How a Coastal Community
Partnered to Build a More Resilient Future

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Extreme weather such as hurricanes complicate water management decisions and bring increased challenges to local utilities.

Water resource management is a global challenge with far-reaching significance that will become increasingly difficult under a less predictable climate. While planning for uncertainty is not a new concept for utility managers, incorporating climate data into water management decisions is more novel. This realization is sparking diverse partnerships between utility providers – such as local governments – and climate scientists who recognize that freshwater is a finite resource to be used and reused wisely to serve an array of One Water needs – e.g. drinking water, stormwater, wastewater, agriculture, fisheries and recreation.

Climate change and water supply are inextricably linked – a challenge that is increasingly understood by entities tasked with managing water. Fresh perspectives are needed to understand how changes to our climate – such as precipitation and temperature – will impact utility providers and the customers they serve. As climate change continues to manifest, local governments will increasingly be tasked to develop strategies that not only confront these challenges, but also embrace innovative opportunities to adapt and become resilient.

Weather is both a contributor to the success of water management and a hazard to infrastructure resilience. As air temperatures rise, the atmosphere destabilizes and the consequent changes add unpredictably to our weather cycle – intensifying tropical storms, fluctuating extreme precipitation and droughts, and exasperating inland flooding. These weather extremes complicate water management decisions such as forecasting water supply, managing wastewater, and discharging stormwater, the latter of which can lead to flooding and poor water quality. Rising global air temperatures will also continue to contribute to rising sea levels along coastlines where many infrastructure assets lie vulnerable.

Resiliency is nothing new

We've been designing infrastructure to last decades – and sometimes a full century – while facing extreme weather and resource scarcity. But as infrastructure ages and climate disruptions intensify, we must adjust our thinking and formulate short- and long-term solutions to manage water infrastructure. A community that makes choices to proactively protect built infrastructure will be better positioned to sustain system shocks related to periodic climate stressors.

Communities across Florida are experiencing the effects of climate change, and these changes are producing consequences.

Florida weather is prone to interannual variability in precipitation with notable periods of drought and extreme precipitation. Local, regional, and global climatic influences, such as sea breeze convection, El Niño/La Niña, and tropical systems, as well as human influences and microclimates, "complicate" Florida weather. Atmospheric instability – periods of drought and extreme rainfall – is not a new phenomena, but the new regularity of instability is cause for concern. Recent tropical weather – Hurricanes Harvey, Florence, Maria, Irma, Michael, and Dorian – forewarn of this instability.

Until somewhat recently, the climate has been relatively stable and design standards to manage water have been developed based on expected patterns of weather. As the pendulum swings more erratically between extreme weather events like torrential precipitation and intense droughts, design standards of the 20th century are likely to become antiquated – and planning for future extremes more difficult. Governments that collaborate across management sectors – removing interdepartmental silos – will be better positioned to weather climate unpredictability.

As air temperatures rise, water quality in lakes, rivers, bays, and estuaries is changing. Harmful algal blooms (HAB) – freshwater (blue-green algae) and marine (red tide) – are expected to benefit from a warmer climate and, specifically, warmer winter temperatures with fewer freezes. Some toxic algal species are believed to have a competitive advantage in warmer water. Extreme precipitation and drought can worsen conditions. Naturally occurring algal blooms are fueled by nutrient-loading pollution, which flows into rivers and bays as stormwater runoff. Extreme rain events flush nutrient-laden waters from land to river to sea where they can fuel HABs, which devastate tourism, coastal wildlife, and fisheries – a disaster that affected Sarasota Bay and the surrounding Gulf of Mexico in 2014 and 2017/18.

As a coastal city in southwest Florida, Sarasota offers miles of sandy beaches and months of beautiful weather. It is also near the heart of hurricane country and is projected to experience a rise in sea level of 12 to 18 inches over the next 30 years (NOAA, 2017), and as noted has experienced more extreme precipitation events and increased heat. These climatic factors made Sarasota an excellent place to conduct an Infrastructure Vulnerability Assessment. This assessment looked at the City's water supply, wastewater, stormwater systems, transportation networks, and critical buildings, as well as green infrastructure such as mangroves, living seawalls and shorelines, through the lens of regional climate change projections on both a short-term and long-term basis. The goal was to develop an Adaptation Plan that served as a roadmap to enhancing community resiliency.

> *The City is in charge of critical public services — services that impact our quality of life and business. The assessment of publicly owned assets within the city limits was done with this risk management and responsibility in mind.*
>
> *– Stevie Freeman-Montes, City of Sarasota Sustainability Manager*

Understanding a community's vulnerabilities to climate change – including flooding from sea level rise, tropical storms, and extreme precipitation, as well as extreme wind and heat episodes – is essential for reducing exposure to risk and informing decisions to adapt. HDR was tasked with evaluating the City of Sarasota's infrastructure resilience through an assessment of vulnerabilities to natural and man-made hazards. Our holistic approach to resiliency focused on the array of local vulnerabilities to understand the broader picture of overall resilience. We incorporated a **six-step approach** that enabled us to systematically work through a vulnerability analysis in a manner that was interactive across every City department responsible for managing infrastructure. This allowed us to engage collectively and one-on-one with emergency services, planning, transportation, stormwater and utility managers.

1. *Identify Climate Projections*
2. *Infrastructure Inventory*
3. *Vulnerability Assessment*
4. *Prioritize Vulnerabilities*
5. *Develop Adaption Strategies*
6. *Adaption Plan*

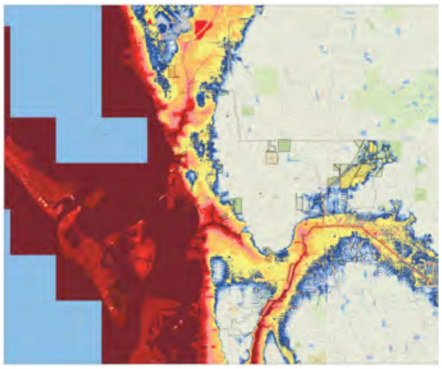
Step 1: Identify Regional Climate Trends

This first step focused on regional climate trends to understand vulnerabilities specific to Sarasota and to identify the latest climate science and industry standards available for conducting a comprehensive infrastructure resiliency study. This step laid the foundation for the analysis of infrastructure vulnerabilities to sea level rise (SLR), tropical storms, extreme precipitation and droughts, inland flooding and extreme wind and heat.

Looking at recorded tide gauge data, Sarasota has gained over seven inches of SLR since 1947 (approximate 70 year period). Model projections for just the next 30 years are showing that SLR is likely to increase 12 to 18 inches, indicating that the rate of SLR is accelerating. Average annual air temperatures are also on the rise having increased 2.2° F over the past 50 years as observed at a nearby meteorological station. Currently, Sarasota experiences around nine days over 95° F annually. Projections suggest a continued rise in temperatures leading to 50 to 60 additional days that exceed 95°F each year. Warmer air will warm surface waters and this air can also hold more water, intensifying rainfall events.

Step 2: Inventory Infrastructure

This step included an infrastructure inventory of the City's water supply, wastewater treatment and conveyance systems, and the stormwater components, as well as transportation networks, critical buildings, public parks, and green space.



Using Geographic Information System ArcMap software, we geo-spatially mapped infrastructure and organized it into an interactive database. The maps helped visualize the infrastructure grid and provided a foundation upon which to model climate hazards. Light Detection and Ranging (also known as LiDAR) and digital elevation model tools were used to estimate ground elevations to better understand localized conditions surrounding infrastructure assets.

Step 3: Conduct a Vulnerability Assessment

Vulnerability is the degree of exposure to physical damage that an infrastructure asset could experience due to a climate impact. To complete this assessment, infrastructure assets were ranked by looking at sensitivity and adaptive capacity, which was used to inform decisions for improving resiliency.

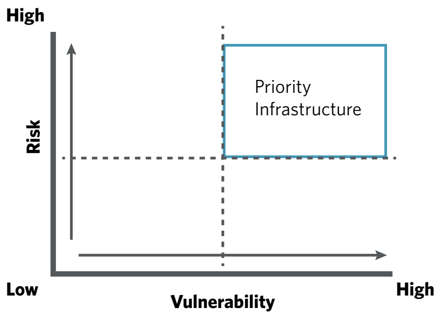
Vulnerability =

Sensitivity x Adaptive Capacity

Sensitivity was defined as the degree to which an asset would be impacted by exposure to a known or projected climate threat. Adaptive Capacity was the asset's ability to withstand impacts caused by exposure to a climate impact and considered whether the asset would be repaired, removed, or relocated and the associated time and cost.

Step 4: Prioritize Vulnerabilities

To identify overall risk to the community's infrastructure assets, climate projections were applied over maps to enable a comprehensive review of near- and long-term infrastructure vulnerabilities to climate threats. Risk was characterized as the likelihood of a particular climatic event impacting the asset and the consequences of that impact.



The prioritization process produced gradients of risk through a ranking evaluation that prioritized the most vulnerable infrastructure.

This process benefited from interdepartmental communication among infrastructure management sectors, as well as regular engagement with City officials and the public, which enabled the assessment team to harness varied perspectives to prioritize the likelihood and consequence of infrastructure loss.

Likelihood x Consequence

= Risk (1-125)

Gradients of the threat to specific infrastructure were looked at through a likelihood of impact ranking using GIS ArcMap spatial analysis. This analysis was used to evaluate the location of each asset with consideration of the surrounding conditions in conjunction with climate projections. A subsequent consequence analysis was conducted to gauge whether the loss of a particular asset would adversely impact the City.

The results were used to determine the overall risk associated with the loss of a particular asset.

ASSET NAME	RISK SCORE
Bayfront Marina Park	90.0
Bayfront Park East 41	34.0
Bird Key Park	70.0
Bobby Jones Golf Club	48.0
Centennial Park	63.0
Dr. MLK Jr. Park	18.8
Eloise Werlin Park	47.5
Ken Thompson Park	65.0
Lawn Bowling	80.0
Lido Beach	36.0
Lukewood Park	76.5
Pioneer Park	30.0
Ted Sperling Park	63.8
St. Armand's Circle Park	95.0
Whitaker Gateway Park	58.5
Sarasota Gateway Park	64.0
Sarasota Bay Estuary	77.0
Seawalls (Public Lands)	65.0

By prioritizing vulnerabilities, Sarasota was able to assign risk score to each of its asset.

Those assets that score highly vulnerable and at high risk were prioritized for improving resiliency. The vulnerability and risk assessments prioritized 80 assets that were considered most critical to bolstering the City's resiliency to climate change.

Step 5: Develop Adaptation Strategies

We developed adaptation strategies for the 80 most vulnerable assets. Green infrastructure such as parks, green space, and living shorelines were recognized for their importance to buffer the community and facilitate adaptation opportunities. Given the interconnected nature of many infrastructure assets – including the unique value of green assets – adaptation measures identified for one department's assets at times overlapped or were complemented by improvement opportunities recommended for seemingly unrelated assets. Finding interdepartmental synergies was important for harnessing innovative adaptation opportunities. Looking across all public infrastructure and viewing each sector as part of the overall system, rather than individual components in isolation, resulted in a robust understanding of critical areas where the City could best enhance resiliency.

Step 6: Present the Adaptation Plan

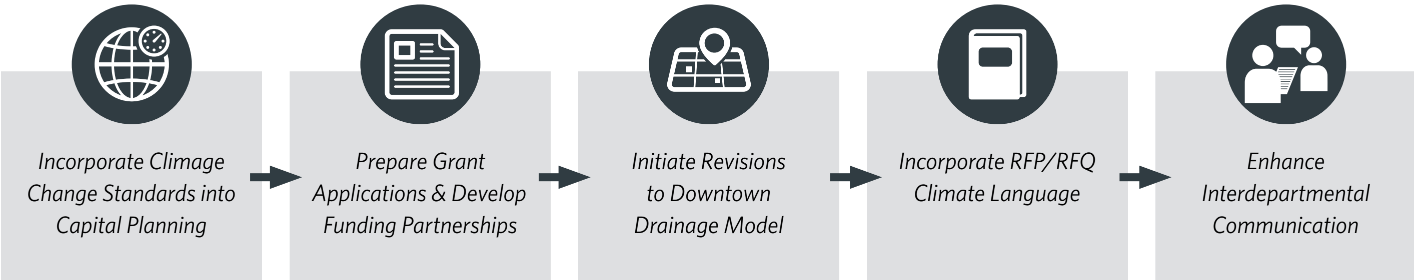
We coalesced the results into a Climate Adaptation Plan, which provided a framework for the City to make decisions to protect infrastructure and enhance coastal resiliency.

"HDR surpassed our expectations in quality and expertise while guiding the interdepartmental team of over 10 staff through an analysis of 200+ city-owned assets. The final report continues to be a source of pride that is being integrated throughout existing and future city planning and investments."

– Stevie Freeman-Montes, City of Sarasota Sustainability Manager

The next steps will determine how best to protect vulnerable infrastructure assets. Immediate funding to address all of the City's infrastructure vulnerabilities was unrealistic; however, the results reinforced the initiative of community leaders to target opportunities to heighten community resiliency. As City infrastructure ages and requires replacement, this Adaptation Plan will support capital investment planning, enhance grant applications, establish vendor expectations, guide resilient project designs, and promote inter-departmental communication.

As a less predictable climate emerges, water management will challenge coastal cities like Sarasota. Embracing new and diverse partnerships and looking holistically at impending climate changes will help confront these challenges and inform water management decisions that prioritize adaptation and resiliency. The City of Sarasota Adaptation Plan established such partnerships and created a foundation upon which to build urban resilience. Ensuring this resilience will require ongoing engagement with citizens, businesses, and organizations, as well as collaboration with other government entities and public partners to protect the infrastructure that sustains the array of uses – e.g. drinking water, stormwater, wastewater, agriculture, fisheries and recreation – for a more resilient future.



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