Climate Vulnerability and Adaptation Report for Indian River County

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EcoAdapt
Meeting the challenges of climate change

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Table of Contents

Introduction

Climate change is already affecting Indian River County (IRC) and will continue for decades to come. This change includes sea level rise, high tide coastal and inland flooding, extreme heat, and increased frequency and decreased speed (more time in place) of hurricanes. Climate-related changes, coupled with pre-existing challenges such as potable water supply, lack of green spaces for recreation, population growth, stormwater management, nuisance flooding, aging infrastructure, invasive species, and habitat loss and fragmentation have significant implications for the people, infrastructure, and environment of IRC.

The purpose of this report is to improve understanding of local climate change impacts and vulnerabilities and present adaptation responses that can help reduce community vulnerability and/or increase resilience. The report synthesizes the results of a three-part virtual workshop series held in October and November 2021 that brought together more than 20 stakeholders from across IRC to evaluate community vulnerability and develop adaptation strategies for three focus areas: (1) utilities, (2) transportation, and (3) conservation lands and parks.

The **Project Methods and Workshop Activities** section of this report provides an overview of the climate adaptation planning process, workshop series, and selection of pre-existing conditions and climate stressors. The **Overview of Climate Projections and Impacts** section presents a summary of current and projected climate changes for the community. The **Vulnerability Assessment and Adaptation Strategies** section summarizes vulnerability and adaptation information for each of the three topic areas considered. Finally, the **Conclusions** section highlights common concerns, impacts, and adaptation strategies across the three focus areas.

Project Methods and Workshop Activities

Climate Adaptation Planning Overview

Climate change adaptation refers to how we prepare for, respond to, and recover from changes we are already experiencing and/or are expected to experience. *Adaptation*, which focuses on managing the impacts of climate change, can be distinguished from *mitigation*, which refers to efforts intended to decrease the potential for climate change itself (i.e., by reducing greenhouse gas emissions or enhancing carbon sequestration). The adaptation planning process (Figure 1) intentionally integrates the consideration of climate change into plans, programs, projects, and operations, and is meant to be iterative.

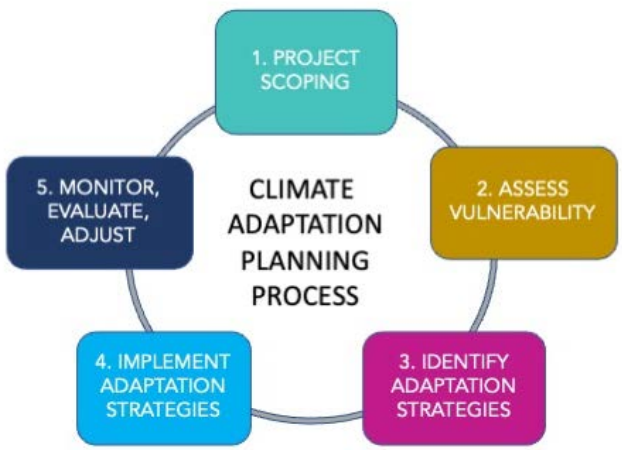

Figure 1. Steps in a basic climate adaptation planning process.

While there are many different climate adaptation planning frameworks, they generally consist of the same steps: (1) define project scope, (2) assess vulnerability, (3) identify adaptation strategies, (4) implement strategies, and (5) monitor, evaluate, and adjust strategies, as needed.

(1) **Define Project Scope**. This step includes identifying goals and desired outcomes of the process, establishing the geographic boundaries and time frame of interest (e.g., near-term: 10-20 years; mid-term: 25-50 years; long-term: 50+ years), identifying and engaging with key stakeholders and partners, and identifying key climate stressors and pre-existing conditions (i.e., stressors that already impact a community). Completion of this step is critical to provide the foundation for a clear and efficient adaptation planning process.

(2) **Assess Vulnerability**. Vulnerability assessments improve understanding of how climate change is likely to impact a community and its ability to respond to those impacts. Vulnerability assessments include consideration of the likelihood of exposure to climate change, the consequence of those impacts, and the community's capacity to adapt to those impacts. These assessments include consideration of the following three components of vulnerability:

- **Likelihood** is the degree to which a community is exposed to significant changes in climate and considers both the anticipated direction and magnitude of change.
- **Consequence** is the degree to which a community is affected by exposure to a changing climate and considers both the anticipated impacts of climate stressors as well as the impacts of pre-existing conditions.
- **Adaptive capacity** is the ability to adjust to climate change to minimize potential damages, take advantage of opportunities, or cope with consequences.

Likelihood and consequence together give an estimation of risk which, when combined with adaptive capacity, provides an overall picture of vulnerability (Figure 2). It is important to evaluate all three components – likelihood, consequence, and adaptive capacity – to gain a holistic perspective of the factors that are driving vulnerability.

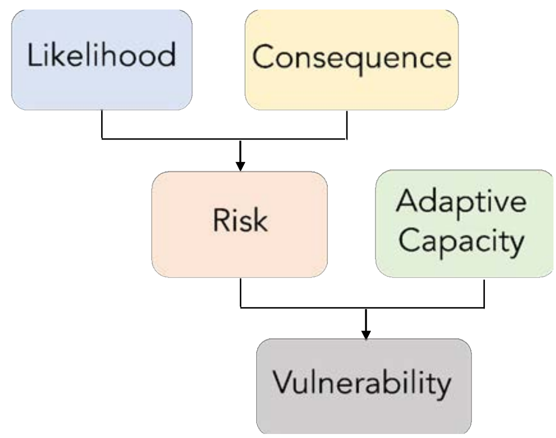

Figure 2. Components of vulnerability.

The vulnerability assessment step of the adaptation planning process includes evaluating the impacts of climate change on a community; characterizing the community's ability to minimize or cope with impacts; assigning likelihood, consequence, and adaptive capacity rankings; and summarizing overall vulnerability based on rankings, impacts, and adaptive capacity information.

(3) **Identify Adaptation Strategies**. Adaptation strategies aim to reduce the negative effects or take advantage of the opportunities provided by climate change. The goal of this step is to identify adaptation strategies that reduce risk (limit exposure or minimize consequence) and/or enhance resilience (increase adaptive capacity). Understanding what drives vulnerability to climate change

(e.g., likelihood, consequence, adaptive capacity, or some combination of these) provides a good starting point for identifying possible adaptation strategies. General types of adaptation strategies that may be considered include programmatic; capital improvements and infrastructure; coordination and/or collaboration; knowledge and evaluation; and plans, regulations, and policies. To help decide which actions to prioritize for implementation, it can be helpful to articulate co-benefits (e.g., greenhouse gas reduction, public health improvement, water quality improvement, etc.) and conflicts or challenges (e.g., unintended consequences on people or community assets).

(4) **Implement Adaptation Strategies**. Once a list of adaptation strategies has been generated and prioritized, they must be put into action. Developing an adaptation implementation plan for each prioritized strategy helps communities articulate how and when (e.g., immediately, within the next 5 years, etc.) the strategy should be implemented, leads and partners responsible for implementation, existing resources and those that are still needed, and potential barriers to implementation.

(5) **Monitor, Evaluate, and Adjust**. Climate change adaptation planning should be an iterative process. Monitoring and evaluation are essential components that allow communities to make progress while also adjusting actions based on project outcomes and new information. For instance, post-implementation monitoring of adaptation strategies helps to determine whether the strategies are having their intended effect and when or where adjustments may be needed. Developing a monitoring and evaluation plan is critical to minimize wasted time, money, and effort, and these plans should include identification of desired outcomes, parameters to monitor and the method to do so, thresholds that may signal desired outcomes are not being met, and possible alternative strategies to pursue if these thresholds are crossed.

Tools Used in the Workshop

Climate Change Adaptation Certification Tool[1]

The Climate Change Adaptation Certification Tool (CCAC) is intended for use during regulatory or procedural review processes carried out as part of routine community functions. The CCAC can be applied to decisions about any project or proposal that will involve the use of public funds, has a life cycle of greater than five years, and can

[1] http://ecoadapt.org/data/documents/EcoAdaptCCACToolfillableIndianRiverCounty.pdf

impact public good (e.g., fiscal expenditures, capital planning, permitting, infrastructure design and siting). Applying the CCAC to these decisions allows explicit evaluation of future conditions on project function and longevity, increases understanding of the long-term sustainability of a project at the funding or permitting phase, and considers how to reduce community risk that could arise from actions that become a liability under future conditions. The CCAC process includes three steps: (1) identification of climate change risk factors, (2) evaluation of climate impact on a project, and (3) determination of project review.

Rapid Vulnerability and Adaptation Tool[2]

The Rapid Vulnerability and Adaptation Tool for Climate-Informed Community Planning (RVAT) was developed to make climate adaptation planning a simple, direct, and feasible process for communities. The purpose of the tool is to improve understanding of community vulnerability to climate impacts and to develop implementable solutions that reduce vulnerability and/or increase resilience. The RVAT is designed to cover the major steps of a basic climate adaptation planning process, which include: (1) project scoping, (2) vulnerability assessment, (3) adaptation strategy development, and (4) adaptation implementation.

Workshop Series

The Indian River County Climate Change Adaptation Workshop series was held on October 26, October 28, and November 3, 2021, from 1 to 5 pm ET each day.[3] The first day of the workshop focused on discussing climate impacts, the second on assessing vulnerability, and the third on developing adaptation strategies. Workshop activities for each day are discussed in more detail below.

Climate Adaptation Workshop Activities: Day 1

The first day focused on orienting participants to the workshop series, introducing climate adaptation planning and the steps involved, identifying and prioritizing pre-existing conditions (i.e., stressors that currently impact the community), presenting climate change projections and discussing impacts, introducing and completing the first step of the CCAC, and completing the first step of the RVAT (prioritizing pre-existing conditions and climate stressors and evaluating adaptive capacity). To aid in the adaptive capacity evaluation, workshop participants were provided with a network mapping tool[4] developed based on the registrants' surveys completed prior to the

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[2] http://ecoadapt.org/data/documents/RVATIndianRiverCounty.pdf

[3] The workshop support page (http://ecoadapt.org/workshops/indian-river-county-adaptation-workshop) includes links to presentation slides and all other workshop materials.

[4] https://network-mapping-41fb1.web.app/about

workshop, which shows the existing relationships among local government departments/agencies and/or community organizations and how each links to different focus areas.

Workshop activities were divided between presentations, large group discussions, and breakout group activities. Workshop participants were divided into three small groups:

Group 1: Utilities
Group 2: Transportation
Group 3: Conservation Lands and Parks

Workshop participants, including affiliations and breakout group assignments, can be found in Appendix A.

Pre-Existing Conditions and Climate Stressors

As part of the first step of the RVAT, workshop participants were asked to identify pre-existing conditions for IRC (i.e., stressors that already impact the community). Participants identified over 22 pre-existing conditions which, through group discussion and ranking, was narrowed down to a list of nine priority conditions. These included stormwater management and water quality, potable water supply, lack of green spaces for recreation, habitat loss and fragmentation resulting from development, aging infrastructure, nuisance flooding, and community perception and awareness of key stressors. Key climate stressors for IRC were pre-identified by workshop facilitators, and included increases in air temperature, extreme heat and wildfire risk, changes in precipitation, hurricanes, sea level rise and storm surge, and high tide flooding. The pre-existing conditions and climate stressors identified provided the basis for the vulnerability assessment.

Climate Adaptation Workshop Activities: Day 2

The second day focused primarily on assessing the vulnerability of all three focus areas to pre-existing conditions and climate stressors. Much of the time was spent in small groups applying the second step of the RVAT, which included discussing the impacts of pre-existing conditions and climate stressors on a given focus area, identifying impacts of greatest concern, and assigning vulnerability rankings to priority impacts. Participants then engaged in a large group discussion to share the findings of the vulnerability assessment. Facilitators also gave presentations on developing adaptation strategies and introducing the second step of the CCAC. Workshop participants were asked to complete the second step of the CCAC as homework, and then send it to workshop facilitators prior to the start of the third day.

Climate Adaptation Workshop Activities: Day 3

The third day focused on small group work to identify adaptation strategies that would reduce impacts of greatest concern for each focus area and then develop implementation plans for priority strategies (steps 3 and 4 of the RVAT, respectively). Summary presentations included a review of examples from the homework that illustrated successful use of the CCAC tool, discussing how the results of the workshop could be used to incorporate consideration of climate change into County operations, a summary of key questions and adaptation strategies for each focus area to be further developed and moved forward into implementation by workshop participants, and what to expect for final products.

Overview of Climate Projections and Impacts

The following summaries provided foundational information for the workshops about current and projected future climate changes for the IRC area. A table of observed and projected climatic changes can be found in Appendix B.

Air Temperature and Extreme Heat

By 2050, average daily minimum temperatures (i.e., minimum daily temperatures averaged across the whole year) in IRC are likely to increase by 3.6°F above the 1961–1990 historical average of 62.5°F and increase by 7.7°F above the observed average by 2100.[5] Increases in average daily maximum temperatures are projected to increase by 3.8°F above the historical average of 82.7°F. By 2100, maximum temperature is expected to increase 8.0°F.

Extreme heat events are likely to increase significantly. The number of days with maximum temperatures over 95°F are likely to increase from the 1961–1990 historical average of 3.3 days per year to 48.8 days per year by 2050 and 138.5 days per year by 2100.

Precipitation

Changes in annual precipitation in IRC are expected to be relatively small. Model projections suggest increases of 1.8% to 53.1 inches per year by 2050 and then a decrease of 3.5% to 49.4 inches by 2100, based on an observed average of 51.2 inches of rain per year from 1961–1990. However, there are expected to be more significant shifts in how precipitation is distributed within the course of the year. The largest change is expected in summer rainfall, which may decrease by 21.1% by 2100. Smaller changes are expected in spring (–8.4%) and fall (+8.9%), and little or no change is expected to occur in winter rainfall.[6]

Extreme Precipitation

Extreme precipitation, which is strongly associated with severe flooding events, is likely to increase in both intensity and frequency over the coming century. By 2100, rainfall totals during a 20-year-storm event in the southeastern U.S. are projected to increase by 21%.[7] The frequency of extreme precipitation events is not expected to change by

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[5] U.S. Climate Resilience Toolkit Climate Explorer (https://crt-climate-explorer.nemac.org), generated using the high-emissions (RCP 8.5) scenario for the average of 2041–2049 and 2091–2099 time periods compared to historical conditions (average of 1961–1990).

[6] Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey (https://doi.org/10.5066/F7W9575T), generated using the high-emissions (RCP 8.5) scenario for the mid-century (average of 2025–2049) and late-century (average of 2075–2099) time periods compared to recent conditions (average of 1981–2010).

[7] D. R. Easterling et al., in Climate Science Special Report: Fourth National Climate Assessment, Volume I, D. J. Wuebbles et al., Eds. (U.S. Global Change Research Program, Washington, DC, 2017), pp. 207–230.

2050, but by 2100 there is likely to be an 8% increase in the number of days each year with 24-hour rainfall totals of at least 2 inches (from a 1961–1990 historical average of 1.2 days per year to 1.3 days per year by 2100).[4]

Hurricanes

Extreme precipitation events will occur during hurricanes, and a warmer, moister atmosphere is projected to affect both hurricane intensity and speed. Between 1979 and 2017, hurricane surface wind speed increased globally by 8% per decade, and this pattern is likely to continue (translating to more intense, higher-category storms).[8] The movement of hurricanes in the Atlantic Ocean also slowed down by 16% between 1949 and 2016, which is associated with significant increases in the amount of rain that falls in a given area.[9]

Sea level rise and high-tide flooding

Compared to sea levels in 2000, sea level is expected to increase by 1.4 feet by 2040 (range of likely possibilities between 0.7 and 1.8 feet).[10] By 2070, sea levels are projected to increase by 3.2 ft (range 1.2–4.4 ft), and by 2120 sea levels are projected to increase by 7.4 ft (range 1.9–11.2 ft). Under extreme scenarios (representing potential collapse of the Antarctic ice sheet), sea level rise of up to 14.3 ft is possible.

As sea level rise continues over the coming century, high-tide flooding is also likely to increase. In Indian River County, high-tide flooding is calculated for days with tides greater than 1.8 ft over mean higher high water (MHHW, which is the annual average of the highest daily tides). Between 1995 and 2016, high-tide flooding occurred an average of 2.1 days per year at the Trident Pier tide gauge in Port Canaveral, just under 50 miles north of IRC.[11] By 2040, days with high-tide flooding are expected to increase to 97 days per year (range of likely possibilities between 17 and 176 days), then to 364 days per year by 2070 (range 66–365) and to 365 days per year by 2100 (range 148–365).

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[8] J. P. Kossin, K. R. Knapp, T. L. Olander, C. S. Velden, PNAS. 117, 11975–11980 (2020).

[9] J. P. Kossin, Nature. 558, 104–107 (2018).

[10] U.S. Army Corps of Engineers Sea-Level Change Curve Calculator (Version 2021.12) (https://cwbi-app.sec.usace.army.mil/rccslc/slcc_calc.html), using NOAA et al. 2017 relative sea level change scenarios calculated for an interpolated grid point between the Trident Pier and Virginia Key tide gauges; NOAA Intermediate-High scenarios are presented (range represents Intermediate-Low to High scenarios, which encompass all likely possibilities). Calculation includes vertical land movement of 0.066 ft/year at the interpolated grid point, and compares future sea levels with 2000 mean sea levels.

[11] W. V. Sweet et al., Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold. (NOAA Tech. Rep. NOS CO-OPS 86, 2018); data presented for Trident Pier tide gauge for Intermediate High scenarios (range represents Intermediate-Low to High scenarios) compared to recent conditions (1995–2016).

Summary of Projected Impacts

Likely impacts of projected climate changes on **utilities** may include:

- Damage to critical infrastructure (e.g., wastewater treatment plants) during flood events
- Reduced pump station capacity and/or increased risk of failure during flooding events and increasingly frequent high-tide flooding
- Increased energy demand during heat waves, potentially straining electrical grids and increasing costs for users
- Increased concentration of contaminants and increased risk of algal blooms in water sources during warm, dry and/or drought periods, reducing effectiveness of water treatment

Likely impacts of projected climate changes on **transportation** may include:

- Damage to transportation infrastructure (e.g., roads, bridges, culverts) following storms, floods, and extreme heat
- Road blockages and loss of access following extreme events, impacting evacuation routes, emergency access, and other critical travel
- Slower travel or road closures due to melting asphalt, overheating engines, and other impacts associated with extreme heat
- Loss of electricity due to flooding or heat waves, limiting use of electric vehicles and impacting public transit
- Decreased use of non-motorized transit due to more frequent/severe inclement weather
- Inundation of coastal roads and bridges due to sea level rise

Likely impacts of projected climate changes on **conservation lands and parks** may include:

- Reduced growth and productivity of native vegetation due to heat stress and increases in evapotranspiration
- Increased risk of harmful algal blooms in freshwater, estuarine, and nearshore marine environments, impacting water quality and potentially causing widespread mortality of fish and other aquatic organisms
- Changes in plant survival due to more frequent coastal inundation and/or saltwater intrusion into freshwater habitats, likely altering the distribution of native plant communities (e.g., salt marsh vegetation)
- Potential increase in insect pests and diseases, with associated impacts to native plants and wildlife

- Increased heat stress for people using parks and recreation areas as well as changes in patterns of recreational use (e.g., heavier use of sites with water features, increases in maintenance costs)
- Decreased accessibility/use and increased maintenance costs of park lands due to flooding
- Altered or decreased ecosystem functioning on conservation lands due to changes in hydrology and plant species composition and distribution

Vulnerability Assessment & Adaptation Strategies for Focus Areas

The following sections summarize the vulnerability and adaptation information for each of the three focus areas covered in this workshop series. The information presented is based on the discussions and input of workshop participants during breakout group activities.

Utilities

This focus area considers future planning for utilities including water, wastewater, stormwater, and broadband. Electrical utilities were touched upon, but the primary focus of this group was on water and water management utilities. The time frame considered for this assessment was long term (50 - 100 years) to address the expected life span of utility infrastructure.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of climate stressors and pre-existing conditions

Extreme heat, sea level rise and high-tide flooding, extreme precipitation and inland flooding, and **hurricanes** were identified by breakout group participants as the climate stressors that have the most significant impacts on Utilities.

Aging infrastructure and development not meeting current design criteria, **nuisance flooding**, and **community perceptions and level of education** were identified by participants as the primary pre-existing conditions that impact Utilities.

Climate stressors

Drought and extreme/prolonged heat are likely to lead to increased demand for electricity, increasing residential and agricultural water demand, and consequent increased pressure on the aquifer as well as the exacerbation of saltwater intrusion.

Sea level rise is likely to lead to the undermining of utilities on barrier islands, saltwater intrusion into aquifers and consequent potential increases in the cost of potable water and the loss of wells, and the inability to effectively drain stormwater to the lagoon.

Extreme storm/precipitation events and hurricanes are likely to lead to flooding of residences, blocked roads, increased demand on resources and increased utility operation costs, the undermining of capital planning (e.g., infrastructure is developed to meet current needs, but those needs may change if the area becomes less habitable), and the possibility that demand for water reuse declines if there is more rain.

Pre-existing conditions

Aging infrastructure and development not meeting current design criteria causes impaired water quality and nuisance flooding, adds to stress on the aquifer, and causes confusion for development planning because of the existence of inconsistent standards.

Nuisance flooding causes delays in stormwater abatement (longer periods of standing water before it can drain), adds to stress on staff who are redirected to address nuisance flooding events, blocks access or egress for residents, and can lead to increases in mosquito populations.

Community perception and level of education: A low current level of understanding of hydrology, lack of knowledge of who is responsible for various utility infrastructure, and lack of knowledge of personal roles and responsibility for water quality (e.g., proper use of fertilizer, proper disposal of dog waste) are barriers to effective utility function.

Combined impacts of pre-existing conditions and climate stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified challenges including:

- Aging infrastructure combined with all the identified stressors of sea level rise, extreme flood events and hurricanes, and extreme heat will drive a search for alternative water sources, such as surface water and desalination.
- Sea level rise and increased flooding and extreme precipitation events combined with aging infrastructure will lead to an increase in septic failure rates and leakage of drain fields, impacting surface water quality.
- Aging infrastructure combined with hurricanes, particularly Category 4 and higher, will lead to utilities being offline for increasing periods of time and potential destruction of well heads and water plants.
- Aging infrastructure combined with increases in precipitation and flooding can lead to greater delays in system upgrades because there are fewer days that building can take place.
- Extreme heat events can put additional stress on already aging infrastructure and lead to brownouts and can create challenges delivering power to vital infrastructure such as water supply as not all lift stations have generators.
- Nuisance flooding will be exacerbated by both extreme precipitation and by sea level rise, as standing water will remain on site longer and have fewer places to go.

- Nuisance flooding will be made worse by extreme heat as hot stagnant water is a recipe for increased mosquitoes and increased public health challenges. However, it was pointed out that higher temperatures could potentially evaporate flood waters more quickly.
- Community perceptions and awareness may be impacted by extreme weather because the public may not grasp that these extreme events are happening more frequently and are a root cause of decline in jurisdiction responsiveness as staff work to address emergencies.
- It is challenging to educate the public about the likelihood and trajectory of sea level rise without scaring them.
- Extreme heat will lead to the need to conduct further education and outreach to the public regarding water usage and electricity during heat events.
- Community perception of extreme weather events and sea level rise will benefit from more education and outreach about what government services are available, and how to access them.

Summary of adaptive capacity

Overall, breakout group participants evaluated the adaptive capacity of IRC departments and organizations relevant to Utilities as **moderate**. Organizations identified as playing a role in Utilities include the Cities of Fellsmere, Sebastian, and Vero Beach, the Indian River Farms Water Control District, the St. Johns River Water Management District, IRC Engineering Division, including Public Works, the Soil and Water Conservation District, IRC Utilities Services, the Town of Indian River Shores (which receives utilities from the City of Vero Beach), and the Town of Orchid (which receives utilities from the County).

Organizational potential

Overall, the organizational potential (based on staff expertise and availability, responsiveness, stakeholder relationships, and the stability of the organization or agency) of IRC was evaluated as moderate. Most organizations received a low to moderate score for staff capacity, and responsiveness was considered mostly moderate. Stakeholder relationships were variable across organizations, and stability/longevity was considered almost entirely high. The Town of Indian River Shores and the Town of Orchid were ranked moderate for stakeholder relationships but low for the remaining components of capacity, responsiveness, and stability specifically with respect to stormwater management.

Management potential

Overall, the management potential (based on whether there is an existing mandate for the work, capacity for monitoring and evaluation, to what extent the agency or organization is capable of learning and changing, its partner relationships, and the availability of scientific and technical support) for most of IRC was evaluated as moderate. Most organizations ranked highly for having an existing mandate, while there was much greater diversity in organizational rankings from low to high for factors including monitoring & evaluation capacity and science and technical support. Most organizations were rated as having a moderate ability to learn and change, and partner relationships were ranked as low to moderate for all the organizations. The Town of Indian River Shores and the Town of Orchid were ranked low for management potential specific to stormwater management.

Overall vulnerability

On-site sewage treatment and disposal system (OSTDS) failure due to ground saturation, nuisance flooding, increasing demand for water and electricity, and the **future need for alternative water sources for both potable water and irrigation** were ranked by breakout group participants as impacts with **high vulnerability** due to the extreme risk (*certain or almost certain likelihood and major to almost catastrophic consequence*) and moderate adaptive capacity. **The unmet need of educating the public about sea level rise** was identified as an impact with **moderate vulnerability** due to the high risk (*almost certain likelihood and moderate consequence*) and moderate adaptive capacity, with participants emphasizing the need for communicating this message while avoiding the scare factor (See Table 1 for comparison of vulnerability rankings).

Table 1. Vulnerability assessment ranking results for effects/impacts of greatest concern for Utilities.

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
On-site Sewage Treatment and Disposal System (OSTDS) failure due to saturation of ground from altered precipitation and sea level rise	Certain	Major	Extreme	Moderate	High
Nuisance flooding will be longer, as water will have nowhere to go	Almost Certain	Major	Extreme	Moderate	High
Increasing demand for water (including for irrigation) and electric power; irrigation with wells leads to increased pressure on aquifer, exacerbating or accelerating saltwater intrusion	Almost Certain	Major	Extreme	Moderate	High
Future need for alternative water sources (surface, de-sal) for both potable water and irrigation	Almost Certain	Major (almost catastrophic)	Extreme	Moderate	Moderate
Challenge of increasing need to educate public about sea level rise, without scare factor	Almost Certain	Moderate	High	Moderate	Moderate

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Breakout group participants identified adaptation strategies for Utilities ranging from **programmatic** (e.g., conversion of septic to sewer) to **improving knowledge** (e.g., hosting climate change workshops with groups like HOAs and interested citizens to help them understand what is being planned and what actions are occurring) to **creating new regulations** (e.g., new codes to increase water efficiency standards or mandate water reuse). The following table summarizes possible adaptation strategies in response to effects of greatest concern identified by breakout group participants (Table 2).

Table 2. Identified effects of greatest concern and possible adaptation strategies for Utilities.

Effects of greatest concern	Adaptation strategies to reduce vulnerabilities
On-site Sewage Treatment and Disposal System (OSTDS) failure due to saturation of ground from altered precipitation and sea level rise	• Conversion of septic to sewer (and municipal wastewater treatment) • Raised bed drain fields or other advanced OSTDS *Co-benefits:* improved water quality, decreased local overflows *Potential challenges/unintended consequences:* affordability, more reuse water that needs to be disposed of from a point source
Nuisance flooding will be longer, as water will have nowhere to go	• Ponds, infiltration basins, water farming (intentionally flooding farmland), stormwater retention ponds/dry retention • Dual use stormwater treatment/reservoirs • Creation of new infrastructure to redirect water flow (not to Lagoon) • Green infrastructure (swales, increased vegetation, especially trees; permeable application limited where soil already too saturated) • Update stormwater master plan for new flooding projections (stormwater infrastructure, flood protection) *Co-benefits:* development of alternative water sources, water quality, localized cooling *Potential challenges/unintended consequences:* costs to lease lands for water farming, costs of water pumping infrastructure, need agreement from EPA regarding conversion to wetlands with potential to use again as farmland in the future if species of concern are introduced
Increasing demand for water (including for irrigation) and electric power; irrigation with wells leads to increased pressure on aquifer, exacerbating or	• Shift irrigation to surface water (extract from drainage canals) • Reservoir creation • Water and energy conservation measures (code preventing excessive water use, water efficiency standards, water reuse) • rain gardens, rain barrels, more water-efficient landscaping for a range of water conditions

accelerating saltwater intrusion	*Co-benefits:* water quality benefits, especially to Lagoon from reduced runoff, cost savings to residents and government *Potential challenges/unintended consequences:* additional costs, resident frustrations with new rules, land use limitations
Future need for alternative water sources (surface, de-sal) for both potable water and irrigation	• State One Water (closed loop system- toilet to tap)- above ground or aquifer recharge • Reservoir creation (uncaptured water to meet timing needs) • Water conservation to decrease demand, possible increased use of grey water or composting plumbing applications (e.g. toilet flushing) • Desalination • Water harvest from air (possible in high-humidity location) *Co-benefits:* toilet-to-tap can help reduce demand on aquifer, reduce salt water intrusion, job creation, extend timeline of habitability of region, environmental benefits *Potential challenges/unintended consequences:* expensive, desalination issues with brine disposal, implications of reuse for water quality (e.g., microplastics, pharmaceuticals)
Challenge of increasing need to educate public about SLR, without scare factor	• Coordinating responses could increase confidence- create "a Treasure Coast Regional Approach" • Host climate change workshops with groups (HOAs, interested citizen groups) to give them a sense of what is being planned and that there is action in play. Be on the forefront • Bond issue to raise roads and other vulnerable infrastructure as well as to address coastal hazards created by SLR • Disclosure requirements with property purchase, development and redevelopment to inform about flooding (historic and projected) --using FEMA data (work with realtors association for creation of a rider) • Community conversation about changing FEMA flood insurance rates (make this part of disclosure) • Climate Change Coalition to host climate change workshop update *Co-benefits:* sustain or adjust beachfront tax base, survival, getting everyone on the same page, knowledge is power, potential for coordinated decision making (individually and as a community) *Potential challenges/unintended consequences:* panic, reduced local tax base, higher insurance costs, decreased demand for coastal property, population shifts

Implementation plans for priority strategies

Breakout group participants selected five priority adaptation strategies, and developed implementation plans for each:

1. Conversion of septic to sewer (and municipal wastewater treatment)

   How to implement: Currently on-going at the county level, 35-40 communities to prioritize based on age of septic tank, type of soil and water level. All new subdivisions require connection to sewer and water, older subdivisions still need connection to sewer. At the City level, Septic Tank Effluent Pump (STEP) system means that within city limits users can convert at will but are required to hook up when a septic tank fails. It was projected that within 30 years of adoption of this policy, 100% of septic systems would be converted, and at the time of the workshop (6 years into this policy) 1/3 of the remaining systems failed in the last year. Prioritize barrier islands. Plan to complete within 30 years but would like it to be sooner.

   Leads & partners:

   Leads: City and County utilities

   Partners: St Johns water management district, National Estuary Program, State of Florida, environmental groups advocating connection

   Resources & barriers: STEP system installation as a resource, availability of funding and costs to residents are barriers

   Efficacy: High

   Potential for Success: High, but current rate of implementation too slow so may be Moderate

2. Creating water storage, including ponds, reservoirs, infiltration basins, stormwater retention ponds and water farming

   How to implement: Revise Stormwater Master Plans (currently just for flood protection and water quality), additional stormwater regulations (from local government and from State Technical Advisory Committee), land acquisition for water retention, within 5-10 years

   Leads & partners:

   Leads: City and County Public Works

   Partners: State of Florida, water management districts that regulate water farms, individual landowners, federal agencies (e.g., agreement with EPA regarding conversion to wetlands with potential to use again in the future), Citrus League

Resources & barriers: Availability of funds to buy/lease land, slow to act (solutions to stormwater and flood problems have been provided in both newer and older studies, e.g., dating back to Engineering Drainage study 3, City of Vero Beach, Smith and Hill, December 1982, but have not been acted upon).

Resources: See report above

Efficacy: High

Potential for Success: Low for reservoirs, moderate for larger retention ponds and water farming

3. Water (and energy) conservation measures such as grey water use, composting, efficiency standards to decrease demand

How to implement: Code preventing excessive water use, via local ordinance, Florida building code on plumbing efficiency and plumbing lines (need 2nd line for reuse), implement 2nd use systems in new structures (and new regulations to make it happen). Implementation should be immediate.

Leads & partners:

Leads: St. John's Water Management District

Partners: Planning department, council, environmental advocacy groups, state agencies

Resources & barriers: Educational mission of water district is a resource; barriers include it is not clear who takes the lead on this conversion, and enforcement is limited

Efficacy: Moderate to high

Potential for Success: Moderate: High for reducing amount of water used, Low for transitioning to grey water systems

4. Disclosure requirements with property purchase, development, and redevelopment to inform about flooding (historic and projected)

How to implement: Same route as used for other disclosures (state or federal), develop partner buy-out/retreat plan to support existing residents/owners. Use FEMA data and work with realtors' association for creation of a rider, including disclosure of changing FEMA flood insurance rates

Leads & partners:

Leads: State and/or Federal agencies responsible for disclosure requirements (by topic)

Partners: Realtors, insurance companies, banks, planning departments, community development

Resources & barriers: FEMA maps are a resource; barriers include liability, cost and responsibility, and loss of assets

Efficacy: Moderate

Potential for Success: Low

5. Green infrastructure and water efficient landscaping

How to implement: Scale up through LID implementation, community outreach; make a requirement in planning and permits, include in stormwater management plans. This should be an ongoing strategy.

Leads & partners:

Leads: City and County Planning Departments

Partners: Environmental groups, local government, Indian River Land Trust, University of Florida Extension, 100,000 Trees

Resources & barriers: Resources include University of Florida- Institute of Food and Agricultural Sciences (IFAS), incentive funds for sod removal and native plantings; barriers include public perception of what constitutes a beautiful yard and a continued desire for lawn as landscaping; while it may be costly to re-landscape, it can be cheaper than other LID techniques

Efficacy: High

Potential for Success: High

Transportation

This focus area considers roadways (secondary and highways), bridges, railway crossings, and navigable waterways. Transportation and open space planning, and development distribution were also included. The time frame considered for this assessment is 10 to 20 years for planning, and 20+ years for infrastructure, including both maintenance and replacement.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of climate stressors and pre-existing conditions

Changes in precipitation, extreme precipitation and inland flooding, and **hurricanes** were chosen as the primary climate stressors impacting transportation.

Population growth, land use and development patterns, and **aging infrastructure** were identified by participants as the primary pre-existing conditions that impact Economic Vitality.

Climate stressors

Precipitation changes may have a beneficial or negative effect on transportation. For example, if there are fewer rain days, it may allow for more work time for construction projects, although more rain or extreme heat days could alternatively reduce available work time for construction.

Extreme precipitation and inland flooding may overwhelm stormwater drain systems that are not designed to handle the runoff. This is already being complicated by sea level rise which is decreasing flow where systems drain into the Indian River.

Slower moving *hurricanes* of growing intensity will continue to be very stressful on transportation systems, particularly barrier island infrastructure. Demands on staff capacity and resources, as well as siphoning staff and resources to other areas to prepare for and respond to acute events are also expected to grow. These include preparations such as sandbagging and responses such as damage inspections and emergency building permits. Hurricanes are already likely to bring greater delays to regular work. However, this region does have the benefit of extensive experience with hurricane response, and this may be a strong asset in adapting for the future.

Pre-existing conditions

Population growth rate is stressing the capacity of the transportation system.

Road systems are not keeping up with *land use and development patterns* and the shift that is occurring from a historically agricultural area to a primarily residential region. Increasing rail traffic blocks traffic crossings that have become much busier.

Aging infrastructure and outdated or overlooked design criteria create greater needs to maintain and replace roadways and bridges, particularly barrier island bridges (though this is a state responsibility); stormwater drainage system design specifications are inadequate for current and future conditions.

Combined impacts of pre-existing conditions and climate stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified challenges including:

- Population growth is significant, and at the same time, public understanding of risk and drainage issues is low
- Older neighborhood roadways are suffering increased flooding because their design is not sufficient, while newer building code is better
- Flooding stresses existing roadway drainage system and can lead to premature failure through processes like rusting
- Canal systems that were built for agricultural runoff are expected to take increasing quantities of runoff
- Increases in hurricane intensity and residence time combined with population growth
- Increases in hurricane intensity and residence time may cause additional flooding of roadways and erosion along waterways (smaller hurricanes may be an opportunity to test infrastructure and design specifications and look for improvement opportunities)

Summary of adaptive capacity

Overall, breakout group participants evaluated the adaptive capacity of IRC departments and organizations relevant to Transportation as **high**. Organizations identified as playing a key role in this focus area included the City and Towns of IRC, including Fellsmere, Sebastian, Vero Beach, Indian River Shores, and Orchid; IRC Commissioners; IRC Public Works Department, including Engineering, Roads and Bridges, Traffic Engineering and Coastal Engineering; Drainage and Water Control Districts; and the Florida Department of Transportation.

Organizational potential

Overall, the organizational potential of IRC was evaluated as high. Responsiveness, stakeholder relationships, and stability/longevity were all ranked as high, while staff capacity and resources were ranked as moderate to high.

Management potential

Overall, the management potential for the organizations listed was evaluated as high, with all the categories, including existing mandate, monitoring and evaluation, ability to learn and change, partner relationships, and science/technical support receiving high rankings by participants.

Overall vulnerability

The effects of flooding on aging infrastructure and on inadequate stormwater system design received a **moderate vulnerability ranking** (*high risk x high adaptive capacity*). **Damage to transportation infrastructure and particularly barrier island infrastructure and stress on jurisdictional capacity resulting from increased hurricane intensity and duration** was ranked by breakout group participants as having **high vulnerability** due to extreme risk (*almost certain likelihood x major consequence*), although participants believed there is a high adaptive capacity to respond. **The impacts of climate change intersecting with population growth and consequent development** was ranked as having **low vulnerability** (*moderate risk x high adaptive capacity*).

Table 3. Vulnerability assessment ranking results for effects/impacts of greatest concern for Transportation.

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Past and current stormwater system design inadequate to flooding impacts (and sea level rise complications)	Likely	Major	High	High	Moderate
Impacts of increasing hurricane intensity and duration on transportation, barrier island infrastructure, and staff capacity and shifting of resources for emergency response	Almost Certain	Major	Extreme	High	High

Managing new development and population growth in the face of climate change impacts, including agricultural to residential shift	Likely/ Almost Certain	Moderate	Moderate	High	Low
Impacts of flooding on aging infrastructure, including maintaining and replacing roads and bridges	Almost Certain	Moderate to Major	High to Extreme	High	Moderate

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Breakout group participants identified adaptation strategies for Transportation ranging from **programmatic** (e.g., conducting coastal habitat restoration and beach nourishment, additional shelter facilities for hurricanes) to **improving knowledge** (e.g., gather data about impacts to infrastructure following major storm events and hurricanes to inform future responses) to **creating new policies** (e.g., modify land development codes to allow for additional flood storage). The following table summarizes possible adaptation strategies in response to effects of greatest concern identified by breakout group participants (Table 4).

Table 4. Identified effects of greatest concern and possible adaptation strategies for Transportation.

Effects of greatest concern	Adaptation strategies to reduce vulnerabilities
Past and current stormwater system design inadequate to flooding impacts (and sea level rise complications)	• Modify land development codes to address floodplain use limitations, flood storage challenges • Consider creating regional lakes for storage in flood prone areas through collaborative building approaches including cost sharing and credits to developers to meet flood mitigation goals
Impacts of increasing hurricane intensity and duration on transportation, barrier island infrastructure,	• Conduct habitat restoration such as mangrove planting to combat erosion • Continue and expand beach nourishment • Modify land development codes to reduce vulnerability

and staff capacity and shifting of resources for emergency response	● Create safe options to shelter in place or in local shelters to limit movement and road use during hurricanes ● Improve safe reentry and post-hurricane transportation issues like addressing traffic signal vulnerabilities ● Continued hurricane-hardening of infrastructure
Managing new development and population growth in the face of climate change impacts, including agricultural to residential shift	● Modify land development codes to address floodplain use limitations, flood storage challenges ● Long range transportation planning to integrate sea level rise- think 2040 and beyond ● Goal setting for planning (address issues including increased growth, high end housing conflict, development vs agricultural/rural character)
Impacts of flooding on aging infrastructure, including maintaining and replacing roads and bridges	● Address difficult cost-effective treatments sooner ● Look more closely at life cycle expectations ● Enforce maintenance expectations on drainage systems ● Modify land development code and standards (e.g., 1 ft over water table for septic is outdated guidance) ● More study is needed as to how groundwater levels will be influenced by sea level rise ● Learn from examples of rising groundwater levels (e.g., Indian River Blvd swales are now always wet) ● County-wide post-event impacts data gathering needed ● Learn resilience by understanding why infrastructure was damaged or underperforming

Implementation plans for priority strategies

Breakout group participants selected five priority adaptation strategies, and developed implementation plans for each:

1. Modify land development codes and update the "Greenbook" (state engineering standards)

   How to implement: Make improvements to development design and specifications. Can be done on the timeline of Greenbook updates

   Leads & partners:

   Leads: For local codes, IRC Public Works, Community Development; for Greenbook standards, State-wide committees, and IRC representation

   Resources & barriers: Existing local code change process is in place and responsive, and there is a statewide process for updating Greenbook codes

Efficacy: High

Potential for Success: Low to Moderate (range of influence for change limited)

2. Increasing stormwater storage through regional lakes in flood prone areas

   How to implement: Engineering studies of new approaches (is it a win for everybody?) and outreach to promote the idea. Nearer term implementation is better, especially as available land is decreasing with development and this could be a long (5-10 year) process. Could there be a mining code waiver? Could sales of fill and floodplain credits be used to finance the project?

   Leads & partners:

   Leads: Private lead would be preferred (parks, land conservation organization); IRC Public works and commissioners; City Councils in support

   Partners: St. John's Water Management District; FL DOT; private developers

   Resources & barriers: May win support because of multiple benefits (flood mitigation, recreation)

   Efficacy: High

   Potential for Success: Moderate

3. Managing safety of traffic associated with hurricanes, including limiting movement and road use, and improving safe reentry and post-hurricane transportation

   How to implement: Use codes and standards, increase support to community immediately following hurricanes (e.g., food, water, ice). These efforts are already underway.

   Leads & partners:

   Leads: Public Works, Emergency Management, and Utilities Departments

   Partners: FL Department of Emergency Management; FEMA

   Resources & barriers: FEMA mitigation dollars are available, and a local strategies mitigation committee exists to which these priorities could be added

   Efficacy: Moderate because this relies on public behavior and trust

   Potential for Success: High

4. Enforcing maintenance expectations and design standards, including adopting longer service life requirements

   How to implement: Enforcement (via St. John's River Water Management District, FL DOT), design improvement, adopt longer service life requirements. Should be done immediately and some already underway.

   Leads & partners:

      Leads: Public Works Departments, Community Development Departments

      Partners: County Public Works, land developers, St. John's River Water Management District, engineering firms, maintenance parties

   Resources & barriers: Existing code change process is in place and is responsive; but St. John's River Water Management District is understaffed for enforcement

   Efficacy: High

   Potential for Success: Low to moderate (the range of influence for change is limited)

5. Prioritizing/triaging aging infrastructure repair/replacement and address difficult cost-effective decisions sooner

   This strategy was not developed further due to workshop time constraints.

Conservation Lands and Parks

This element considers publicly managed, non-agricultural lands including state, county, municipal and stormwater (e.g., Spoonbill Marsh) parks. The time frame considered was 2022-2060.

VULNERABILITY ASSESSMENT

Summary of observed and/or anticipated effects of climate stressors and pre-existing conditions

Extreme heat and wildfire risk, extreme precipitation/hurricanes, and **sea level rise/storm surge** were identified by breakout group participants as the climate stressors that have the most significant impacts on Conservation Lands and Parks.

Habitat fragmentation from development, invasive species, and **community perception/level of community education** were identified by participants as primary pre-existing conditions that impact Conservation Lands and Parks.

Climate stressors

Extreme heat and wildfire risk are likely to increase the risk of heat stroke for recreational users, especially elderly users, as well as managers and operators of park systems. Extreme temperatures are associated with increases in harmful algal blooms, and may have implications for native species reproduction, migration, and survival. Extreme heat is also associated with increased risk of wildfire, which will also increase expenses associated with firefighting. Air quality impacts from both extreme heat and wildfire may lead to park closures, which can impact revenue streams. Expenses may also rise as water needs increase for plants, wildlife, and humans.

Extreme precipitation events and hurricanes may drive imbalances in lagoon salinity and associated changes in species composition (e.g., loss of manatees as seagrass declines). Increased soil saturation after heavy rain events could also impact species composition. Hurricanes impact beaches and managed inlets through increased erosion and damage to structures, which can prevent use of beaches and impact navigation within inlets. Severe and/or repeated hurricanes could also result in the total loss of tree canopy in some areas. As extreme precipitation increases, inadequate water control structures could result in dewatering or changes to outfalls that impact water quality. For instance, lowering of Lake Okeechobee levels in advance of storms can cause an influx of freshwater and contaminants (e.g., fertilizer) in receiving water bodies.

Sea level rise and storm surge are likely to cause damage and loss of use of beaches and managed inlets, and habitat loss may occur due to direct inundation of open spaces. Sea level rise and storm surge also pose challenges for the maintenance of canals and swales. Increased salinity may cause shifts in species composition, and saltwater intrusion may cause the loss of maritime hummocks.

Pre-existing conditions

Habitat loss and fragmentation from development increase edge effects and encroachment of invasive species (and associated increases in herbicide use) and can alter fire regimes. These processes frequently result in the loss of native species, particularly threatened and endangered species; for example, loss of mangrove habitats and associated species reduces nurseries for marine life. Fragmentation associated with development also reduces habitat connectivity and, in turn, migratory species that depend on stopover areas. Additionally, habitat loss may reduce options for native species relocation, and it is likely that human-wildlife conflict will continue to increase as resources become more limited.

Invasive species can lead to displacement and decline of native species and can drive changes in fire regimes. Increased use of herbicides to address expanding invasive species populations contaminates water, impacting aquatic and marine life, but in some cases, there are limited options for effective treatment that doesn't cause ecological damage.

Community perceptions and community education can be a barrier to maintaining ecologically intact parks and conservation lands, because people may not understand management best practices or may be more concerned with property values or aesthetics than with functioning ecosystems. This can be a particular concern with people who have moved into the area from other regions, because they may not understand Florida's unique ecology and instead continue to rely on landscape practices that aren't well-suited to local conditions (not "Florida-friendly").

Combined impacts of pre-existing conditions and climate stressors

Climate change is likely to exacerbate the impacts of or be exacerbated by all three pre-existing conditions. Breakout group participants identified challenges including:

- Extreme heat and wildfires increase the risk of property damage to proximate human development, which is continuing to fragment remaining natural areas. Extreme heat can increase water use for humans, plants, and wildlife, and fighting wildfires increases water use, both of which can result in well depletion.

Extreme heat also increases human/wildlife conflict as animals seek refuge from extreme temperatures in developed areas.

- Extreme weather and hurricanes can intersect with human development that is already putting pressure on mangrove systems, further increasing erosion and loss of function. Turbidity associated with heavy precipitation is exacerbated by sediment from nearby development and increased nutrient runoff from developed areas increases the risk of harmful algal blooms that impact water quality.
- Sea level rise is likely to partially submerge new areas as the intertidal zone expands, which has important implications for private land ownership due to Florida laws that grant the State ownership of land below the mean high-water line.
- Extreme heat and wildfires are expected to increase the abundance of invasive species and drive further expansion of their ranges, particularly for invasive species that are heat-, drought-, or fire-tolerant. In coastal areas, salt-tolerant invasive species (e.g., hydrilla) may also have a competitive advantage over native species due to sea level rise and saltwater inundation. Extreme storms and hurricanes can also accelerate the spread of invasive species (i.e., blown to new areas).
- The presence of invasive species can exacerbate the effects of extreme storms and hurricanes where species that are not wind-tolerant (e.g., Australian pines) may be uprooted more easily than native species, increasing storm damage and habitat loss.
- Lack of public understanding about fire dynamics (e.g., how far and fast fire can travel) and the importance of controlled burns. For instance, many people don't understand that fire can easily jump roads and highways, and that unattended/unextinguished campfires can pose an extreme wildfire risk. There is also a need for more education about landscaping plants that are approved but may increase wildfire vulnerability due to higher flammability or fuel loads.
- Additional public education is needed to increase awareness about the importance of maintaining shoreline vegetation (e.g., mangroves) that provide stabilization during storms and prevent habitat loss. Awareness is also lacking about the impacts of salt spray on vegetation during hurricanes, and that landscaping plants may be blown from yards into neighboring parks or conservation lands. Finally, there is a lack of public understanding about how hurricanes and storm surge may interact with sea level rise and seasonal patterns such as king tides, which could result in people underestimating the level of risk during storms.

Summary of adaptive capacity

Overall, breakout group participants evaluated the adaptive capacity of IRC agencies and organizations relevant to Conservation Lands and Parks as **moderate**. Entities reviewed included the IRC Parks and Recreation Department, the Indian River Land Trust, the Sebastian Inlet District, and the University of Florida Institute of Food and Agricultural Sciences (IFAS) extension program. While not ranked for adaptive capacity, additional organizations were identified that play a role in conservation lands and parks, including Sebastian Inlet State Park and the Cities of Sebastian, Fellsmere, and Vero Beach.

Organizational potential

Overall, the organizational potential of IRC was evaluated as moderate. Staff capacity (e.g., training, time), responsiveness, and stakeholder relationships were all evaluated as moderate, while organization stability/longevity was evaluated as high.

Management potential

Overall, the management potential for IRC was evaluated as moderate due to moderate rankings for the presence of an existing mandate, monitoring and evaluation capacity, and ability to learn and change, with only partner relationships and science/technical support ranked as high.

Overall vulnerability

Higher expenses for firefighting/increased water needs for plants, wildlife, and humans; **damage/loss of use of beaches and managed inlets** from hurricane impacts; and **proliferation of invasive species** were all ranked by breakout group participants as having **high vulnerability** due to extreme risk and moderate adaptive capacity. Extreme risk rankings were calculated as the result of almost certain likelihood for all three of these impacts; however, consequence was ranked as catastrophic for **damage/loss of use of beaches and managed inlets** and major for the other two impacts.

Overall vulnerability was ranked as **moderate** for **loss of mangroves and other changes resulting from development** due to high risk *(likely and major consequence)* and moderate adaptive capacity, though participants noted that the consequence could be catastrophic in some areas. **Lack of public understanding of interacting factors that affect storm surge** also received a ranking of **moderate vulnerability** due to moderate to high risk *(likely and moderate to major consequence)* and moderate adaptive capacity.

Table 5. Vulnerability assessment ranking results for effects/impacts of greatest concern for Conservation Lands and Parks.

Effects/Impacts of Greatest Concern	Likelihood	Consequence	Risk	Adaptive Capacity	Vulnerability
Higher expenses and increased water needs for firefighting, plants, wildlife, and humans	Almost Certain	Major	Extreme	Moderate	High
Damage and loss of use of beaches, jetties, and navigation access from hurricanes and storms and subsequent erosion	Almost Certain	Catastrophic	Extreme	Moderate	High
Loss of mangroves and other changes because of development, destabilizing and altering ecology and reducing their protective functions for shorelines	Likely	Major (potentially catastrophic in some areas)	High	Moderate	Moderate
Proliferation of invasive species exacerbated by heat, wildfires, extreme precipitation, hurricanes, and sea level rise	Almost Certain	Major	Extreme	Moderate	High
Lack of public understanding about interacting factors that affect storm surge (e.g., hurricane + king tide)	Likely	Moderate to Major	Moderate to High	Moderate	Moderate

PROPOSED ADAPTATION STRATEGIES AND IMPLEMENTATION PLANS

Adaptation strategies for effects of greatest concern

Breakout group participants identified adaptation strategies for Conservation Lands and Parks ranging from **programmatic** (e.g., increasing public education around native and non-invasive plant choices for landscaping use) to **improving knowledge** (e.g., educating private property owners with pictures and signage about why hardened infrastructure is problematic). The following table summarizes possible adaptation strategies in response to effects of greatest concern identified by breakout group participants (Table 6).

Table 6. Identified effects of greatest concern and possible adaptation strategies for Conservation Lands and Parks.

Effects of greatest concern	Adaptation strategies to reduce vulnerabilities
Higher expenses related to firefighting and increased water needs for plants, wildlife, and humans	● Educate neighboring landowners about controlled burns to increase public support ● Add rain capture systems such as tower cisterns on county facilities to increase water availability (for firefighting or other uses) and reduce fire risk by alleviating dryer conditions (e.g., along I-95) ● Use planted areas as additional firebreaks to limit fire spread and/or improve maintenance of existing firebreaks and defensible spaces ● Consider access routes for firefighting ● Incorporate greywater recycling systems at county park facilities to reduce water use
Damage/loss of use of beaches and managed inlets, resulting in increased erosion, damage to structures/jetties, and impacts on navigation	● Incorporate climate change into management plans (e.g., comprehensive plans, beach preservation plans, inlet management plans, etc.) to identify changing needs and management triggers, and ensure plans are followed ● Use living shorelines or other strategies that slow water on the tidal inlet side to reduce the need for revetments o Increase dune vegetation through community planting opportunities (e.g., county provides plants or supports beachfront property owners to build dune protection rather than harden shorelines) o Add plantings at canal inflows/outflows to slow water and reduce erosion and sediment transport ● Evaluate options to address future inundation of the historic Jones Pier access road (include consideration of trail problems may be accelerated by boat wakes, an issue that is likely to be exacerbated by sea level rise) o Document areas already known to experience problems with flooding/erosion due to factors other than sea level

	rise, such as storms approaching from the west that create higher lagoon waves
Loss of mangroves and other changes because of development, destabilizing and altering ecology and reducing their protective functions for shorelines	• Use dredged sediment to increase accretion (e.g., add properly vegetated spoil islands) • Hold backyard fishing tournaments or other community events to promote awareness of the role of mangroves as nurseries (people catch more fish!) and demonstrate how people can simultaneously protect natural and developed areas (why mangroves are better than an unobstructed view)
Proliferation of invasive species exacerbated by heat, wildfires, extreme precipitation, hurricanes, and sea level rise	• Build on state incentive programs that reduce populations of invasive fish and wildlife (e.g., python hunting, lionfish fishing, invasive reptile leather market) • Consider biological controls for invasive plants • Increase public education around native and non-invasive plant choices used for landscaping purposes (e.g., windbreaks, screens) • Build on existing "Florida-friendly" landscape program to reduce the use of invasive plants in residential areas • Create an adopt-a-park program that targets invasive plant species for intensive management (start with 5 acres and expand)
Lack of public understanding about interacting factors that affect storm surge (e.g., hurricane + king tide)	• Educate property owners (i.e., with pictures, signage, etc. to show people how downstream areas are impacted) about why hardened infrastructure is problematic and incentivize the use of better alternatives • Use visual aids to educate the public about how king tides can intersect with sea level rise and storm surge to increase risk in coastal areas

Implementation plans for priority strategies

Breakout group participants selected four priority adaptation strategies, and developed implementation plans for each:

1. Add rain capture systems such as tower cisterns on county facilities to increase water availability (for firefighting and other uses) and reduce fire risk by alleviating drier conditions (e.g., along I-95)

   How to implement:

   - Add as capital improvements budget item to be implemented over 5 years, pursue state funding and grant opportunities, and/or get communities to sponsor these systems through cost-sharing or raising money in remote/high risk areas that will benefit from these systems

- Place rain capture systems on existing county infrastructure (e.g., public toilets), though the most remote areas may not have this type of infrastructure
- Consider redirecting water from roadside swales and building roofs to fill cisterns, and consider using an automatic top-off mechanism to maintain minimum water levels in dry years
- Ensure that planning considers the safety implications in case of cistern failure

Leads & partners:

Lead: Indian River County

Partners: Florida Fish & Wildlife, UF IFAS, homeowner's associations (may be challenging due to high turnover rates on these committees)

Resources & barriers:

- Could retrofit existing infrastructure such as gutters, though some additional space would still be needed for cistern placement.
- Funding and historical wildfire data (to suggest high-risk fire areas that could inform site decisions) are still needed
- Lack of rain in dry years could be a barrier to effective implementation, and it may be difficult to get buy-in and approvals

Efficacy: Moderate (may not be dense enough or well-positioned to cover large areas, particularly in more remote locations)

Potential for Success: Moderate

2. Incorporate climate change into management plans (e.g., comprehensive plans, beach preservation plans, inlet management plans, etc.) to identify changing needs and management triggers, and ensure those plans are followed

How to implement:

- Take advantage of scheduled plan revisions (and move forward with revisions that are overdue)
- Focus on proactive goals rather than just reactive management
- Collaborate with partners (e.g., other departments/agencies) to leverage existing projects and resources

Leads & partners:

Lead: Indian River County Community Development & Planning Department

Partners: Public Works department, UF IFAS, Sebastian Inlet District, Coastal Connections, FL Department of Environmental Protection (there is a need to understand their plan for coastal development), broader community

Resources & barriers:

- Existing partners may be important resources
- It would be helpful to have examples of similar plans from other areas that have successfully incorporated climate change (e.g., for ideas and lessons learned)
- Additional shoreline data and surveys are needed, and it may be necessary to commission a hydrologic study if data is not available)
- Barriers include accountability (i.e., need to actually do the revisions) and lack of clarity about what work is already being done by other departments/agencies

Efficacy: Moderate

Potential for Success: High

3. Educate property owners (i.e., with pictures, signage, etc. to show people how downstream areas are impacted) about why hardened infrastructure is problematic and incentivize the use of better alternatives

How to implement:

- Show concrete examples of what works; for example, post signage that shows what the damage was, how the site has changed, and how it is connected to other shoreline areas
- Need to ensure that the right people are being reached and that the message is not being over-concentrated (i.e., just the same people seeing it repeatedly)
    - Create a good marketing campaign (a good example being the Public Works video with drone footage of the stormwater park), with a social media strategy
    - Speak directly with small groups (e.g., homeowner's associations)
    - Target outreach for months when snowbirds are living here and have time/interest for engagement

Leads & partners:

Lead: IRC Parks and Conservation

Partners: IRC Community Development and Planning Department, UF IFAS, Coastal Connections, Sebastian Inlet District, St. John's River Water Management District

Resources & barriers:

- Historical and current photographs, plan materials, community volunteers and revegetation funding are all needed
- Barriers may include avoiding the impression of shaming or targeting individuals; the difficulty of getting the message in front of the right people in the right format; and ensuring community buy-in.

Efficacy: High

Potential for Success: High

4. Create an adopt-a-park program that targets invasive plant species for intensive management

How to implement:

- Start with small parks that will get good results quickly, and establish realistic goal and expectations
- Survey park to identify the most problematic species and which areas are most affected
- Create a detailed management plan to ensure success, and ensure that it includes ongoing maintenance needs
- Ensure that the timing of removal efforts is going to be effective for treatment of the target species
- Make sure cleared areas are replanted to prevent reestablishment of invasive species in disturbed soil
- Have local community volunteers conduct actual removal; could create a volunteer field guide, and assign volunteers to coordinate work with the Parks Department
- Consider getting donations for tools and protective equipment by coordinating with local businesses

Leads & partners:

Lead: IRC Parks and Conservation

Partners: UF IFAS

Resources & barriers:

- UF IFAS already has a field guide that can be used as a template
- Will need interested community volunteers (which could reduce labor costs), the capacity to train them (could be done through the Master Gardener program), and tools/protective equipment for them to use.

- The need for ongoing maintenance to prevent reestablishment of invasive species in treated areas may be a barrier to long-term success.

Efficacy: High

Potential for Success: High

Conclusions

The virtual workshop series and resulting report improve understanding of how utilities, transportation, and conservation lands/parks in IRC are vulnerable to changing climate conditions. The workshop series and report also present possible adaptation strategies as well as adaptation implementation plans designed to minimize vulnerabilities and/or increase resilience of each focus area.

Many similarities emerged across focus areas, including:

- *Climate stressors*: extreme precipitation, hurricanes, sea level rise, extreme/prolonged heat, and wildfire were the most selected climate stressors
- *Pre-existing conditions*: land use and development patterns and aging infrastructure were the most selected pre-existing conditions
- *Combined impacts of pre-existing conditions and climate stressors*:
    - Land use development patterns along with extreme precipitation/storms/ flooding are likely to exacerbate existing challenges related to the provision of both human and ecological services, including flooding of older neighborhoods; a growing need for alternative sources of drinking water and other water supplies that are facing increased demand combined with compromised water quality and quantity; impacts on native species and ecosystems, including mangroves damaged by flooding and hurricanes which are already facing losses due to development and increases in algal blooms and turbidity, driven in turn by erosion and nutrient inputs that are exacerbated by both development and extreme weather.
    - Extreme events (e.g., flooding, fire, extreme heat) combined with aging infrastructure will exacerbate existing damages and failures, and compromise water quantity and quality, reducing the County and other jurisdictions' ability to provide services.
    - Sea level rise intersects with multiple pre-existing conditions, including aging infrastructure, nuisance flooding, and increasing development, with impacts including loss of habitat, property loss and inundation and longer periods of flooding, challenging IRC and jurisdictional staff capacity to respond to flooding events of increased duration and volume.
    - Community perception and level of knowledge intersects with all these climate factors in mediating how effectively public opinion and public behaviors can support jurisdictional efforts and has ramifications for public safety as well. If residents do not understand the risk of exposure to climate stressors like extreme heat events, more powerful hurricanes, or sea level rise and flooding, public safety risks can increase. Public

education around home landscaping to achieve lower water use, reduce wildfire risk and limit the spread of invasive species are key to supporting infrastructure such as water supply and to reducing risks of invasive species to conservation lands and parks.

Many of the combined impacts of pre-existing conditions and climate stressors listed above were also identified by breakout groups as their impacts of greatest concern, including:

- Inadequacy of stormwater infrastructure, such as sewer and septic design, to withstand stressors including flooding and hurricanes (Transportation, Utilities)
- Altered and/or damaged natural habitats (Conservation Lands and Parks)
- Loss of water supply both on an acute event (e.g., during hurricanes) and long-term timeline (e.g., overuse, saltwater intrusion) timeline (Utilities, Conservation Lands and Parks)
- Loss of roads and bridges and access to roads, bridges, and recreational areas due to flooding, erosion, and inundation (Transportation, Conservation Lands and Parks)

The similarities in impacts of greatest concern also resulted in many overlapping adaptation strategies, such as:

- Modify regulatory frameworks including stormwater plans, development codes and building codes to improve opportunities for flood storage, water storage for firefighting and other uses, septic design, and water conservation opportunities.
- Prioritize coastal habitat restoration through direct action including beach nourishment and planting native vegetation, as well as educating homeowners and the public about issues like appropriate plant palettes for coastal dune living, better alternatives to shoreline hardening, and why mangrove habitat is important to protect ecological functions including flooding protection and fisheries.
- Learn from examples of responses to impacts, including collecting data about jurisdictional responses to hurricanes and how jurisdictions are incorporating newer building codes to address issues like prolonged flooding and septic and stormwater capacity.
- Increase proactivity in implementing water conservation activities and evaluating options for alternative surface water supply systems, recognizing the growing stressors of increased development, extreme temperatures and sea level rise on drinking water and other water use capacity.
- Promote the use of native plants better suited for anticipated conditions (increased drought, wildfire) and/or plant with climate ready species and

educate the public about the risks of invasive plant species both in the context of wildfire risk and threats to native species and habitats.

- Implement climate-informed planning and stewardship, including building volunteer capacity and public buy-in for priorities controlling invasive species, planting native species, low impact development and greener stormwater alternatives, fire-aware and less water-intensive landscaping.
- Create greater public awareness of and capacity for adaptation to climate change risks, including social marketing and outreach strategies on issues including reducing wildfire risk, being water-wise, emergency preparedness and sheltering in place during extreme storm events and hurricanes, and front-end disclosure requirements prior to property purchase and development informed by FEMA flood risk maps and sea level rise projections.

This report can be used as a reference for decision-makers as they plan for and commit resources to create more sustainable and resilient communities. The adaptation strategies listed above are likely priorities for IRC to pursue for implementation as they advance resilience and may present opportunities to leverage resources across multiple focus areas. Because climate adaptation is an iterative process and new research and modeling on projected climate change and its impacts are regularly released, it is important to revisit and/or revise the vulnerability assessments and adaptation strategies on a regular basis (e.g., every 5-10 years), as well as when additional topics of concern become priorities.

Appendix A. Workshop Participants, Affiliations, and Breakout Group Assignments

Participant Name	Affiliation	Breakout Group
Jean Catchpole	Indian River Neighborhood Association	Utilities
Kendra Cope	Coastal Connections	Conservation Lands and Parks
Joe Earman	County Commissioner, IRC	Transportation
James Ennis	IRC Public Works	Transportation
Edward Garland	Sebastian Inlet District	Utilities
James Gray Jr.	Sebastian Inlet District	Conservation Lands and Parks
Steven Hitt	IRC Planning	Conservation Lands and Parks
Kevin Kirwin	IRC Parks and Recreation	Conservation Lands and Parks
Molly Klinepeter	IRC Coastal Division	Conservation Lands and Parks
Ryan Lloyd	IRC Emergency Services	Transportation
Robert Loring	City of Fellsmere Planning Dept.	Transportation
Matthew Mitts	City of Vero Beach Public Works	Utilities
Nickie Munroe	University of Florida IFAS	Conservation Lands and Parks
Peter O'Bryan	County Commissioner, IRC	Utilities
Alexis Peralta	IRC Stormwater Division	Utilities
George Simons	Carter Associates, Inc.	Transportation

Appendix B. Climate Changes and Impacts Table for Indian River County

CLIMATE CHANGES	METRIC	TREND	OBSERVED/PROJECTED CHANGES
Air temperature	Minimum temperature AVG DAILY MIN TEMP (°F)	▲	66.1°F (+3.6°F) by 2050 and 70.2°F (+7.7°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 62.5°F FROM 1961–1990
	Maximum temperature AVG DAILY MAX TEMP (°F)	▲	86.5°F (+3.8°F) by 2050 and 90.7°F (+8.0°F) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 82.7°F FROM 1961–1990
Extreme heat	Days over 95°F # OF DAYS WITH MAX TEMPS >95°F	▲▲	48.8 days (+1,478%) by 2050 and 138.5 days (+4,196%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 3.3 DAYS PER YEAR FROM 1961–1990
Precipitation	Annual precipitation AVG INCHES PER YEAR	–	53.1 in (+1.8%) by 2050 and 49.4 in (–3.5%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 51.2 INCHES PER YEAR FROM 1961–1990
	Seasonality	▲▼	Significant decrease in summer rainfall (-21.1% by 2100), with smaller changes in spring (-8.4%) and fall (+8.9%); no change in winter rainfall[2]
Extreme precipitation	Amount 20-YEAR RETURN PERIOD TOTAL	▲	+21% increase in amounts during 20-year events projected by 2100[3]
	Frequency # OF DAYS WITH 2" RAIN IN 24 HOURS	▲	1.2 days (0%) by 2050 and 1.3 days (+8%) by 2100[1] COMPARED TO HISTORICAL AVERAGE OF 1.2 DAYS PER YEAR FROM 1961–1990
Sea level rise	Relative sea level change INCREASE FROM SEA LEVEL IN 2000	▲▲	1.4 ft (range 0.7–1.8) by 2040; 3.2 ft (1.2–4.4) by 2070; 7.4 ft (1.9–11.2) by 2120, with up to 14.3 ft possible under the most extreme scenario[4]
High-tide flooding	Days with high tides >1.8 FT OVER MHHW	▲▲	97 days per year (range 17–176) by 2040; 364 days per year (range 66–365) by 2070; 365 days per year (range 148–365) by 2100[5] COMPARED TO RECENT AVERAGE OF 2.1 DAYS PER YEAR FROM 1995–2016
Hurricanes	Intensity MAGNITUDE OF SURFACE WINDS	▲	+8% per decade in global hurricane intensity from 1979–2017[6]
	Speed	▼	-16% in rate of forward motion for North Atlantic hurricanes from 1949–2016, significantly increasing local rainfall totals[7]