Analysis of City of St. Petersburg Comprehensive Plan with Special Reference to Coastal Management Considering Climate Change

Michael F. Johnson

A thesis submitted in partial fulfillment
of the requirements of the
Judy Genshaft Honors College
University of South Florida

April 30th 2021

Thesis Director: Christopher Meindl, Ph.D.
Associate Professor of Geography
Associate Chair, School of Geosciences

Judy Genshaft Honors College
University of South Florida

CERTIFICATE OF APPROVAL

Honors Thesis

This is to certify that the Honors Thesis of

Michael F. Johnson

has been approved by the Examining Committee
on April 30th, 2021
as satisfying the thesis requirement
of the Judy Genshaft Honors College

Examining Committee:

Thesis Director: Christopher Meindl, Ph.D.
Associate Professor of Geography
Associate Chair, School of Geosciences

Thesis Committee Member: James Ivey, Ph.D.
Professor, College Geosciences

Table of Contents

Abstract

Land Development and the policy that drives it has long been an important issue in the Tampa Bay Area and by extension the state of Florida. Flooding and hurricanes have had to be considered in the future development of most places in Florida. But as climate change begins to pose a serious, leading to rising sea levels, increasingly powerful hurricanes, coastal erosion, increasing drought, and periods of unusually heavy rain, the role of policy, specifically the state-mandated comprehensive plan, in either mitigating or enhancing the susceptibility of any given area to these threats must be evaluated. This paper reviews the current iteration of the St. Petersburg Comprehensive plan and how it addresses climate change. This was done through the examination of relevant elements and policies. The plan addresses the threats of flooding and hurricanes but makes no mention of climate change or of strategies that work to predict and mitigate climate change damage. It was found through this analysis that the current iteration of the city's comprehensive plan is missing key elements of recommend climate change response strategies.

Intro

As research continues on natural and human-induced climate change, mounting evidence indicates that global climate change is not just already in motion, it may be inevitable at this point (Randers et al., 2020) via positive feedback loops that have developed to perpetuate the change, such as the melting of arctic permafrost that releases greenhouse gases such as $CH4$ and $CO2$ (Schurr et al., 2015). This possible upending of the current earth system is unprecedented in modern human history and brings with it a host of challenges to humans all over the world. In the United States, Florida is often seen as ground zero for climate change. This is for good reason, as the state faces rising sea levels, the impacts of which are already occurring in the city of Miami (Wdowinski et al., 2016), and the possibility of increased hurricane frequency and intensity due to warming Atlantic sea surface temperatures (Murakami et al., 2018). These hazards bring with them associated hazards, such as storm surge along coasts and flooding of local rivers and lakes from increased precipitation and inundation. These threats are amplified in Florida due to its unique geography because it is a relatively flat, low-lying peninsula underlain by karst geology. Flooding in karst areas can lead to sinkhole formation and increased flood damages in the future. Florida's larger, coastal metropolitan areas are particularly vulnerable, due to a high concentration of people and developed land located in close proximity to the coast. The Tampa-St Petersburg region is a top ten U.S. city in terms of highest asset value exposed to sea-level rise (SLR) (Nicholls et al., 2008). St. Petersburg may be one of the most threatened cities in the state, again due to its heavy development, high population density, and its unique geography, at the southern end of the Pinellas peninsula, surrounded by water on three sides. Previous studies have indicated that SLR alone has the potential to cause up to $7.15 billion of property damage in Pinellas County (Fu et al., 2016), within which St. Petersburg is by far the largest municipality. These circumstances place St. Petersburg in a precarious position, because

climate change is beginning to pose a serious risk, the likes of which have not been seen in modern human history. This risk comes in the form of rising sea levels, increasingly powerful hurricanes, increased coastal erosion, and periods of unusually heavy rain. This threat has been confirmed by recent studies, such as one by the Tampa Bay Climate Science Advisory Panel (TBCSAP) which found that the Tampa Bay area could face anywhere from 2-8 ft of SLR by 2100 (TBCSAP, 2019). Furthermore, much of the infrastructure and buildings built today can have long lifespans of up to 80+ years if maintained properly, which puts both existing and future structures on a collision course with the effects of climate change. Thus, the future of urban coastal communities like St. Petersburg is dependent upon land development and management practices that serve to both mitigate current risk posed to people and coastal real estate, as well as implementing long-term adaptive/resilience measures that address the many challenges brought by climate change. Land development is a very broad subject and while it is primarily driven by market forces, it can be guided and shaped by legislation and input from administrative bodies on national, state, and local levels. As part of a statewide comprehensive process, St. Petersburg is required to have a comprehensive plan. The St. Petersburg Comprehensive Plan (SPCP) is a document designed to guide the future actions of the city and covers a variety of topics, including land development policy. This paper aims to take a multifaceted approach to analyzing the city of St. Petersburg's comprehensive plan and how it addresses the dual threats of increased flood damage due to increasingly powerful hurricanes and SLR. This is done to understand how the current iteration of the St. Petersburg Comprehensive Plan contributes to helping development withstand the predicted impacts of climate change.

Literature Review

To understand the complexities and implications of the St. Petersburg comprehensive plan, it is necessary to understand the history of city planning in not only St. Petersburg but the State of Florida and the United States. Thus, this literature review section will cover these topics.

While city planning has always been present in the United States, it did not become widespread until the late 19th - early 20th century. Urban planning efforts in the United States before this time were mostly undertaken by local entities and were not very extensive, chiefly because the majority of the population lived in rural agrarian communities until 1910-1920 (Gibson, Jung, 2002). One of the best-known early occurrences of city planning in the United States was formulated for the city of Philadelphia by William Penn in 1682 (Reps, 1965). The Philadelphia City plan as it was known, made use of gridiron street patterns, large public squares, and called for a long-term urban development growth vision. The population of Philadelphia at the time of the first census in 1790 was about 30,000. Comparatively, according to the Florida Office of Economic and Demographic Research (EDR) he population of St. Petersburg today is about 265,000 (EDR, 2020). Another prominent pre-1900s example of city planning was the city plan for Washington D.C., known as the L'Enfant Plan, and was developed in 1791, although it was not fully implemented until 1902 (Reps. 1965). In the early 1900s, the first significant land use planning implementations were undertaken by the federal government, the most significant actions being the establishment of the reclamation service in 1902, the U.S. Forest Service in 1905, and the National Park Service in 1916. The first National Conference on City Planning was held in Washington D.C. in 1909 (Peterson, 2009). This was followed by the establishment of the National Planning board in 1933, and the eventual establishment of the Department of Housing and Urban Development (HUD) in 1965 by President Lyndon B. Johnson (Tyler and Ward, 2011). The establishment of HUD was significant because from 1965 onward there was a federal agency devoted to community planning, as well as he development and enforcement of housing law and policy.

The state of Florida's first attempt to implement statewide growth management and city planning legislation occurred in the 1970s when the legislature enacted a series of laws that attempted to manage the intense and uncontrolled development that characterized Florida for the previous decades and had resulted in a decreased quality of life in many parts of the state. The most significant of these was the Local Government Comprehensive planning act (LGCPA) which was adopted in 1975 (Chapin et al.,2007). The LGCPA required every local government to enact a comprehensive plan that met listed statutory requirements by 1979. However, this first version of LGCPA is generally looked at as a failure, primarily because it did not give the state planning agency the authority to reject local plans that did not meet the set requirements and gave the state no enforcement measures to ensure that local governments adopted or enforced local plans. Thus, the LGCPA was "not taken seriously" (Chapin, 2007, pg. 9). The 1980s marked a more successful planning endeavor for the Florida legislature. In 1984, the legislature passed the 1984 Florida State and regional planning act, which mandated the preparation of a state comprehensive plan. In the same year, the legislature amended the LGCPA to require that local plans be consistent with state and regional plans and provided a standard for how the plans should be implemented. In 1985, the legislature required all 11 of the state regional planning agencies to implement a regional comprehensive plan. Some other important legislation adopted in this period includes the Omnibus Growth Management Act, the Local Government Comprehensive Planning and Land Development Regulation Act, and the Founding of the Environmental Land Management Study Committee (Chapin, 2007). Collectively, the series of bills passed and other legislative actions undertaken during this time is known as the Growth Management Act (GMA). The Comprehensive Planning process and GMA were amended almost annually through the 1990s and early 2000s, with major

amendments made in 1993, 1995, and 2005 (Chapin, 2007). The Department of Community Affairs (DCA) – the state's planning agency – was tasked with reviewing local plan amendments to make sure they were consistent with state and regional plans. It has been criticized for not adequately reviewing the amendments to local comprehensive plans, reportedly approving around 90% of the estimated 12,000 annual proposed amendments (Chapin, 2007). The state has also been criticized for having an outdated comprehensive plan, as well as not providing funding for concurrence, a policy that mandated that developers needed to have adequate infrastructure in any given area to proceed with development. In 2011 then Florida Governor Rick Scott signed HB7207, which significantly weakened the GMA. The Legislation eliminated state oversight in local planning decisions, made it more difficult for citizens to issue legal challenges to local development actions, and ended concurrence as a requirement for development completely. During his tenure, Scott also all but eradicated the Florida Department of Community Affairs, the state's planning agency which he has referred to as a "job killer" (Dunkelberger 2011).

St. Petersburg has a long history of comprehensive planning, sometimes unsuccessful, dating back to the early 1920s (Stephenson, 1997). The first major plan to be considered was prepared by John Nolan. His plan envisioned the city of St. Petersburg as a series of interconnected parks and preserves, which he believed would set a path for sustainable development and tourist attraction for decades to come. Figure 1 shows Nolan's plan for part of the city.

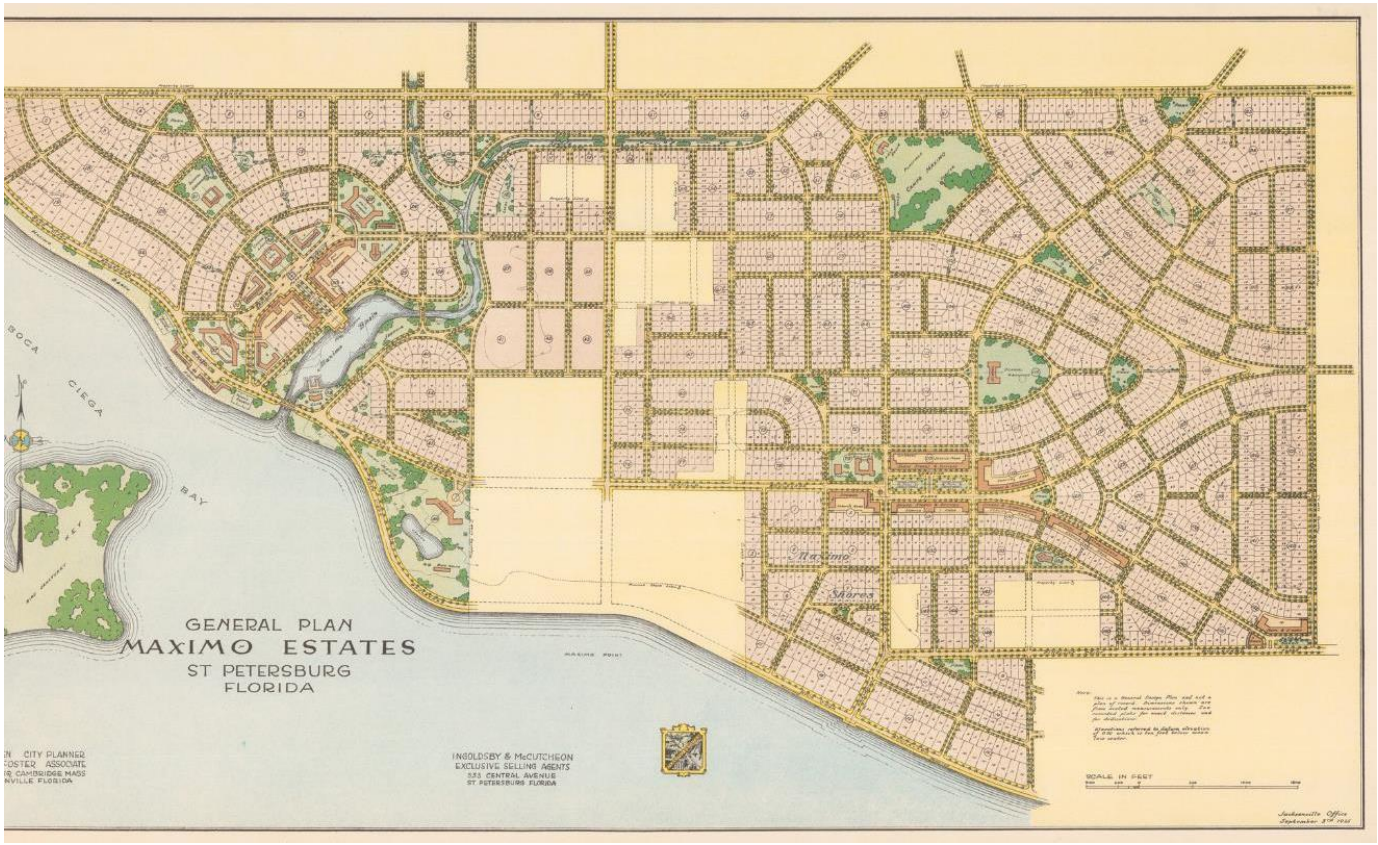

Figure 1 – General Plan for Maximo Estates. Adapted from Cornell Digital Archives.

The voters of St. Petersburg did not share his vision, however, and in 1923 Nolan's city planning initiative in St. Petersburg was soundly rejected in a referendum, receiving only 12.9% of the vote (Stephenson, 1997). Nolan's plan was rejected due to a variety of factors, including pressure from city officials, local news outlets, and developers, as well as the fact that Florida was in the midst of a tremendous, speculative, land boom. In his book *Visions of Eden,* Bruce Stephenson contends that *"*[The land speculators] paradise, in contrast to Nolan's, was based on unbounded growth, not on control. They dreamed of an ever-expanding city where profit always followed speculation" (Stephenson, 1997, Pg.70). The rejection of the planning law eventually allowed a paving contractor to pave parts of the city that would not develop for decades, leading to the city practically going bankrupt, an ordeal it would not fully recover from until the late 1930s. The

city took another stab at planning in the 1940s, with the collective efforts of the city planning board, local influential figures such as Nelson Poynter (owner of the *St. Petersburg Times*), and the planning firm of Bartholomew and Associates culminating in the aptly named "Bartholomew Plan". The plan emphasized more efficient urban development, was but heavily criticized for not protecting the natural landscape, the most prominent example being the pollution, dredging, and filling of Boca Ciega Bay. The next growth plan to seriously be considered in St. Petersburg was the 1974 conceptual plan, finally followed by what is considered to be the first environmentally sound comprehensive plan of the city, adopted in the 1980s.

Methods/data sources

To effectively analyze how the threats of SLR and hurricanes are addressed in the comprehensive plan of the City of St. Petersburg, elements of the plan deemed relevant to the aforementioned risks were thoroughly examined. A select group of elements was chosen due to the wide variety of topics addressed in the plan, some of which are not relevant to the topic of this paper, such as the public-school facilities and recreation elements. Each element has several sub-sections that address specific issues. Only those element sub-sections deemed relevant are analyzed in this thesis. The most recent revision of the St. Petersburg comp plan occurred in November 2019, so this edition of the plan is the primary source for this thesis. In addition to the plan itself, the discourse surrounding the plans and future revisions of them is just as important, as the plan is meant to be a 'living document'. To address this point, actions taken by local politicians, such as city council members or county commissioners, were taken into consideration. Additionally, an interview was conducted with former St. Petersburg city council member Karl Nurse. Lastly, it is important to realize that the policy decisions being examined do not occur in a

vacuum. Since the goal of this paper is to analyze and critique how the comprehensive plan addresses the growing threats of climate change and its associated risks of SLR and hurricane vulnerability, research done on these topics, such as projections of SLR, were incorporated into the analysis as well.

Study Site

St. Petersburg is located at the southern end of Pinellas County, which is situated on the gulf coast of central Florida and along with Hillsborough County, makes up part of the Tampa Bay region. Figure 2 visualizes St. Petersburg's location in Florida. St. Petersburg is the largest municipality in Pinellas County, with a population of about 265,000 (EDR, 2020). Pinellas County is the most densely populated county in Florida, with an average of 3,347 people per square mile (Pinellas County, 2012). Geologically, St. Petersburg is underlain by mostly sandy soils and by a series of porous limestone formations (Pinellas County, 2012, p. 1.1).

Figure 2 - *Map of St. Petersburg and its location in Florida.* Adapted from 2019 St. Petersburg Comprehensive Plan, Pg. 257.

This unique feature of the city provides another threat from climate change, as rising seas threaten to push saltwater beneath as well as on top of the county. St. Petersburg, like much of the rest of Florida, enjoys a subtropical climate. The city receives around 54 inches of rain annually. (Florida Climate Center, 2010). The monthly and annual high, low, and mean temperatures are shown in table 1. It should also be noted that St. Petersburg has a large quantity of public waterfront, particularly on the bayside of the city. About a third of the city is less than 10 ft above sea level.

Table 1 - *St. Petersburg 1981-2010 Temperature Normals.* Adapted from the Florida Climate Center 2010.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max	70.5	73.2	76.5	81.5	86.2	90.0	90.5	90.6	88.8	84.4	77.7	72.4	81.9
Mean	61.4	64.1	67.7	72.4	77.8	82.2	83.2	83.4	81.9	76.9	69.9	63.7	73.8
Min	52.3	54.9	58.9	63.4	69.4	74.5	75.9	76.2	74.9	69.3	62.0	55.1	65.6

Comprehensive Planning in Florida, Pinellas County, and St. Petersburg

Comprehensive plan.

The 1985 GMA mandates that all local municipalities have a comprehensive plan in place, which includes Pinellas County and all of its municipalities. State statutes identify eight different elements that every municipal plan must-have. Local plans are allowed to implement additional elements, but any minimum, maximum, or otherwise specified standards in the state plan serve as the baseline for local plans. Thus, among all the policies, plans, and codes that govern land development in St. Petersburg, the city's comprehensive plan is by far the most influential. Each element is comprised of sections that address specific issues. Each section includes an objective that the plan hopes to achieve and policies meant to facilitate the achievement of the stated objective. For example, the "transportation" element of the SPCP has individual subsections dedicated to both greenhouse gas emissions and traffic circulation and mobility. The plan is meant to be a living document and must be biannually revised, and major updates must occur every 5-7 years. Although the plan's continued existence is mandated by state statutes, the city is responsible for creating and amending its plan, as long as it conforms to the standards set in the state comprehensive plan and is not preempted by any statutes in Pinellas County's Comprehensive Plan (PCCP) or the state's comprehensive plan. Table 2 shows elements addressed in the SPCP.

Table 2 – *Elements of the St. Petersburg Comprehensive Plan*

Chapter	Element Name
1	General Introduction
2	Vision
3	Future Land Use
4	Conservation
5	Coastal Management
6	Transportation
7	Housing
8	Recreation and open space
9	Utilities
10	Capital Improvements
11	Intergovernmental Coordination
12	Historic Preservation
13	Public School Facilities
14	Plan Monitoring and Evaluation

Of the listed elements, five were chosen for review in this thesis; Coastal Management, Future Land Use, Utilities, Conservation, and Capital Improvements. Similarly, sections in each element were chosen for review based on their potential to mitigate the impacts of climate change. The elements and sections selected were picked because they were deemed to have the most direct effect on the city's ability to cope with climate change. This is not to say that other elements and sections have no effect/are not relevant in the climate change discussion, but that their effect is more peripheral than direct. Consider the public-school facilities element. While the placement and construction of public schools will no doubt in the future have to consider climate change, the element itself has little to no control of zoning, development, or location of public-school facilities.

Results

Coastal Management Element.

The Coastal Management element's stated objective is to manage the coastal system and infrastructure "in a manner that will maintain or enhance environmental, recreational, historic and economic qualities and protect human life" (St Petersburg, 2019, Pg.125). In its introduction, the element recognizes the biological, economic, and practical value of the city's coastal resources and notes how they have been diminished by human activity. The sections chosen for review in this element are Coastal High Hazard area, Post Disaster Redevelopment, Hazard Mitigation, Infrastructure, and Hurricane Evacuation Planning.

Coastal High Hazard Area.

This section discusses the development of a Coastal High Hazard Area (CHHA), which are areas of St. Pete that are extremely vulnerable to flooding because they are below the elevation likely to be flooded by Category 1 storm surge. The CHHA is an area on a city map highlighted by a line that is determined by a Sea, Lake, and Overland Surges from Hurricanes ("SLOSH") computerized storm surge model (see Figure 3). Although St. Pete's CHHA already has structures that were built before current regulations were adopted, building in the CHHA now is limited in a number of ways, such as a state law that limits public expenditures that subsidize development in the Coastal High Hazard Area (Florida Statutes,163.3177(6)6). The stated goal of the SPCP as it relates to CHHA is to "direct population concentrations away from known or predicted [CHHA]" (St. Petersburg, 2019, Pg. 135) via restrictions on population densities and the prohibition of public spending that subsidizes the increase of population concentrations in the CHHA. The Tampa Bay Regional Planning Council (TBRPC) created maps of the Tampa Bay region that display the likelihood of

each area will be protected from inundation and erosion from SLR, and much of St. Petersburg's CHHA is labeled "protection almost certain" (Pinellas County, 2014, p. 6.3-4) which highlights the intense development in these areas. In 2016, the SLOSH model was updated and the CHHA in St. Petersburg was expanded (Solomon, Sampson, 2020). Figure 3 visualizes the updated CHHA in St. Petersburg.

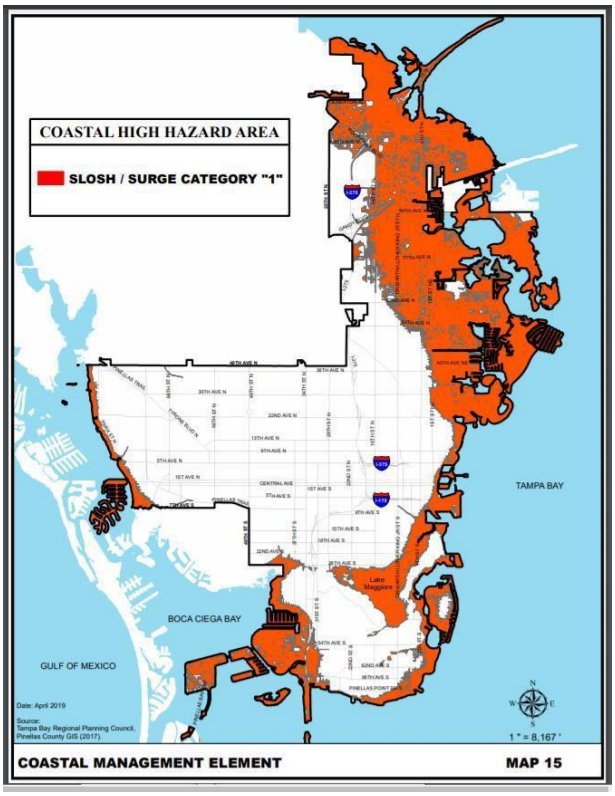

Figure 3 -*Map of Coastal High Hazard Areas in St. Petersburg FL.* Adapted from 2019 St. Petersburg Comprehensive Plan, Pg. 273.

This severely limits future development opportunities in some areas of St. Petersburg, because the CHHA now covers nearly 40% of the city, when previously St. Pete's CHHA was much smaller, mostly in preservation areas. On 10/8/2020, the St. Pete city council voted 6-2 to amend the city's municipal code (St. Petersburg, Florida, Municipal Code §16.30.040.1.), weakening rules that prohibit increasing building densities in the CHHA (Solomon, Sampson, 2020). After the first amendment passed, the council unanimously passed another amendment, which set requirements for new structures built in the CHHA, including a rule that new structures be built at least two feet above the minimum Federal Emergency Management Agency (FEMA) design standard (St. Petersburg, Florida, Municipal Code §16.30.040.2.).

Hazard Mitigation. This section of the Coastal Management element references actions the city must take to reduce the impacts of natural hazards (St. Petersburg, 2019). There is a wide range of policies in this section. Some policies state that the city must comply with FEMA regulations, and participate in the National Flood Insurance Program's (NFIP) Community Rating System (CRS) while others address properties that are either vulnerable or repeatedly flooded. The CRS is a program that offers discounted flood insurance rates based on floodplain management that exceeds the minimum requirements set by NFIP. This encourages stronger building regulations and zoning practices that decrease flood damage risk. St. Petersburg's comp plan has a policy that demands continued participation in this program (St Petersburg, 2019). Other significant policies of the section include one that mandates that site plan review – a step in the planning stages of most development projects – shall consider flood potential and hurricane hazards, including evacuation levels and sheltering, and another that mandates that the city must maintain an inventory of repetitive loss properties and target hazard mitigation programs to these properties (St. Petersburg, 2019). Multiple policies demand thatthe city will make amendments to the comprehensive plan and act in accordance with local efforts to reduce hazard damage, such as the Pinellas County Local mitigation Strategy. Finally, two strategies task the city with continually promoting the use of development principles and strategies in the Florida Building Code, as well as federal flood plain regulations. This section does mention sea level rise once, but it only says to refer to the suggestions of theFlorida building code in this regard and does not provide any specific framework or course of action.

Post Disaster Redevelopment. This section concerns the redevelopment of areas that have been damaged, inundated, or otherwise affected by natural hazards (St. Petersburg, 2019).

This section is of paramount importance, as the changing climate will no doubt cause damage to coastal infrastructure and buildings despite our best attempts to mitigate damage and there will no doubt be many things to consider in how to address areas damaged by hazards, especially repetitive loss areas. There are several policies of note in this section. One policy asserts that the city shall maintain "Damage Assessment Teams" that will identify clean- up and repair actions in the event of a storm as well as estimate and document damage of any given site (St. Petersburg, 2019) Another stipulates that in an event where 50% or more of homes have been destroyed in a CHHA, a temporary building moratorium in those areas may be enacted to assess the damage and the feasibility of redevelopment (St. Petersburg, 2019). The city must also identify properties recommend for acquisition after an event, presumably to prevent further building and redevelopment in those areas. Additionally, the city must maintain an inventory of all infrastructure located in CHHA, which must include a "hazard vulnerability assessment" (St. Petersburg, 2019) which is one of the few instances of risk assessment strategies present in the SPCP. Finally, the city must propose and adhere to post-disaster redevelopment guidelines set by other local governments and Pinellas County, which must include the "relocation, mitigation or replacement" of CHHA infrastructure, as well as distinguishes between the recovery phase and long-term redevelopment (St. Petersburg, 2019)

Infrastructure. The infrastructure section of the coastal management element is small compared to other sub-elements. The primary focus of this section is on maintaining an acceptable level of service (LOS) in coastal areas. The SPCP defines infrastructure as "Structures which serve the general population" (St. Petersburg, 2019, Pg. 27) and includes a variety of

different facilities, from roadways and bridges to potable water systems and waste disposal sites. LOS has different meanings depending on the context, but in the SPCP it is defined as “An indicator of the extent or degree of service provided by or proposed to be provided by a facility based on and related to the operational characteristics of the facility. Level of service shall indicate the capacity per unit of demand for each public facility” (St. Petersburg, 2019, Pg.28) Thus the term acceptable LOS could refer to many different metrics of many different public facilities, such as the drivability of a road or capacity of a sewage disposal system. Improvements in flood-prone areas are required to include repairs that minimize disruption to the LOS and shall be made according to standards set in the capital improvements element of the SPCP (St. Petersburg, 2019) and infrastructure is required to be available for the development or redevelopment of coastal areas in the city (St. Petersburg, 2019). The type of improvements to be made is not specified. Further down in the plan, the “Future Land Use” element, addresses infrastructure again and that the expansion of infrastructure in the CHHA shall “only be permitted as necessary to protect the public health, welfare, and safety” (St.Petersburg, 2019, Pg. 138).

Hurricane Evacuation Planning. The stated objective of this section of the coastal management element is to maintain and reduce hurricane evacuation times via cooperation with state regional and county agencies, as well as provide space for evacuation shelters. The current LOS for out-of-county evacuation is in the case of a category 5 hurricane is 36 hours, which is the LOS recommended by the TBRPC (St. Petersburg, 2019). This goal is supported by a variety of policies, some of which mandate the prioritization of maintenance, supervision, and administration of major evacuation routes. There are also a multitude of policies in this section that requires the city to coordinate with other entities in hurricane evacuation, including the

County, local municipalities, Red Cross, the school board, and more. Several policies demand the city's compliance with state and county agencies. Notably, this section says little about improving evacuation times, as the majority of the policies focus on maintaining the recommended LOS. Climate change is not mentioned in this section.

Utilities Element.

The utilities element of the SPCP is comprised of five sub-elements, only one of which has been selected for review in this thesis: drainage.

Drainage.

The SPCP defines drainage as the conveyance, treatment, and attenuation of water generated from storm events. This is especially important in St. Petersburg, as an intense storm event could damage or inundate large swathes of the city. Like most Florida cities, St. Petersburg has long wrestled with drainage. The city's attempt to produce a plan to address drainage started in 1977 when the City's Engineering Department produced the "Master Stormwater Drainage Plan" which was then replaced in 1997 by the Stormwater Management Master Plan (SMMP). The goal of the SMMP is to identify the drainage problems that exist within the city, characterize flood-prone areas, establish factors that cause flooding, and come up with projects that correct flooding problems. After being revised from its initial form, the SMMP identified 85 projects that were estimated to cost the city around $6 million a year over a projected 20-year project implementation schedule. This sub-element of the SPCP was created in 1989 to assist in addressing the need for storage and treatment of stormwater runoff (St. Petersburg, 2019). This relationship between the drainage sub-element and the SMMP manifests itself in multiple places. For example, the LOS standards for drainage have been changed to accommodate both the fiscal viability of the SMMP as well as the capacity of the city drainage system (St. Petersburg, 2019). The current LOS for St. Pete drainage systems is the ability to convey the runoff from a significant, one-hour storm that will occur on average, once

every decade (what many officials call a 10-year storm). The sub-element also stipulates that the city will commit to completing the projects in a timely and effective manner, which is reflected in St. Pete's stormwater utility fee, a dedicated source of funding for stormwater projects (St. Petersburg, 2019). This sub-element also commits the city to coordinate with many different entities when addressing drainage, including the Southwest Florida Water Management District (SWFWMD), neighboring municipalities, Pinellas County, and others. A recent example of this cooperation is the Clam Bayou Habitat Restoration and Stormwater Treatment project, which included the cities of St. Petersburg and Gulfport, as well as SWFWMD, and was completed in 2012. The project restored 64 acres of estuarine and coastal habitats and created 20 acres of ponds to treat stormwater runoff (SWFWMD 2012). Finally, this sub-element recognizes the benefits natural landscapes can offer in terms of drainage, especially allowing excess water to soak into the ground. This means that development projects in St. Petersburg are often accompanied by a modest retention pond on site. Several policies demand that all drainage projects must consider the impact upon mangroves and other wetland environments, lakes, and even uplands, as well as requiring permits from appropriate agencies that seek to disturb natural drainage features of the environment. (St. Petersburg, 2019). There is no mention of SLR in this sub-element.

Conservation Element.

The conservation element of the SPCP begins by noting that intense urban development in St. Petersburg for over a century has irreversibly changed the natural landscape. The element notes how peoples' welfare is dependent on natural resources, and how it is in the interest of St. Pete to preserve and expand its remaining resources. The stated objective of this element is that the city "shall protect, conserve, responsibly manage and, where appropriate, restore or enhance the quality of air, water, vegetative and land resources and

natural systems in St. Petersburg" (St. Petersburg, 2019, pg. 108). Two sections of this element were chosen for analysis: protection of areas with the 100-year floodplain, and protection of wetlands.

Protection of areas within the 100-year floodplain. The SPCP notes that for residents to receive federal flood insurance, construction within a 100-year flood plain must be regulated. The 100-year floodplain is an area that is designated to have a 1-in-100, or 1%, chance of flooding each year. This concept is commonly subject to misinterpretation. It does not mean that areas within the 100-year floodplain cannot flood more than once every 100 years; indeed, some places can flood more than once in the same year. This section of the conservation element simply states that the city will actively enforce the minimum building standards in the state building code and state land development regulations for areas in the 100-year floodplain aswell as cooperate with FEMA to update the city's 100-year floodplain maps and continue to adhere to FEMA regulations (St. Petersburg, 2019).

Protection of wetlands. The section recognizes that the many wetlands in and around St. Petersburg provides significant wildlife, aesthetic, and stormwater control benefits to the city. Thus, the plan states that St. Pete shall preserve and enhance all existing wetland environments. Notable policies that serve this goal include a prohibition on further alteration of wetlands except for enhancement projects, a required assessment of the city's coastal mangrove communities every five years, and cooperation between St. Petersburg and neighboring municipalities in protecting wetlands and sharing data on them (St. Petersburg, 2019).

Future Land Use Element. The Future Land Use Element of the SPCP serves as the principal guide to all physical development in St. Petersburg. The element covers a wide array of

topics, of which four have been chosen for analysis: Land Development Regulations, Coastal Hazard Areas, Future Land Use Needs, and Innovative Land Development Regulations. Among other things, the stated goal of the element is to "protect the public health, safety, and general welfare" and "protect and enhance resources and amenities" (St. Petersburg,2019, Pg. 64).

Coastal Hazard Areas. The coastal hazard areas section in the future land use element is similar to the coastal management element, but instead covers *future* land use in these areas, rather than the administration of current land uses. Some notable policies of this section include prohibiting the building of hospitals, retirement and convalescent homes, and mobile home parks in certain hurricane evacuation zones. Several policies prevent residential density increases in the coastal high hazard area. Moreover, the city shall consider a number of means (such as land purchases and transfer of development rights) to decrease the population density in these areas. Finally, the city shall reference the TBRPC's hurricane evacuation study in general land use applications in the CHHA (St. Petersburg, 2019), which will assist in future planning and risk assessment in the CHHA. This section addresses the threat of hurricanes via building prohibitions in certain evacuation zones, and while it does not explicitly refer to hurricanes of increasing intensity, the policy requiring the city to refer to the TBRPC's hurricane evacuation zones provide some basis to address them. However, there is a noticeable lack of any mention of coastal erosion, SLR, or climate change-related coastal hazards in this sub-element.

Conceptual Land Use Patterns. This section covers the city's commitment to what it describes as the "key conceptual component" of the overall structure and form of urban development in St. Petersburg: the facilitation of compact urban development by concentrating more intensive growth in activity centers. The section then lists seven distinct activity centers throughout the city. The listed areas are the Gateway, Central Plaza, Innovation District, Intown, Central Avenue Corridor, Tyrone, and the Skyway Marina District. Of the seven listed activity centers, three of them are fully or partially in the CHHA. The Skyway Marina District (Figure 4) is located in southwest St Petersburg. Much of the land in this district is in the CCHA because it is little more than 3-5 feet above sea level and notoriously prone to flooding and erosion, due to its low elevation and the inability of the soil in the area to effectively retain large volumes of water (Stephenson, 1997 pg. 56), qualities that are sure to be exacerbated by climate change.

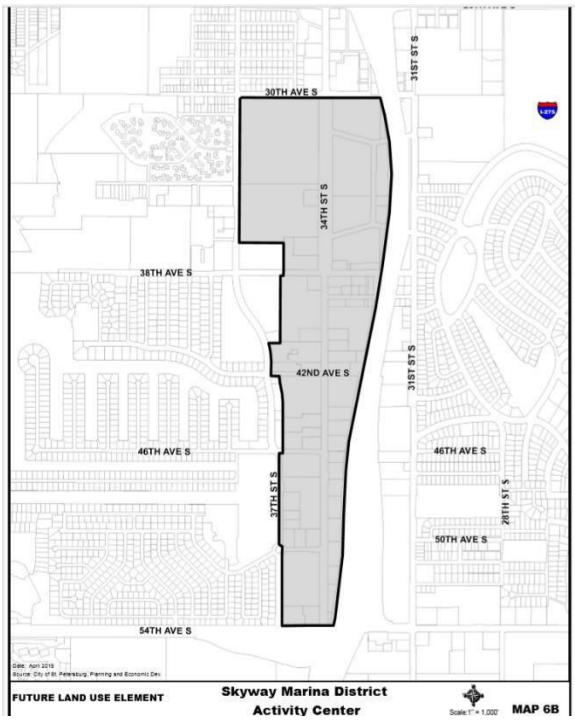

Figure 4 – *Map of Skyway Marina District Activity Center.* Adapted from St. Petersburg Comprehensive Plan 2019 Pg. 263

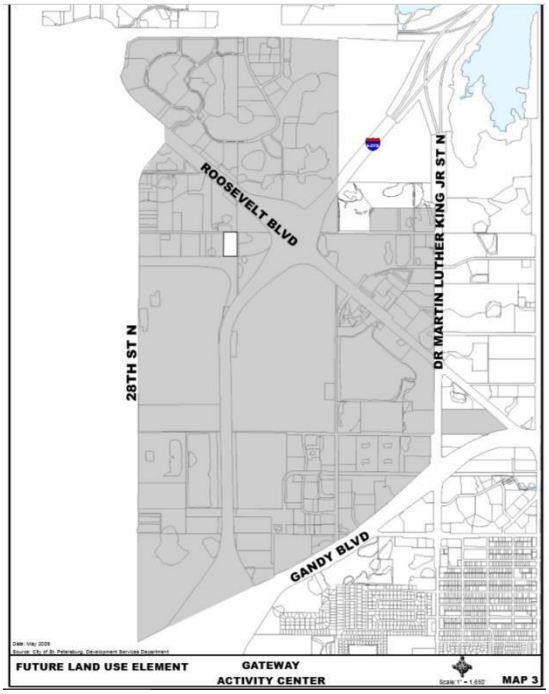

Figure 5 – *Map of Gateway Activity Center.* Adapted from St. Petersburg Comprehensive Plan 2019, Pg. 259

The Gateway activity center (Figure 5) is located in the northernmost part of the city at the intersection of Roosevelt Boulevard, Gandy Boulevard, and MLK Street North, with an elevation less than 10 ft above sea level (Gausseaux, 1985). Intown (Figure 6) comprises much of downtown St. Petersburg, including the University of South Florida St. Petersburg. This area is perhaps the most intensely developed of the three activity centers within the CHHA and is also less than 10 ft above sea level (Gausseaux,1985). The compact urban development vision that is stated in the goal of the element is reflected by its policies, such as one that stipulates the city must concentrate development in the listed activity centers and prioritize infrastructure repair and construction in said areas (St. Petersburg, 2019).

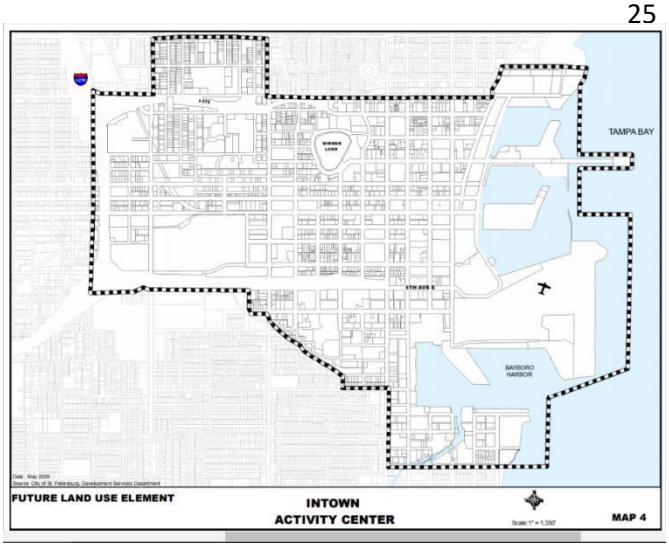

Figure 6 – *Map of Intown Activity Center*. Adapted from St. Petersburg Comprehensive Plan 2019 Pg. 260

Innovative Land Development Regulations. This section of the SPCP recognizes that innovative solutions are required to address ever-present and complex land development issues. For its lone policy prescription in this element, the city must continuously review and consider for adoption amendments to both the SPCP and land development regulations via cooperation with the private sector, neighborhood groups, special interest groups, and monitor regulatory innovations in other places (St. Petersburg, 2019). Like much of the rest of the SPCP, this sub-element fails to mention climate change and SLR.

Capital Improvements Element.

The Capital Improvement element is meant to show the financial feasibility of the SPCP. This is to be done by estimating costs of improvements, estimating the feasibility of implementation of improvements, and creation of policies to guide funding. One section of the element was chosen for review: Public expenditure in high hazard zones.

Public Expenditure in High Hazard Zones.

This section realizes that certain areas of the city are at a significantly higher risk of repetitive and intense damages due to hazards, citing CHHA specifically. The section notes that growth in these areas puts both public expenditure and lives at risk. The stated objective of this section is to "protect vulnerable coastline avoid property destruction and personal injury by limiting expenditures on public facilities in the designated coastal high hazard area" (St. Petersburg, 2019, pg.229) There are two policies in the section. The first notes that infrastructure expansion in CHHA shall only occur in a small set of scenarios, such as including stormwater and sewer improvements. The second policy notes that the City shall not locate potable water line extensions in the CHHA beyond what is necessary for planned zoning densities. There is no mention of SLR or climate change in this section.

Discussion

The St. Petersburg Comprehensive Plan meticulously maps out the future development of St. Petersburg and takes a monumental amount of information into account to do this. However, when it comes to addressing the threat posed to the city by rising sea levels, coastal erosion, intensifying hurricanes, increased flooding, and other climate change-related hazards, the plan falls short. The term "climate change" is mentioned just once in the entire 292-page document, and only when referring to a commission that had the term in its name. The

SPCP makes use of risk-assessment strategies, but climate change is not taken into consideration in this regard. While the development vision articulated throughout the plan does not have a timeframe set, it becomes clear after reading through that it is not a long-term vision. The city does address threats posed by climate changes, like hurricanes and coastal flooding, but it does not take into account the possibility that the risk posed by such hazards will substantially increase in the near future.

Certain parts of the SPCP do work to mitigate climate change effects on the city. The "drainage" and "protection of wetlands" specifically work to this end, through the protection and utilization of the city's natural features. Wetlands, lakes, and especially coastal mangrove communities have the potential to mitigate the effects of both SLR and intensifying hurricanes, as they can act as both drainage sites as well as storm surge barriers. The emphasis on preservation and expansion of natural resources is a valuable part of the SPCP and will help the city cope with the effects of climate change.

One of the primary faults of the SPCP is the lack of mandated risk-assessment strategies that specifically reference climate change. The Hazard Mitigation and Post Disaster redevelopment sections of the Coastal Management element are the only instance in the plan where risk-assessment strategies are mandated. The problem in these sections is not the strategies themselves, but rather their failure to consider climate change and associated SLR. The employed strategies address the risk posed to infrastructure and development in the present day by flooding and hurricanes, but they do not consider that risk may increase in the future. What is a 100-year floodplain today may well be a 25-year floodplain in 50 years, which would then pose a monumental risk to the people and property within at-risk areas. There are multiple instances in the SPCP where the city is required to adhere to outside organizations guidelines to address

specific issues such as flooding. But this does not completely solve the issue. The minimum standards set by FEMA, the NFIP, and the state may not be adequate to protect the population and property in the floodplain of an area such as St. Petersburg. Additionally, the NFIP has long been criticized for subsidizing risky building practices. Participation in Community Rating System is an attempted fix to this but runs into the same issue. Having slightly stricter standards than those required in the NFIP guidelines will certainly assist in mitigating flood damage. But when the only stipulation to the system is that local development exceeds minimum requirements of the NIFP in exchange for reduced flood insurance premiums, it is feasible that many of the standards implemented may not be extensive enough to make a difference. A structure that is built 4 feet instead of 2 feet above a predicted category 1 hurricane flood zone could still easily be flooded from a category 2 hurricane, which Pinellas County has noted could cause up to 11+ ft of storm surge (Pinellas County, 2014, p. 1.3).

This lack of planning in this regard is worrisome, especially when it comes to infrastructure, as the utilities of not only the coasts, but the whole city will be susceptible to the effects of rising sea levels and increased hurricane intensity. Flooding, especially from extreme weather events, is just as much a problem inland as it is on the coast (Chassignet et al., 2017) due to rising water tables and reduced soil water storage capacity. This is especially true in St. Petersburg, as the city is underlain by sandy soils and porous limestone. This means that even outside the CHHA, buildings and infrastructure are at risk of flooding as the sea level rises. TheFlorida Climate Institute recognizes infrastructure as ***the*** most important aspect of climate change adaption to address now (Chassignet, 2017) due to its huge impact on the community and the fact that retrofitting infrastructure for an entire city could take 50+ years. The first step in combating this problem would be the implementation of a policy that mandates climate change based risk assessment strategies, such as a scenario-based or threshold-scenario risk assessment, as suggested by the Florida Climate Institute (Chassignet et al., 2017).

These strategies work to identify the risk posed by climate change to individual systems or infrastructure components based on a range of simulated variables, including SLR, flood risk, potential hurricane damages, local geology, and more. Such a policy would need to be continuously reviewed and updated at regular intervals to ensure its continued accuracy and effectiveness and might be mandated to reference outside organizations, such as the TBCSAP, to make sure that such strategies are always up to date with the latest climate science facts.

Once proper risk assessment strategies have been developed, the question remains of how to implement the knowledge into feasible projects and policies. Deyle et al. (2007) references three broad categories of adaptive responses to climate change: Protection, Accommodation, and Retreat. Protection refers to physical measures and hard engineering solutions, such as seawalls, bulkheads, and levees. Accommodation refers to a multitude of actions that could be taken to decrease future vulnerability to development. This includes rules that require new structures to be built back from the shore by some multiple of the annual average erosion rate, as well as the public purchase and prohibition of development in areas deemed to be vulnerable in the future. Retreat refers to the relocation of any people, buildings, and infrastructure, in an area deemed vulnerable and a moratorium on further development for said area. To know which of these three responses to implement and where, as well as create effective resiliency efforts , the SPCP should implement what the Florida Climate institute refers to as a “toolbox” based framework (i.e. a series of solutions) which would provide the city with multiple avenues to reduce climate change damage to at-risk infrastructure, buildings, and systems both now and in the future (Chassignet, 2017). There is no single adaptive response that this

the framework suggests as it calls for an individual assessment of different systems, buildings, and infrastructure. Figure 6 outlines basic factors to be considered in a "toolbox" based framework.

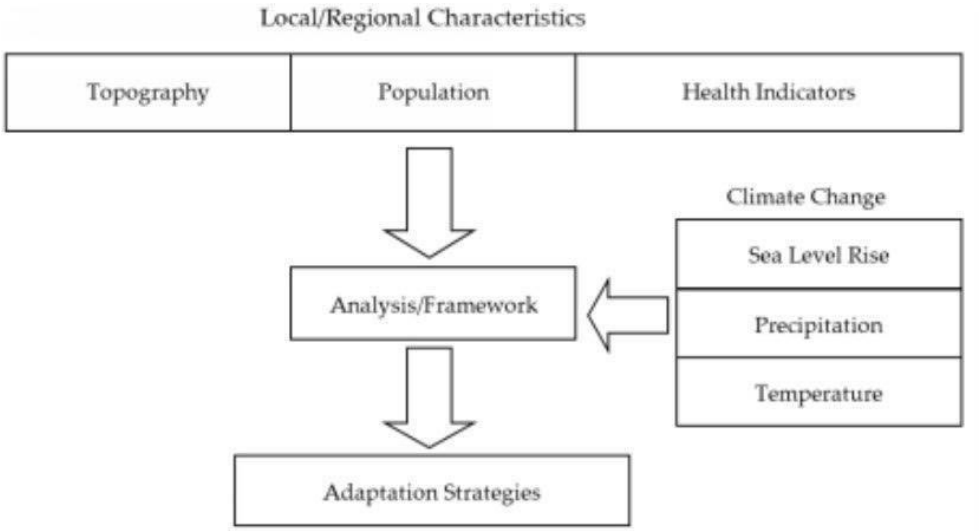

Figure 6- *Conceptual components of a toolbox-based framework.* Adapted from Chassignet 2017, Pg.322

One of the greatest benefits of a toolbox-based framework is that due to the nature of the components considered (as seen above), resultant adaption/resilience strategies are community and site-specific. This would address problems in parts of the SPCP such as the "protection of areas within the 100-year floodplain" section, which mandates adherence to FEMA and NFIP guidelines. As previously mentioned, St. Petersburg's unique geography makes it very susceptible to flooding and extreme storm events. Mandating the use of a toolbox framework would need to include language that requires a range of professionals to be consulted regarding the formulation and implementation of adaption strategies. The addition of this framework to the

SPCP could easily be implemented into the language of the last two policies in the hazard mitigation section. These two policies as they exist now urge the city to promote the use of adaptive development and redevelopment strategies but provides no specific strategies to use, provide no framework to implement any of the recommended practices, and does not mention climate change.

Ideally, the use of a toolbox-based strategy would culminate in the three adaptive response types being used where deemed necessary throughout the city as necessary. This would likely include a moratorium on building and development in areas deemed particularly vulnerable, such as the Skyway Marina District and the other vulnerable activity centers. This strategy would also be useful in determining new LOS standards, which will no doubt have to change in some areas of the city depending on the estimated impact of climate change. Of course, the implementation of adaptation or resilience strategies is reliant on a variety of independent variables, such as the local economy, feasibility of completion, and public perception and acceptance. The total cost to the city may be quite high considering the combined cost of lost revenues for stopping development, lowering of property values (and therefore tax revenues), and construction cost of significant engineering projects. There indeed may be areas of the city that the only feasible option to protect them from the future effects of climate change may be hard engineering solutions such as elevating streets or building seawalls. These kinds of solutions have been scrutinized for being very expensive and not entirely effective. Seawalls and levees must also be continually maintained, making them a continuous financial burden on the city. The use of levees and seawalls also risks a manifestation of the levee effect, whereby the guise of protection offered by levees induces property owners to invest more in their property, thereby increasing flood risk.

When asked about this issue, former St. Pete city council member Karl Nurse noted how it is not feasible nor efficient to implement these kinds of strategies en masse in St. Petersburg, as nearly 1/3 of the city is designated as being in a flood zone (K. Nurse, personal communication, April 4, 2021). He instead advocated for the abandonment of areas of the city deemed to be most at risk. This may be the best course of action for certain areas of the city to minimize future damages. Policies in the SPCP could implement this by identifying areas for abandonment, and then mandating that the city issue a moratorium on development in these areas and set a timeline for the relocation of the people living in any of these given areas. The fiscal Feasibility of abandonment in St. Petersburg may be a limiting variable, however. Deyle et al. (2007) has noted that some municipalities in Florida have found it would be more costly to abandon an area and relocate its citizens than to continually protect the same area via engineering solutions. Whether or not this would be the case for St. Petersburg is a question that could likely be answered via the use of the previously mentioned toolbox solution framework. The costs to retrofit the city's character now will, theoretically, minimize the cost to the city and its denizens decades from now. Regardless of the adaptive response used, efforts to implement the response will likely be subject to pushback both from citizens, city officials, and realtors, unwilling to sacrifice their homes, businesses, communities, and development prospects.

The role that public perception plays in the implementation of adaption strategies must be addressed, as people are generally unwilling to accept sacrifices to address environmental issues at hand, in this case, climate change, until it becomes too apparent to ignore. This a trend that can be seen throughout the history of environmental regulation in the United States, and St. Petersburg is no different. The first sound environmental comprehensive plan was not adopted by the city until the late 1970s – early 1980s after a series of environmental disasters and noticeable

quality of life changes. Unfortunately, the restructuring of the city's development is a time-sensitive issue, due to both the time it would take to implement any significant changes, and the increasing speed at which climate change effects are seen to be manifesting themselves in SLR and more. This phenomenon is not new to St. Petersburg and can be seen throughout its history.

Consider the recent actions by the city council to allow population density increases in CHHA. The city council voted 6-2 to allow this, with the two dissenting votes being Amy Foster of district 8 and Gina Driscoll of District 6. A sizable portion of Councilwoman Driscoll's district is designated as CHHA, and also contains a large portion of the Intown activity. Councilwoman Foster's district is located in central St. Petersburg and does not have any area designated as CHHA. The move will likely increase population concentrations in parts of the city most likely to be flooded. Despite the arguments made by some members of the city council, the new rules intended to mitigate the risk of developing so heavily in these areas do little to offset the risk posed by building there. The new structures may be raised two feet, but they will be in an area that is below the likely level of storm surge flooding from a modest category 1 hurricane. Even if new structures can withstand the storm surge of a category one storm, increased population density in CHHA will put many people and much property at risk during a category 2 or higher storm. Indeed, the PCCP predicts that a category 2 hurricane could cause up to 11 feet of storm surge in some areas (Pinellas County, 2014, p. 1.3). Pinellas County took direct hits from powerful hurricanes in 1848 and 1921, so, it seems foolish to pretend it will never happen again. If a category 2 hurricane were to hit St. Petersburg today, the two-foot elevation and sturdier buildings in the CHHA would do little to stop it from being inundated by 11+ feet of storm surge. And hurricanes are only part of the problem. The extreme shortsightedness of the move cannot be overstated because new construction in the CHHA is on a collision course with

SLR. The Florida Climate Institute has suggested that development policies that serve to mitigate property damage must be made with a 50–100-year vision of development (Chassignet, 2017). The Tampa Bay Climate Science Advisory Panel has indicated that it is feasible that sea levels could rise as much as 4+ ft in St. Petersburg by 2050, and as much as 8+ feet by 2100 (TBCSAP, 2019). Perhaps the most troubling part of the city council's actions was the campaign waged by pro- increased densities parties. Figure 7 shows a mailer sent out to residents of St. Petersburg encouraging them to contact their city council representative and urge them to approve density increases. Figure 8 shows a headline from an edition of the St. Petersburg Independent in August of 1923, urging the denizens of the city to oppose the planning law and by extension the comprehensive plan of John Nolan, which if passed would have severely limited the development opportunities for realtors and other land speculators.

Figure 7 – *Mailer sent to citizens of St. Petersburg urging them to support CHHA amendments.*

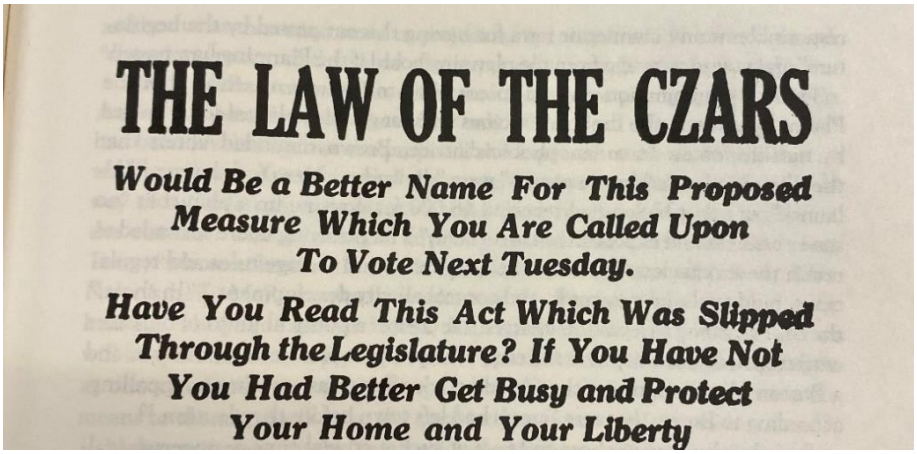

Figure 8 – *August 1923 Headline from the St. Petersburg Independent.* Adapted from Stephenson 1997, Pg.75

The of the language and purpose of the two pieces are very similar, despite them being almost a century apart. The shown images are propaganda pieces, intentionally presented in a way to misconstrue the nature of the legislation at hand and is but one example of a multidecadal struggle between property rights champions who stand to gain from continuous and frankly reckless development practices, and the public's interest in not wasting tax money in the expansion and repair of infrastructure in CHHA and other areas deemed too risky to build. In the past, such attitudes have wreaked havoc on the city. The rejection of John Nolan's Planning law and desire for quick profits eventually led to the bankruptcy of the city and a decade of economic decline. Boca Ciega Bay has suffered irreparable damage, most notably in the 1960s and 1970s, from dredging and filling operations, due to the market for waterfront property, and has lost most of its recreational, and commercial value (Stephenson, 1997). The famous Fifth Circuit Court of Appeals 1970 decision *Zabel v. Tabb* stemmed from a conflict in St. Petersburg between a realtor and the U.S. Army Corps of Engineers, which had denied a permit to dredge. The decision allowed the dredging of the bay to continue and affected dredge and fill operations on a national scale. The Public Expenditure in High Hazard Zones section has the potential to address this issue of reckless development, but the policies in it currently only prohibit infrastructure or potable water line expansion in high hazard areas. Language that could be implemented could

refer to risk assessment strategies required in other parts of the plan, as well as set limits on how much any given development action can impact LOS Standards.

This quick profit over sustainable development mindset has unfortunately continued to plague the city and its developers over the past decades, even as climate science has begun to take shape, and the threats posed by climate change to certain areas of St. Petersburg, have become increasingly clear. Thus, as with most environmental issues, public outreach and education are of the utmost importance to implement meaningful changes. Although even if the citizens of St. Petersburg fully supported such monumental changes to the city's structure, Deyle et al. (2007, pg 36) noted that "Property rights law presents a formidable barrier to completely prohibiting development of [vulnerable] areas, while public funds for fee-simple acquisition are entirely inadequate to buy-out property".

There is no easy solution to the barriers presented here short of a fundamental change in the property rights laws of Florida as well as a shift in the priorities of developers, realtors, and the citizenry of St. Petersburg. Thus, the most immediate and effective changes that the city can implement into the SPCP to prepare for the effects of climate change are as follows:

- Implement Climate-Change based risk assessment strategies.
- Utilize Toolbox solutions framework.
- Extend vision of development in all regards to at least 50+ years
- Work to minimize public expenditure in vulnerable areas.

Conclusion

The purpose of this thesis is to analyze the city of St. Petersburg's comprehensive plan and how it addresses the predicted effects of climate change. After this analysis, it can be concluded that the SPCP in its current iteration lacks many essential components to address climate change. The elements and policies of the plan do not mention climate change, an omission that sets much existing and future development on a collision course with climate change. The plan and by extension the city could greatly benefit in this regard from the use of climate change-focused risk assessment strategies to determine areas that will be vulnerable in the future. The value of such assessments, and their skillful communication to the public, is that they put information into circulation. This is the first step in building support for more substantive action. People have to be convinced of what is coming at them and when. Additionally, a framework should be added to the plan that mandates the formulation of community and site-specific solutions to addresses the newly found vulnerabilities. It remains to be seen, however, if the needed changes will be realized, as they will subject to opposition from both local and statewide sources and may be unable to be implemented without significant changes to the Florida Legislature. Given more time, studies like this could be greatly improved via communication with city officials concerning specific issues in the plan. Overall, St. Petersburg's vulnerability to the effects of climate change in the future will be determined by the attitude taken by its citizenry and the ability of its comprehensive plan to implement changes that actively work to discover, assess, and address threats posed by sea-level rise, intensifying hurricanes, coastal erosion, and increased flooding.

References

Chapin, T., Connerly, C., Higgins H. (2007) Growth management in Florida. Ashgate

Chassignet, E. P., Jones, J. W., Misra, V., & Obeysekera, J. (2017). Executive summary. In E. P. Chassignet, J. W. Jones, V. Misra, & J. Obeysekera (Eds.), Florida's climate: Changes, variations, & impacts (iii-viii). Gainesville, FL: Florida Climate Institute.

Churchill, Ward (2000). Charny, Israel W. (ed) *Encyclopedia of Genocide* p.437

Deyle, R. E., Bailey, K., & Matheny, A. (2007). *Adaptive response planning to sea level rise in Florida and implications for comprehensive and public-facilities planning*. Florida State University.

Dunkelberger, L. (Jun 3, 2011) *Gov. Rick Scott reverses 25 years of growth management policy.* Sarasota Herald Tribune https://www.heraldtribune.com/article/LK/20110602/News/605199870/SH

Florida Climate Center. (N.D.) *St. Petersburg.* Retrieved from https://climatecenter.fsu.edu/products-services/data/1981-2010-normals/st-petersburg

Fu, X., Song, J., Sun, B., & Peng, Z. R. (2016). "Living on the edge": Estimating the economic cost of sea level rise on coastal real estate in the Tampa Bay region, Florida. Ocean & Coastal Management, 133, 11-17.

Gausseaux, K. W. (1985*) THE SURFICIAL AQUIFER IN PINELLAS COUNTY, FLORIDA.* Tallahassee: Florida Geological Survey.

Gibson, C., & Jung, K. (2002). *Historical census statistics on population totals by race, 1790 to 1990, and by Hispanic origin, 1790 to 1990, for the United States, regions, divisions, and states*. Washington, DC: US Census Bureau.

Reps, John William. (1965) *The Making of Urban America; a History of City Planning in the United States.* Princeton, NJ: Princeton University Press.

Murakami, H., Levin, E., Delworth, T. L., Gudgel, R., & Hsu, P. C. (2018). Dominant effect of relative tropical Atlantic warming on major hurricane occurrence. Science, 362(6416), 794-799.

Nicholls, R. J., Hanson, S., Herweijer, C., Patmore, N., Hallegatte, S., Corfee-Morlot, J., ... & Muir-Wood, R. (2008). Ranking port cities with high exposure and vulnerability to climate extremes: exposure estimates.

NOAA. (October 23, 2011). 1921 Tarpon Springs Hurricane. Retrieved from https://www.weather.gov/tbw/tampabay1921hurricane

Office of Economic and Demographic Research. (2020, November) Pinellas County Florida's 6th most populous county with 4.6% of Florida's population. Retrieved from http://edr.state.fl.us/Content/area-profiles/county/pinellas.pdf

Peterson, J. A. (2009). The birth of organized city planning in the United States, 1909–1910. *Journal of the American Planning Association*, *75*(2), 123-133.

Pinellas County Planning Department. (2014, October 21) Comprehensive Plan - Coastal Management Element Chapter 2: Beaches and Dunes. https://www.pinellascounty.org/Plan/comp_plan/05coastal/ch-2.pdf

Pinellas County Planning Department. (2014, October 21) Comprehensive Plan - Coastal Management Element Chapter 6: Awareness and Implications of sea level rise. https://www.pinellascounty.org/Plan/comp_plan/05coastal/ch-6.pdf

Pinellas County Planning Department. (2012, March 27) Comprehensive Plan - Natural Resource Conservation & Management Element Chapter 1: Pinellas County's Natural Landscape. Retrieved from https://www.pinellascounty.org/Plan/comp_plan/04natural/ch-1.pdf

Pinellas County Planning Department. (2008, March 18) Comprehensive Plan. Retrieved from https://www.pinellascounty.org/Plan/comprehensive_plan.htm

Pinellas County Planning Department. (2008, March 18). Coastal Management: Completed Projects. Retrieved from https://www.pinellascounty.org/environment/coastalMngmt/completed-projects.htm

Randers, J., Goluke, U. (2020). An earth system model shows self-sustained melting of permafrost even if all man-made GHG emissions stop in 2020. Sci Rep 10, 18456 https://doi.org/10.1038/s41598-020-75481-z

Schuur, E. A., McGuire, A. D., Schädel, C., Grosse, G., Harden, J. W., Hayes, D. J., ... & Natali, S. M. (2015). Climate change and the permafrost carbon feedback. Nature, 520(7546), 171-179.

Solomon J., Sampson T. (2020, October 9.) St. Petersburg opens door to more development in flood-prone areas. Tampa Bay Times. https://www.tampabay.com/news/st-petersburg/2020/10/09/st-petersburg-opens-door-to-more-development-in-flood-prone- areas/

Solomon J., Sampson T. (2020, October 8.) Realtors pressure St. Pete to loosen development rule in flood-risk zone. Tampa Bay Times. https://www.tampabay.com/news/pinellas/2020/10/08/realtors-pressure-st-pete-to-loosen-development-rule-in-flood-risk-zone/

Stephenson, R. (1997) *Visions of Eden; Environmentalism, Urban Planning, and City building in St. Petersburg, Florida, 1900-1995.* Columbus OH: Ohio State University Press

St. Petersburg Planning Department (2019) *St. Petersburg Comprehensive plan.* Retrieved from https://www.stpete.org/planning_zoning/docs/Comprehensive%20Plan%20-%20Effective%2011142019.pdf

SWFWMD (N.D.) *Clam Bayou Habitat Restoration and Stormwater Treatment.* Retrieved from https://www.swfwmd.state.fl.us/projects/clam-bayou-habitat-restoration-and-stormwater-treatment

Sweet, W. W. V., Kopp, R., Weaver, C. P., Obeysekera, J. T. B., Horton, R. M., Thieler, E. R., & Zervas, C. E. (2017). Global and regional sea level rise scenarios for the United States.

Tampa Bay Climate Science Advisory Panel (TBCSAP). (2019, April) Recommended projecions of sea level rise in the Tampa Bay Region Retrieved from https://www.documentcloud.org/documents/5999901-CSAP-sea level rise-Recommendation- 2019-FINAL.html#pages

Tyler, N., & Ward, R. M. (2011). *Planning and community development: A guide for the 21st century*. WW Norton.

U.S. Census Bureau (1790). First U.S. Census