



Climate Change Hazards Summary Report for Facility Investment Planning

Colonial National Historical Park February 2021

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Introduction

Parks are required to complete a PARK Project Narrative Template for each proposed Great American Outdoors Act Facility Investment Plan (GFIP) project for Legacy Restoration Funding in fiscal years 2023-2025. Information provided in this report is intended to help parks consider climate change related hazards when addressing Question 16 of the narrative template.

Specifically: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?

Step 1: Review summary information for known or potential hazards identified for Colonial National Historical Park

- Review the list of potential hazards below and decide whether or not they apply to your specific GFIP project. NPS Climate Change Response Program (CCRP) staff attempted to identify potential hazards for the park; however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.
- The hazards below were selected from a longer list included in Appendix 1, which also indicates CCRP's 'best professional judgement' about the relevance of the hazard for this park. Note both lists serve as a "coarse filter" screening tool to help identify potential climate-related hazards for facility and asset planning.

Hotter average days and more very hot days

Extreme temperatures can increase weathering of structures, threaten park staff and visitor safety, and increase stresses for HVAC systems. If not addressed through building design or more efficient temperature control systems, the increased demand for complex air conditioning systems can add stress to building envelopes and can require significant alterations to a structure.

For Colonial, by 2050, models project an increase of 8 to 20 more days per year with a maximum temperature >95°F, an increase of 3.6-4.5°F in the annual average temperature, and a decrease of 12 to 13 fewer days per year below freezing (32°F) (Gonzalez et al. 2015; Ricci et al. 2019).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Altered precipitation patterns, increased extreme precipitation, and changing humidity

Changing precipitation and humidity conditions can result in local flooding, encourage mold growth, wood decay, and changing depth to groundwater, depending on the pattern of change. Extreme precipitation events present a variety of threats to infrastructure and operations including flooding of sites, sewage backup, accelerated decay of masonry, overcoming drainage systems, road wash out,

cracks in building infrastructure, destabilization of buildings and pipes, and erosion of supporting ground around structures, among many other effects.

For Colonial, annual average precipitation is projected to increase by 7% by 2050, with heavy precipitation events (>2 inches in 24 hours) increasing in frequency, especially in fall (Gonzalez 2015; Ricci et al. 2019).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Sea level rise and coastal storm surge

Global sea level is rising and will continue to increase (Tebaldi et al. 2012), with local variability. Higher relative sea level causes accelerated coastal erosion, landward migration of shorelines, and saltwater intrusion and changes in groundwater, and amplifies flooding caused by higher storm surges (Field et al. 2007). Sea level rise poses considerable risks to infrastructure, lighthouses, forts, and other historic structures. Tools are available such as the [NPS Sea Level Rise Viewer](#) to visualize the impacts of different sea level rise scenarios. The vulnerability assessment by asset (Peek et al. 2017) is available through the NPS [Climate Vulnerabilities Map](#).

For the Hampton Roads area, projections of sea level for 2050 range from 1.0-2.2 feet (Steinhilber et al. 2016). Note that the sea level rise scenario (0.95 feet by 2050 based on Caffrey et al. (2018)) used in the Facilities vulnerability assessment was less than that because it didn't include subsidence, yet 14% of assets were still found to be highly vulnerable (Peek et al. 2017). First floor threshold elevations have been collected for all buildings and should be considered in project designs. Sea level rise is driving groundwater change on Jamestown Island and in the Glasshouse Point area, including changing the depth to groundwater and increasing saltwater intrusion, which can affect building systems.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Riverine flood

As extreme precipitation events increase, the risk of flooding is expected to regionally intensify with a changing climate (Dethier et al. 2020, Tabari 2020). Floods threaten infrastructure and operations through a variety of mechanisms, including inundation of structures, enhanced erosional forces, road wash out at undersized stream crossings, structural collapse from force of floodwaters, sewage backup, and damage to utilities, generators, and electrical systems. Post-flooding effects include increased rot, fungal and insect attack, mold and mildew, and physical deterioration of wood, brick and stone building materials. The combination of increased runoff from heavy rains and urbanization of the watershed have the potential to damage culverts, bridges, road embankments, dams (Jones Mill Pond), and other

features. The combination of riverine flooding meeting coastal storm surge disrupts stormwater drainage systems, which will be exacerbated by hurricanes increasing rainfall rates (see next section).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Hurricanes

North Atlantic hurricane intensity and rainfall rates are projected to increase under continued climate change, although projections of the total number of North Atlantic hurricanes under climate change vary (IPCC 2013, USGCRP 2017). Under a low greenhouse gas emissions scenario, the maximum intensity during the course of individual North Atlantic hurricanes could increase 4% and rainfall rates could increase 15% to 20% by 2100 (Knutson et al. 2015). Storm surge can cause flooding and road wash outs. The combination of sea level rise and increased hurricane storm surge will flood structures that previously were outside of the floodplain. Flood and storm surge depths may be deeper than in previous storms. Flooding may occur in areas that had no flooding during past storms. Building standard guidance is based on base flood elevations of 2-3 ft above FEMA flood zones of 100-year (1%-annual chance) storms, depending on the building criticality. For existing buildings that are not above base flood elevation, adaptation measures to reduce flood impacts should be considered. Hurricanes also threaten structures via damage from wind, wind-blown rain, treefall, and debris.

Of particular concern for Colonial are shoreline erosion caused by waves and currents and the potential storm surge associated with a category 3 hurricane, which is higher than what historically has made landfall in the area, but with climate change may become a future risk (Ricci et al. 2019). At current sea level, maps of inundation by [hurricane](#) category are available (Caffrey et al. 2018). Both erosion and storm surge will become more damaging and more likely as sea level continues to rise.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Pest infestation

Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of pests (IPCC 2014). Rooting and burrowing mammals and termites have the potential to cause direct damage to power, water, transportation, and building facilities (Vissicelli 2018). Facilities may be impacted indirectly through other mechanisms exacerbated by climate change such as forest insect pest invasions or fluctuating ground water levels leading to increased tree mortality, hazard trees, and treefall. In an extensive review of US forest pests, Pureswaran and others (2018) noted that expansions and/or the area of outbreak of defoliators and wood boring insects is associated with warmer winter temperatures.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
☐ No

Invasive species

Increased temperatures and CO₂, changes in precipitation, and disturbance due to extreme climate events can increase the survival, spread, growth, and establishment of invasive species (IPCC 2014).

Weeds and aquatic mussels have the potential to cause direct damage to power, water, transportation, and building facilities (Vissicelli 2018). Non-native species that may not currently impact facilities may become harmful due to changes in local climates (NRC 2002, IPCC 2014). The region could become even more favorable to the growth of the invasive plants kudzu (*Pueraria lobata*), privet (*Ligustrum sinense*), and cogongrass (*Imperata cylindrica*) (Bradley et al. 2010).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
☐ No

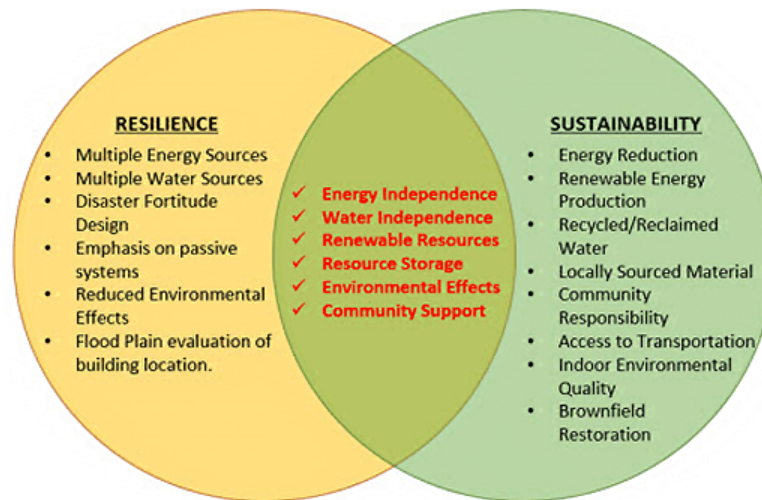
Step 2: Consider adaptation and resiliency strategies

- Review definitions of resiliency and adaptation strategies.
- Identify adaptation strategies that will help park resources respond to the hazards identified in Step 1.

Question 16 requires a screening for climate hazards followed by a review of adaptation and resiliency strategies that would be put in place to respond to these hazards. For the purposes of this report and investment planning, resilience is a property of a system or asset and generally refers to the ability of the system or asset to maintain its intended purpose following a temporary disturbance.

Adaptation strategies, in the context of built infrastructure, refers to the intentional management decision to identify, prepare for, and respond to observed or expected sustained changes in hazards, including climate change, to adjust to a sustained change in conditions.

It is important to note that resilient park operations can be supported through the use of green infrastructure such as sustainable landscaping, as well as sustainable energy, water, and building envelope solutions. The figure below illustrates this relationship.



Lists of adaptation strategies for different types of infrastructure projects in response to different hazards can be found here: [Incorporating Climate Change Adaptation in Infrastructure Planning and Design](#) (see Chapter 4, Tables 25-34). If used, these adaptation strategies will need to be modified for proposed park projects. The NPS [Coastal Adaptation Strategies Handbook](#) has chapters on facility management and protecting coastal infrastructure.

Buildings and assets within national parks may include cultural resources (e.g., historic and pre-historic buildings and structures). The adaptation and resiliency options for cultural resources often overlap with those defined for facilities; however, NPS has detailed specific strategies when dealing with cultural resources and climate change in national parks ([Cultural Resources Climate Change Strategy](#)). “Climate change poses an especially acute problem for managing cultural resources because they are unique and irreplaceable — once lost, they are lost forever” ([NPS Policy Memorandum 14-02](#)).

Step 3: Develop an answer to Question 16 for your specific project and location, as well as strategies to address each hazard

- Example responses to Question 16 are provided below.
- You will need to develop park specific answers based on the hazards identified in Step 1 and the adaptation strategies identified in Step 2 for your park and project. The park response should be as project-specific as possible.
- The NPS Climate Change Response Program (CCRP) and Sustainable Operations and Maintenance Branch (SOMB) are available to help evaluate climate change hazards and resiliency strategies for your specific projects. Requests should be sent to the NPS [GFIP Hazards and Risk Assistance email account](#); a member of the team will reply with support.

Question 16: What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?

Example: Restoring historic structures

Several climate change hazards may affect building-related projects at COLO, including hotter average days, more extreme heat days, sea level rise, increased hurricane impacts from wind and flooding, and increased extreme precipitation. Adaptation and resiliency strategies for the expected hazards are described below:

- Hotter average days and more extreme heat days will increase demand and requirements for higher capacity air conditioning systems unless accommodated through modified building designs or other systems.
- Extreme heat and humidity can stress the building envelope and will require significant humidity control alterations for structures.
- Hurricane force wind and wind-blown rain as well as damage from wind-blown debris or treefall will require wind resistant fortification of the structure. Addressing hazardous trees and retrofitting roof structures to be more wind resistant may also be required.
- Flooding from increased hurricane events, increased extreme precipitation, groundwater change or in conjunction with altered precipitation patterns may require modifications to building infrastructure location or elevation and landscape drainage systems.
- Post-flooding effects may include increased rot, mold and mildew, and physical deterioration of wood, brick and stone building materials. Adaptation actions will include identifying appropriate dehumidification and air handling systems and coordinating with the NPS Historic Architecture, Conservation and Engineering Center or Historic Preservation Training Center regarding alternatives and maintenance for historic structures.
- Early detection and removal of termites or other pests or hazards.
- Historic buildings in Yorktown village would require flood protection measures to protect them from deterioration in order to be able to lease the buildings.

Example: Road improvement project

Several climate change related hazards have been identified that may affect road improvement projects in COLO, including hotter average days, more extreme heat days, altered precipitation and flooding patterns, and increased hurricane impacts. Of the fourteen transportation facilities in COLO rated highest vulnerability, nine are associated with the Colonial Parkway (Peek et al. 2017). These include several creek bridges along both the James and York Rivers, as well as the shoreline portions of the roadbed and travel surface. Many other features, including culverts, parking areas, and overpasses, are considered moderately vulnerable. Furthermore, damage to the road and its features is likely to diminish many of the qualities that contribute to the parkway's historical integrity, including the road's design and materials, scenic views, and overall character (Ricci et al. 2019).

Due to the increasing number of flooding events, storm surges, and erosion, there will be a need for more frequent and extensive maintenance and rehabilitation of transportation infrastructure. Segments

of the parkway should be evaluated where armoring the bank can be a long-term solution or relocating the roadway away from the river is possible, taking into account the future potential hazards and lifecycle cost. Adaptation can reduce these costs through three approaches: protection, accommodation, and retreat:

- Protection – For roads: increase drainage system capacity, install pumping stations, divert to water retention areas, install structures like seawalls to divert storm surge (Beavers et al. 2016), and plan for higher water level. Weather-proof electrical disconnect switchgear and incorporate transformers with disconnects for continuity of service isolation.
 - Accommodation – elevate roads and utilities to avoid the impacts of flooding, use pervious materials to increase drainage capacity of roads and impervious material to limit infiltration of water lines; install pumps.
 - Retreat – anticipate vulnerable sections of road and move them out of harm's way or determine when access may need to change. Allow for wetlands and beaches to move or grow.
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- Vegetated catch basins and swales could be used to slow or divert stormwater runoff.
 - Drainage systems and culverts need to be designed to handle greater water flows.
 - Continue to work with municipalities and other partners to understand and manage storm water and runoff.
 - Increased temperatures may contribute to pavement degradation.
 - Aside from these direct impacts to roads themselves, there are concerns that inundation or closure of some roads can cause congestion to others within the overall transportation network (Nazarina et al. 2020).

Step 4: Seek additional assistance if desired

Additional resources for answering question 16 and related questions can be found in:

- Appendix 1 below, which includes a full hazards checklist, providing additional links for supporting information related to each hazard.
- Appendix 2 below, which provides a map to visualize how climate is changing for the park.
- The [GFIP Guidance and Logistics](#) folder under the [Resources to Assess Risks and Hazards tab](#) includes:
 - An Excel workbook labeled [T75 Parks GFIP NRSS Supporting Materials](#) that provides links to information for natural resources to be considered during project design and construction.
 - A [FAQs – Assessing Risks and Hazards](#) document that provides detailed guidance for answering Question 16.
 - A [Natural Hazard Assessment Webinar](#) recording that provides key information, definitions, and guidance for understanding natural hazards and related resources.

The NPS Climate Change Response Program (CCRP) and Sustainable Operations and Maintenance Branch (SOMB) are also available for assistance in evaluation of climate change hazards and resiliency

strategies as they relate to specific projects. Questions can be sent to the NPS [GFIP Hazards and Risk Assistance email account](#) and a member of that team will reply with support.

Appendix 1: The Climate-Related Hazard Checklist

This appendix provides an initial evaluation of climate hazards for **Colonial National Historical Park** according to the hazard ratings identified below. The information used to identify hazards in the checklist is mostly from regional assessments. Park and project specific information was generally not available when assessing these hazards. NPS Climate Change Response Program (CCRP) staff made an initial attempt to identify potential hazards for the park broadly (see ‘Best Professional Judgement’ column); however, park staff and project planners have more information about hazards that are likely to be applicable to a specific project.

Explanation of Hazard Ratings

Known hazard: Conditions that cause the hazard are well documented in the area where the park occurs. If applicable to the project site, these hazards should always be addressed in the project plan.

Potential hazard: Conditions that cause or underlie the hazard are known to occur nearby or are likely to occur based on studies with conditions similar to the park. If applicable to the project site, these hazards should be considered for inclusion in the project plan.

Not applicable: No evidence *was identified* showing this hazard is relevant to the park. Note this is a coarse filter evaluation; local knowledge of a hazard(s) should be used, when available.

Table 1. Climate-related Hazards Checklist

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Hotter average days and more very hot days	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Inadequate HVAC • Road surface degradation • Lack of water due to increased water for irrigation • Increased humidity • Danger to staff	• National Climate Assessment • State climate summary	• National Climatic Data Center • DAYMet gridded climate data • National park historical and projected climate change

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Increased drought frequency, intensity, magnitude, and duration	Known Hazard ☐ Potential Hazard ☐ Not Applicable ☒	• Limited water supply for cooling, landscaping, structural fire suppression, other equipment • Increased competition for available water and water rights conflicts • Crack/heave damage in drier soils • Increased vulnerability to wildfire (below)	• Drought Monitor • National Integrated Drought Information Center • National Climate Assessment • State climate summary	• Drought Monitor • National Integrated Drought Information Center
Increased wildfire frequency, intensity, magnitude, and duration	Known Hazard ☐ Potential Hazard ☐ Not Applicable ☒	• Damage to facilities and contents • Smoke damage • Air quality dangerous to staff and visitors • Increased runoff • Increased erosion • Damage to water treatment plants	• Barbero et al. 2015 International Journal of Wildland Fire	• NIFC • International Wildland-Urban Interface Code

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Altered precipitation patterns, increased extreme precipitation, and changing humidity	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Local flooding • Mold growth • Wood decay • Drought • Fire • Groundwater change • Surface erosion • Floods (see below) • Water damage to structures from driven rain • Unstable saturated soils	• National Climate Assessment • State climate summary	• National Climatic Data Center • DAYMet gridded climate data • National Park historical and projected climate change • Evaluations are mostly at regional scales
Riverine flood/flash flood	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	• Damage or destruction of infrastructure • Stream channel migration • Stream bank erosion/extreme erosion • Safety • Water quality diminished • Damage to water source and delivery infrastructure • Changing requirements for culvert flow capacity	• FEMA Flood map service	• FEMA Map Service Center • Floodplain maps for HUD projects • Van Dusen et al. 2020 (for select parks) • May require a special flood study

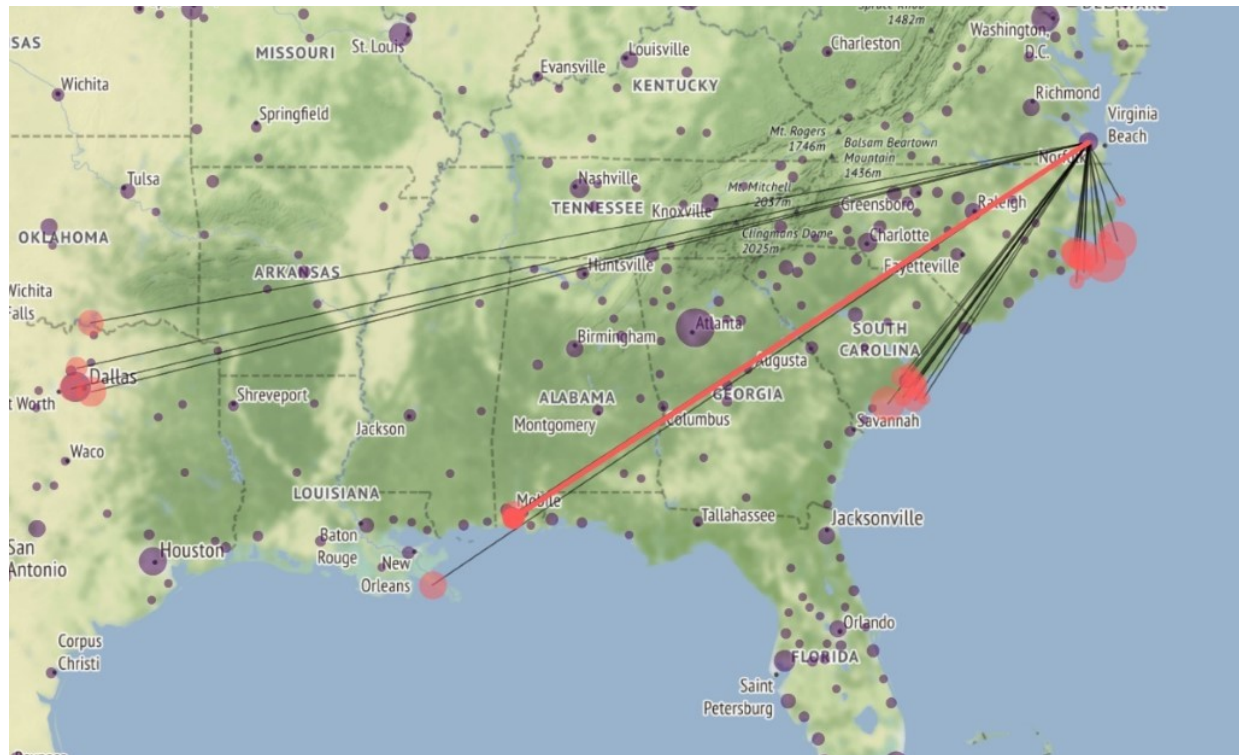
Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Sea level change and coastal storm surge	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Rising sea and lake levels • Rising water – wind driven (e.g. hurricane, nor'easter) • Saltwater intrusion • Vegetation damage	• NOAA SLR viewer • NOAA - Great Lakes Environmental Research Laboratory	• IRMA – Coastal reports • NPS SLR viewer • Specific Hazard Assessment: Coastal Storm Surge with Climate Change Effects (requires VPN connection) • SLR reports • Great Lakes Dashboard Project
Lake and reservoir level change	Known Hazard ☐ Potential Hazard ☐ Not Applicable ☒			
Hurricanes and tornadoes	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Building destruction • Flying debris • Storm surge • Tree fall (see other categories for associated intense rainfall and floods)		• Wind speed data – from local codes • International Building Code • FEMA Map Service Center

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Pest infestation	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	• Historic/facility fabric loss • Vegetation loss • Disease vectors may increase • Termites and other woodboring pests expanding range with warming and increased humidity	• USFS Forest Health Program	• NPS Pest and Invasive Species Management Contacts • Fisichelli et al. forest pests • USFS maps
Invasive species	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• Aquatic mussels – water intakes clogged • Vegetation (kudzu, vines) – damage buildings, kill trees, obstruct waterways	• National Invasive Species Council	• NPS Pest and Invasive Species Management Contacts • Early Detection and Distribution Mapping System (current distribution) • Early Detection and Distribution Mapping System (projected distribution)

Appendix 2. What Will the Park Climate Feel Like in 60 Years?

The map below is intended to help visualize how the present-day climate in the region of **Colonial National Historical Park** is projected to change as a result of climate change (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, Virginia Beach, Virginia's climate in 2080 may feel like today's climate near Tillmans Corner, Alabama. The typical summer in Tillmans Corner, Alabama is 4.6°F (2.9°C) warmer and 36.7% wetter than summer in Virginia Beach, Virginia. The red line shows the average of the 27 climate models; the black lines show the 27 individual projections assuming continued high emissions, providing a sense of the plausible range of future climates. The size of a red circle gives a sense of how good of a match that location is, with smaller circles indicating better matches; all circles (red or purple) denote cities used in the analysis. The analysis is based on twelve climate metrics, including minimum and maximum

temperature and precipitation by season (spring, summer, fall, winter). More details are available in the reference cited above and the website <https://fitzlab.shinyapps.io/cityapp/>.



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Disclaimer

Report Purpose and Scope:

Parks identified for Legacy Restoration Funding in fiscal years 2023-2025 are required to develop a Great American Outdoors Act Facility Investment Plan (GFIP). The intended use of this series of park-specific reports is to help parks address Question 16 of the narrative template: *What risks or hazards (current and projected, e.g. effects of climate change) are likely to affect this project? If applicable, what adaptation strategies and/or resiliency measures have been identified for scenarios that pose high risks to project assets?*

Each report compiled and summarized published information on a suite of climate change hazards. Each report included an analysis of each hazard, for which the report author assigned a 'hazard rating' as follows:

Known hazard: Conditions that cause the hazard are well documented in the area where the park occurs. If applicable to the project site, these hazards should always be addressed in the project plan.

Potential hazard: Conditions that cause or underlie the hazard are known to occur nearby or are likely to occur based on studies with conditions similar to the park. If applicable to the project site, these hazards should be considered for inclusion in the project plan.

Not applicable: No evidence was identified showing this hazard is relevant to the park. Note this is a coarse filter evaluation; local knowledge of a hazard(s) should be used, when available.

As articulated within the report (in an appendix of the hazard ratings) those ratings constitute the author's 'best professional judgement' about the relevance of the hazard for that park based on the reviewed literature (cited in the narrative text for the hazard & provided in the report bibliography).

The intended use of each report is to inform decisions for facility investment planning related to (i) potential hazards that a suggested facility investment concept would need to appropriately consider and avoid or mitigate and (ii) identifying facilities possibly at greater relative vulnerability due to the identified hazards. The level of information quality in the report was calibrated to those purposes, i.e. to inform development of questions for a facility investment scoping process to further explore.

Peer Review Process:

Each report was based on a template, which heavily relied on boilerplate text for the non-park specific elements. The boilerplate text underwent multiple rounds of informal peer review by assorted CCRP staff, including members of the Climate Science and Adaptation Team, the Communications Team, the Regional Climate Change Liaisons, and the Climate Change Liaison to Facilities and Planning. Each report was peer-reviewed by a member of CCRP to check interpretation, consistency in hazard ratings, improve narrative coherence, and flag priority additions/modifications. In situations where revisions were required, the peer reviewer then re-reviewed the final revised report to assure adequate resolution of the identified issues.