built environment within the accommodation zone can **withstand additional permanent or periodic inundation** based on sea level rise projections through structural and non-structural solutions.
  - **Policy 3.1.1: [Performance Standards]** The City shall require **all new construction** within the Accommodation Zone to adhere to performance standards designed to enable development to withstand permanent and/or temporary inundation due to rising sea levels….
- **Objective 3.2: [Land Use]** To reduce the density and intensity of development and redevelopment in the SLR adaptation overlay district landward of unprotected shorelines
  - **Policy 3.2.1 [Down-planning/Down-zoning]** The City shall limit the residential density within the accommodation zone to no more that __ units per acre. The City shall develop design guidelines that promote compact development and redevelopment that maximizes the use of floodways and flood storage within the zone of accommodation.
  - **Policy 3.2.2: [Limitation on Building Footprint]** The City shall limit the building footprint for all new residential structures within the accommodation zone to ( ) square feet and commercial structures to (____) square feet.
- **Objective 3.5 [The Natural Environment]** To facilitate coastal ecosystem migration through the maintenance and restoration of adequate open space within the zone of accommodation.
  - **Policy 3.5.1: [Riparian Buffers]** The City shall establish riparian buffers that reflect projected rates of sea level rise within the planning horizon for all tidally influenced waterbodies. Such buffers shall be designed to allow the conversion of adjacent uplands to wetlands while retaining transitional ecotones where ecologically feasible.

- **Policy 3.5.2: [Conservation Land Acquisition Priority]** The City shall develop priority areas for land acquisition based on their strategic capacity to support coastal ecosystem migration.

Goal 4: [Managed Relocation]: Reduce vulnerability in the built environment and preserve coastal ecosystems through the orderly abandonment and /or landward relocation of structures and associated infrastructure

- **Objective 4.1**:To **reduce the density and intensity** of future land use along unprotected shorelines at a rate consistent with projected rates of shoreline recession over the SLR planning horizon
  - **Policy 4.1.1:** Within the managed relocation overlay, the City shall **eliminate new investment in public infrastructure** likely to be inundated due to sea level rise within the planning horizon
  - **Policy 4.1.2** Reduce residential land use densities to no more than __ units per acre and commercial structures to ____ square feet per acre within the "Managed Retreat Zone"
- **Objective 4.2**: To **preserve coastal ecosystems** by ensuring that natural shoreline migration processes may continue unimpeded.
  - **Policy 4.2.1:** All **hard shoreline stabilization** techniques are **prohibited** within Managed Relocation Zone
  - **Policy 4.2.2:** Establish an erosion-based minimum setback for shoreline development based upon the **(annual coastal erosion rate)** x **(a planning period representing the economic lifetime of the coastal structure) + (an additional buffer)**
- **Objective 4.3**: To develop programs to encourage properties within the "Managed Relocation Zone" to abandon or relocate structures consistent with projected rates of shoreline recession over the SLR planning horizon
  - **Policy 4.3.1: Prioritize and seek to acquire properties** or interests in property within the managed relocation overlay
  - **Policy 4.3.2:** Identify and **establish a land bank** for the purposes of relocating critically important infrastructure and municipal support facilities.
  - **Policy 4.3.3:** Create a **mandatory transferrable development rights** program within the managed relocation overlay that transfers densities and intensities
  - **Policy 4.3.4:** Promote the acquisition **of rolling conservation easements** based on the priorities developed in policy 4.3.1.

Best Policy Practices and Comments:

The following are references identified by the UF researchers for specific policies recommended above.

Protection: *Protection means the use of any means of constructed physical barrier or other managed system to prevent the landward migration of tidally influenced water bodies*

Vulnerable Area: The vulnerable area represents the area that encompasses the cumulative geographic reach of all sea level rise impacts projected for the planning horizon(s) as determined through data and analysis

Best policy practices

Policy 1.1.2: *Town of East Hampton, New York – Coastal Erosion Overlay District*

Policy 1.1.3: *Texas and Florida*

Policy 1.2.1: *Comment*: *Under Florida law local governments must develop planning horizons based on a 10 year interval for most planning purposes. Some transportation and infrastructure planning occurs on longer planning horizons. Current law does not preclude longer planning horizons should a local government choose to ad Best Policy Practice: The Rockingham Planning Commission recommended the Town of Seabrook, New Hampshire to incorporate a minimum of a 50 year planning horizon and assuming a 1.5 foot rise in sea levels within that period, and at least a 3 to 5 foot rise in sea level over 100 years for all basic planning, zoning, and permitting decisions.*

Policy 2.1.4 [Public Interest]: *Best Policy Practice*: *Sarasota County, Florida prohibited shoreline hardening or the construction of shore protection structures unless it's found to be in the public interest.*

GOAL 3: [**Accommodation]: *Comment***: *Accommodation contemplates a suite of policy tools that emphasize maintaining and adapting components of the built environment to periodic and permanent inundation over time. Accommodation policy also emphasizes retention and expansion of existing and potential floodways to manage flooding and to facilitate coastal ecosystem migration. To a significant extent existing floodplain regulations already contemplate, indeed encourage, accommodation within the built environment. Best Policy Practice: The Cape Code Commission Model Floodplain District Bylaws explicitly provides that the regulations are intended to address not only current flood hazards, but future flood hazards based on sea level rise projections.*

Policy 3.1.4: [Performance Standards]: *Best Policy Practice*: *Cape Code Commission's model bylaws require 1 – 2 feet elevation above BFE*

Policy 3.2.1 [Down-planning/Down-zoning] *Best Policy Practice*: *St. Tammany Parrish in Louisiana undertook a comprehensive rezoning. Flood prone areas that were previously zoned for residential or commercial development were down-zoned to lesser densities or rezoned for conservation and land uses compatible with periodic inundation.*

Policy 3.2.2: [Limitation on Building Footprint] *Best Policy Practice*: *The Maine Dune Rule (Code of Maine Rules Chapter 355)* ***requires planning for two feet of sea level rise*** *over the next one hundred years. Maine's rule requires that no building taller than 35 feet or having a*

footprint greater than 2,500 square feet can be constructed within the dune system unless the applicant can demonstrate "by clear and convincing evidence that the site will remain stable after allowing for ***a two-foot rise in sea level over 100 years****. The rule explicitly states that "[r]reliance upon an existing seawall is not sufficient as evidence of site stability."*

Policy 3.5.2: [Conservation Land Acquisition Priority] ***Best Policy Practice****: The State of Connecticut's Coastal and Estuarine Land Conservation Program provides for consideration of landward migration of wetlands due to sea level rise in its land acquisition program priority ranking system. (Note: Florida does not provide for a similar consideration in its own Program)*

Policy 4.1.3: ***Comment****: This may require downzoning or down planning current densities and intensities with the proposed overlay zone.*

Policy 4.2.1: ***Best Policy Practice****: Sarasota*

Policy 4.2.2: ***Best Policy Practice****: Kaua'i Shoreline Setback, Kaua'i County, Hawaii; Structural lifetime multiplier = 70 or 100 years; Storm and safety buffer = 40 feet*

Monitoring and evaluation of results

The following discussion of monitoring and the monitoring plan for this resiliency plan follow the standards and suggestion outline in Perez and Yohe (2004) for ***Monitoring: Continuing the Adaptation Process.***

The purpose of monitoring is to keep track of progress in the implementation of a resiliency strategy and its various components in relation to the targets. This enables management to improve operational plans and to take timely corrective action in the case of shortfalls and constraints. As part of the management information system, monitoring is an integral part of the function of management, and should be conducted by those responsible for the project/program implementation. The resulting data, in whatever form, must be archived so that they can be readily accessed for internal or external evaluation. Monitoring should be carried out during implementation, as well as during the lifetime of the project. Both the selection of indicators for monitoring and the frequency of monitoring can evolve over time as the resiliency process matures; this evolution may continue as the resiliency process is incorporated into a city's overall policy mix. The most important point is that monitoring continues.

Monitoring and Evaluation (M&E) must go hand-in-hand. In the context of resiliency, evaluation is a process for systematically and objectively determining the relevance, efficiency, effectiveness and impact of a resiliency strategy in light of its objectives. Whereas monitoring is carried out only during implementation, evaluation is carried out during implementation (ongoing evaluation), at the completion of a project (final evaluation) or some years after completion (post evaluation). Much of the evaluation activity can be based on self-assessment of the responsible operational staff, but external evaluation is also a common practice. Formal M&E processes should be practical. In principle, a network of concerned institutions and stakeholders (data suppliers and users) could be established. Increasingly, the trend in this field is towards participatory M&E, which includes the most vulnerable group(s) in decision-making.

The concept of a central M&E unit to co-ordinate all of the functions could be established within, or under the jurisdiction of, a strategic government agency (e.g., Public Works, Planning or Environment).While institutional barriers can impede M&E, these barriers can be assessed during project design and addressed during its implementation. Comprehensive resiliency strategies consist of policies, measures and projects. Appropriate M&E processes may be quite different for each strategic level. Furthermore, gaps in the structure and design of the strategy can impede progress toward long-term goals of sustainability. Policies that exist without tangible measures are paper tigers; conversely, projects that exist outside of a clear policy context can be redundant or contradictory. Monitoring for gaps of this sort can pay enormous dividends.

Monitoring alone is useless if the raw data and basic information it generates are not analyzed in the evaluation process. M&E processes depend on carefully developed sets of indicators by which the performance of resiliency activities can be assessed. These indicators provide the basis for before-and-after analyses and describe the effects (positive and negative) of project interventions – anticipated and unanticipated, intended and unintended. Indicators are quantitative or qualitative measures that can be used to describe existing situations and measure changes or trends over time.

Performance indicators developed by the City will be the criteria for success. In the context of the logical framework approach, at least one indicator should be defined as a performance standard for each resiliency to be reached in order to achieve an objective (GEF 2002). Indicators should include both outputs and outcomes (impacts), with explicit statements of how the indicator demonstrates that the project goal has been met, and what the functional relationship is between a change in the indicator and the outcome of a project.

Exploring the success or failure of the resiliency process depends on more than just the success or failure of implemented projects. More critically, it depends upon the concept of learning by doing. This approach enables users to undertake midcourse corrections in implemented resiliencies, so that they meet their objectives more efficiently; and improve their understanding of the determinants of adaptive capacity so that capacity development activities can be more successful from the start. To accomplish these tasks, two earlier insights can be revisited.

First, establish the necessary criteria for evaluation. Second, the M&E process will eventually have historical evidence of what actually happened over a period of time; this can be compared to the conjectural characterization of future conditions. To learn from mistakes and successes, it is important to combine these insights to: compare actual experience with the initial characterization, and with the criteria; and construct a revised resiliency baseline that describes how the system would have performed in the absence of the implemented resiliency. This revised resiliency baseline will differ from the resiliency baseline. It will be more accurate, based on actual experience and on the evolution of the structural, economic, and political context. This can be critical, since it will suggest whether a resiliency to climate is “swimming uphill” against some non-climatic impediment or “being carried along” by other reforms. Thus, an evaluation could improve the team’s forecasting capability. A review of the criteria used for making the original implementation decision will yield insights about needed changes, and will improve the next resiliency decision.

Participatory processes in support of resiliency can add value and enhance feasibility. Engaging as many stakeholders as possible can democratize the overall process of adapting to climate change, including variability. It follows that participatory M&E can be productive, but care must be taken to note the potential pitfalls. Stakeholder engagement can uncover obstacles, including a healthy degree of initial skepticism on the part of the public about the information provided by the government.

In the context of resiliency, mainstreaming refers to the integration of resiliency objectives, strategies, policies, measures or operations such that they become part of the City's development policies, processes and budgets at all levels and stages. The idea is to make the resiliency process a critical component of existing development plans. Likely entry points for mainstreaming climate resiliency include: environmental management plans (particularly when they incorporate environmental impact assessments), conservation strategies, disaster preparedness and/or management plans and sustainable development plans for specific sectors (e.g., agriculture, forestry, transportation, fisheries, etc.). Moreover, working through the determinants of adaptive capacity makes it clear that promoting capacity can complement or even advance the broader objectives of improved economics and sustainable development. The issue is to recognize an opportunity for mainstreaming and to use it.

The ability of resiliency to ameliorate climate impacts is fundamentally path-dependent and site-specific. As a result, a resiliency that works well in one place and time may or may not work in a different place or time. Whether it does or does not is essentially an empirical question, and M&E can inform the framing of such a question. This diversity should not, however, discourage mainstreaming.

While evaluation can occur at any stage in the resiliency process, the final evaluation may require additional funding following the project's completion. To enable the lessons learned to feed back into and inform subsequent actions, it is essential that the necessary resources (e.g., human, financial, technical) be factored in during the project design phase. This step is recommended, but is often neglected.

For successful continuation of the resiliency process, isolated evaluations are not sufficient. The notion of opportunity cost, expressed as monetary units, is really an observation that any action occurs at the expense of another. These costs are diminished if resiliencies complement one another either directly or by promoting synergies across the underlying determinants of adaptive capacity; they are exaggerated when resiliencies contradict and/or create obstacles for each other or with other developmental objectives (maladaptation). Careful evaluation of any resiliency will therefore contemplate the interaction of a suite of resiliencies in the context of a more general pursuit of social and economic objectives.

Current thinking assumes that stand-alone adaptations are neither desirable nor cost-effective. In developing countries, one group of stakeholders responsible for facilitating resiliency includes the international development agencies and donor governments. Like other environmental issues, this group has collectively agreed that climate change resiliency would be cost-effective if mainstreamed into the development processes. As the term "mainstreaming" implies, the approach places environment squarely in the center of development poverty reduction. This

approach is warranted because global environmental issues remain marginalized in all but a few countries – even ten years after Rio – leading to conclusion that rather than introducing additional environmental plans at this stage, governments should renew effort on implementing those plans. Note that mainstreaming is not unique to resiliency; it is a policy principle for introducing all multilateral environmental issues onto the policy agenda.

M&E supports opportunistic review of resiliency processes, particularly if a learning-by-doing approach is adopted, and if significantly informed by engaged stakeholders. The stakeholders can be important players in an assessment of the effectiveness of any resiliency strategy or suite of strategies. The stakeholders can provide valuable information about whether the proposed interventions have been successful in achieving the strategic objectives. They also provide insight into how existing social, economic, institutional and political factors have supported or impeded implementation. More importantly, substantial findings from the M&E process will point to corrective action for the resiliency strategies, measures or policies. The inclusion of resiliency into the development mainstream must focus not only on the pre-decision stages of the process (i.e., project design stage, climate risk assessment), but also on M&E in the implementation and post-implementation stages. Neglecting these important steps can prevent the resiliency process from being an effective management tool. On a larger scale, it could cause the City to miss important opportunities to correct past mistakes and improve current practices.

Summary Conclusion

In combination, the Cape Coral Climate Change Vulnerability Assessment (CCVA) and the Cape Coral Climate Change Resiliency Strategy (CCCCRS) have addressed resiliency measures and strategies that will integrate the most likely time frame for various climate change impacts in Cape Coral. The planning horizons for the CCVA and CCCCRS are the years 2050 and 2100.

Inaction and not planning and implementing actions to address climate change effects would be the worst thing The City of Cape Coral could do to prepare for potential climate change over the next 25 years

Climate change avoidance, minimization, mitigation and adaptation (AMMA) action options are identified and could be developed in order to be implemented based on the timing of the desired management response (prior to or after a climate event has occurred) and the type of action (e.g., physical, technological, institutional). Three different time frames should be considered:

1) Reactive responses: immediate responses initiated once climate change impacts are observed;
2) A*d hoc* reactive responses: actions implemented after climate change impacts have been observed; and
3) Proactive responses: measures to preserve and protect resources in anticipation of climate change impacts.

The priority climate change resiliency actions that have been identified by and for the City are;

1. Elevation increases should be implemented for future critical facilities including fire stations, city public building infrastructure to 15 feet ground floor elevation.

2. No new construction of critical facilities in the Coastal High Hazard Zone. When existing critical facilities reach the end of useful life, do not rebuild in the CHHA.

3. All new residential and commercial construction and building rebuilds should have and increase in base floor elevation of at least 1 foot increase with a 3 foot preferred.

4. The salinity barrier separation weirs should be increased in height in preparation for sea level rise and increased storm surge in coordination with the plans of the SFWMD and USACOE for weir height increases in south Florida.

5. Update drought management plans to reflect more regular droughts

6. Investigate methods to reduce/prevent salt water intrusion from both lateral and subsurface sources.

7. Use native plants and reduced irrigation for City facilities.

8. Use Conservation 20/20 funds to acquire storm buffer, listed species protection and corridor conservation lands within and adjacent to the City.

9. Continually explore increased energy-efficient materials and solar energy systems with a reasonable returns on investment.

10. A educational program to generate a culture of a community landscape that requires less, more reasonable landscape irrigation practices should be developed and implemented in coordination with the Lee County Cooperative Extension/IFAS.

The CCCCRS outlines the processes that can be used to periodically monitor and evaluate: (1) climate-driven changes in Cape Coral, and (2) the effectiveness of resiliency strategies in lessening the negative impacts of those climate-driven changes. To monitor and evaluate climate-driven changes in Cape Coral a simple approach can be developed based on readily available information regarding changes in basic climate parameters (e.g., temperature, precipitation, storm intensity, etc.) and observed impacts (e.g., annual occurrence of reproduction for select species, spring flowering dates for plants, etc.). In addition, more-sophisticated "sentinel systems" that track changes in key indicator species and other environmental indicators developed by the CHNEP can be utilized.

The CCCCRS reflects the need for regular evaluation of resiliency effectiveness and incorporation of newer or better information on climate effects, and will consider the dynamic nature of information and climate interactions, building in a regular process to revisit the plan's specified priorities and actions. This can take the form of a standing or *ad hoc* workgroup consisting of stakeholders and decision makers to ensure that the plan stays up-to-date and effective.

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Appendix I. Glossary

Climate: encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long periods of time.

Climate Change Adaptation: is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, an adjustment that moderates harm or exploits beneficial opportunities

Climate change resilience: is the capacity of an individual, community, or institution to dynamically and effectively respond to shifting climate impact circumstances while continuing to function at an acceptable level. It is the ability to survive, recover from, and/or live with the effects of climate change. It includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular consequence to minimize negative effects and maintain the ability to respond to changing conditions.

***Protection*:** is the use of any means of constructed physical barrier or other managed system to prevent the landward migration of tidally influenced water bodies

Resilience: Resilience (in Ecology) means building the capacity of a system to withstand perturbations and shocks and to rebuild and respond to change, including unanticipated change. Resilience (in Planning) as the capacity of a system to absorb disturbance, undergo change and still retain essentially the same function, structure, identity, and feedbacks

Vulnerable Area: represents the area that encompasses the cumulative geographic reach of all sea level rise impacts projected for the planning horizon(s) as determined through data and analysis

Weather: is the present condition of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region and their variations over periods up to two weeks.

Appendix II. 2009 Construction Costs

2009 Construction Bare Unit Costs for coastal armoring (LF = linear foot; CY = cubic yard; SY = square yard) *SFWMD 2009*	**Unit**	**Unit Cost ($)**
Concrete seawalls, reinforced concrete, up to 6' high, include footing and tie-backs, maximum	L.F.	425.00
Concrete seawalls, reinforced concrete, to 12' high, include footing and tie-backs, maximum	L.F.	625.00
Concrete seawalls, pre-cast concrete bulkhead, complete, using 16' vertical piles, includes vertical and battered piles, face panels, and cap	L.F.	660.00
Concrete seawalls, pre-cast concrete bulkhead, complete, using 20' vertical piles, includes vertical and battered piles, face panels, and cap	L.F.	705.00
Steel sheet piling seawalls, steel sheeting, 12' high, shore driven	L.F.	465.00
Steel sheet piling seawalls, steel sheeting, 12' high, barge driven	L.F.	810.00
Steel sheet piling seawalls, crushed stone, placed behind bulkhead by clam bucket	C.Y.	60.50
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 2'-0" embedment, includes concrete cap and anchor	L.F.	161.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	201.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 4'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	275.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 2'-6" embedment, includes concrete cap and anchor	L.F.	206.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 4'-0" embedment, includes concrete cap and anchor	L.F.	252.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 6'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	330.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 8'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	260.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, coarse compact sand, 8'-0" high, 5'-0" embedment, includes concrete cap and anchor	L.F.	286.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 2'-0" embedment, includes concrete cap and anchor	L.F.	199.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 4'-0" embedment, includes concrete cap and anchor	L.F.	259.00

Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 3'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	320.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 3'-6" embedment, includes concrete cap and anchor	L.F.	295.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 5'-0" embedment, includes concrete cap and anchor	L.F.	355.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 5'-0" high, 6'-6" embedment, includes concrete cap and anchor	L.F.	450.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 7'-0" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	430.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, medium compact sand, 7'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	480.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 3'-0" embedment, includes concrete cap and anchor	L.F.	294.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	360.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 3'-0" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	425.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4' 6" high, 4'-6" embedment, includes concrete cap and anchor	L.F.	395.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4'-6" high, 6'-0" embedment, includes concrete cap and anchor	L.F.	465.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 4'-6" high, 7'-0" embedment, includes concrete cap and anchor	L.F.	550.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 6'-0" high, 5'-6" embedment, includes concrete cap and anchor	L.F.	510.00
Breakwaters, bulkheads, residential canal, residential canal, aluminum panel sheeting, loose silty sand, 6'-0" high, 7'-0" embedment, includes concrete cap and anchor	L.F.	570.00
Rip-rap and rock lining, random, broken stone, machine placed for slope protection	C.Y.	77.50
Rip-rap and rock lining, random, broken stone, 3/8 to 1/4 C.Y. pieces, machine placed for slope protection, grouted	S.Y.	163.00
Rip-rap and rock lining, random, broken stone, 18" minimum thickness, machine placed for slope protection, not grouted	S.Y.	118.00
Rip-rap and rock lining, random, broken stone, 50 lb. average, dumped	Ton	44.50
Rip-rap and rock lining, random, broken stone, 100 lb. average, dumped	Ton	63.50

Rip-rap and rock lining, random, broken stone, 300 lb. average, dumped	Ton	73.50
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 6" deep	S.Y.	59.50
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 9" deep	S.Y.	84.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 12" deep	S.Y.	92.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 18" deep	S.Y.	133.00
Gabion boxes, galvanized steel mesh mats or boxes, stone filled, 36" deep	S.Y.	201.00