Climate Change Hazards Summary Report for Facility Investment Planning

Rock Creek Park

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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 Rock Creek 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 temperatures

Extreme temperatures can increase weathering and stress on infrastructure, staff, and people.

Greenhouse gas emissions from human activities have increased temperatures globally (IPCC 2013), across the U.S. (USGCRP 2017), and in U.S. national parks (Gonzalez et al. 2018). For the area within the boundaries of Rock Creek Park, annual average temperature increased at the statistically significant rate of 1 ± 0.2ºC (1.8 ± 0.4ºF) per century from 1895 to 2017 (Gonzalez et al. 2018). Under the highest greenhouse gas emissions scenario, climate models project additional heating of Rock Creek Park of 4.9 ± 1ºC (8.8 ± 1.8ºF) by 2100. The temperature increase could be kept to 1.7 ± 0.7ºC (3.1 ± 1.3ºF) under a scenario of reduced emissions (Gonzalez et al. 2018). Under the highest emissions scenario, models project an increase of 30 to 40 more days per year with a maximum temperature >32ºC (90ºF) and an increase of 3–4ºC (6–8ºF) in the hottest temperature of the year, from 1990 to 2050 (Vose et al. 2017).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Altered rainfall and snowfall

Changing precipitation and humidity conditions can affect street flooding, mold growth, and wood decay. Extreme storms can cause flooding (see below), damaging water and wastewater systems, drainage systems, roads, buildings, and other infrastructure.

For the area within the boundaries of Rock Creek Park, total annual precipitation changed at the non-statistically significant rate of +9% ± 4% per century from 1895 to 2017 (Gonzalez et al. 2018). Under the highest emissions scenario, climate models project a 14 ± 8% average increase of total annual precipitation by 2100, with nearly all climate models projecting precipitation increases (Gonzalez et al. 2018). Projected increases in temperatures, however, could eliminate snowfall from the Washington, DC, region by 2100 under the highest emissions scenario (Ning and Bradley 2015).

Climate change has contributed to a 55% increase in 100-year storms (a day with more precipitation than any other day, on average, in 100 years) for the northeastern U.S. as a whole from 1958 to 2016 (Easterling et al. 2017). Under the highest emissions scenario, models project that the five-year storm of today (a two-day period with more precipitation than any other two-day period in five years) could occur every one or two years by 2100, for the northeastern U.S. as a whole (Easterling et al. 2017).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Drought

Drought is an extended period of precipitation, surface water, or soil moisture below a long-term average. Drought can affect water supply and water and wastewater systems, water quality (Mosley 2015), and soil stability (Fernandes et al. 2015).

The balance between precipitation and evapotranspiration determines, in large part, the development of drought. In the mid-Atlantic region, projected increases in precipitation under climate change generally outweigh projected increases in evapotranspiration, so climate change does not substantially increase the risk of drought in the region through 2100 (Cook et al. 2015, Wehner et al. 2017). Nevertheless, increases in urban and suburban water use and sedimentation of reservoirs in the upper parts of the Potomac River watershed could increase the risk of low water supply for the Washington, DC, area (Stagge and Moglen 2017).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Wildfire

Wildfire is a natural part of many forest, woodland, and grassland ecosystems. Climate change is intensifying the heat that drives wildfire above natural levels (Jolly et al. 2015) and altering the distribution and density of vegetation that comprises the fuel for wildfires (Gonzalez et al. 2010). These

effects combine with the unnatural buildup of coarse woody debris and understory trees from decades of suppression of all fires, even natural ones (Agee and Skinner 2005). For areas where projected climate change increases fire risk, infrastructure located under or near tree canopies or dense grasslands are vulnerable to burning and destruction.

In the northeastern U.S., analyses have not detected a historical change in the area burned by wildfire attributable to human-caused climate change. Fire suppression in eastern U.S. forests has created moister and shadier conditions and less flammable fuel beds that favor moist tree species and disfavor dry fire-adapted species (Nowacki and Abrams 2008). Under continued climate change, increased precipitation would tend to keep wildfire ignition low in the mid-Atlantic region (Clark et al. 2014). For climate change scenarios in which dry periods between storms or evapotranspiration might increase or snowfall is eliminated, the dryness and flammability of coarse woody debris could increase.

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Sea level rise and storm surge

Flooding from sea level rise could cause billions of dollars of damage to Metro rail, buildings, and other infrastructure (Ayyub et al. 2012). Sea level rise could increase the infrastructure costs of nuisance flooding (low level, frequent flooding) above the costs of major floods (high level, infrequent flooding) in Washington, DC (Moftakhari et al. 2017).

Human-caused climate change has increased global sea level through runoff from the melting of glaciers and ice on land and the expansion of ocean water when it warms (IPCC 2013, Slangen et al. 2016, Frederikse et al. 2020), increasing sea level at Washington, DC, 32 cm (13 in.) since 1924 (https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8594900). The sea level gauge is currently on a wharf on the Southwest Waterfront. Under the highest emissions scenario, continued climate change could raise sea level 80 cm (3 ft.) at Rock Creek Park by 2100 (Caffrey et al. 2018).

In 2003, Hurricane Isabel caused a storm surge up the Potomac River that reached 2.5 m at the Washington, DC, tidal gauge (Wang et al. 2015). Under high emissions, climate change could cause a 100-year storm surge that could add 3 m (9 ft.) of storm water on top of the increased sea level (Tebaldi et al. 2012). Sea level rise could increase periodic flooding in Georgetown at the mouth of Rock Creek and permanently inundate some land along the Potomac River (Ayyub et al. 2012, Moftakhari et al. 2017, Zhang et al. 2019).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

River and Street Flooding

Flood threats to infrastructure include erosion, structural damage from the force of floodwaters, and damage to electrical systems. Post-flooding effects include rot, fungus, insects, mold, and mildew and physical deterioration of building materials.

Many factors influence river flood occurrence in the eastern U.S., including the amount of impervious surface in an urban area, upstream management of dams and reservoirs, and the amount of precipitation and intensity of storms (Yang et al. 2015). In the northeastern U.S., annual high-flow frequency increased in the period 2007-2016 compared to the period 1950-1969 (Dethier et al. 2020).

In addition to potential flooding from sea level rise (section above) in Georgetown and the mouth of Rock Creek at the Potomac River, climate change could increase flooding of Rock Creek and the Potomac River from extreme rainstorms. Under the highest emissions scenario, continued climate change could increase three-day peak river flow 10% by 2100 in Washington, DC (Battaglin et al. 2020, Demaria et al. 2016, Naz et al. 2016). Extreme storms in the watershed north and west of Washington, DC, could increase 100-year river flow in the Potomac at Little Falls 11% by 2055 (Van Dusen et al. 2020). Increases in extreme rainstorms could increase urban street flooding from the lack of green space to absorb stormwater runoff.

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Hurricanes and tornadoes

Sea level rise and storm surges from hurricanes (see section above) can cause severe flooding, including of infrastructure that had no flooding during past storms. Building standard guidance is based on base flood elevations of 0.6-1 m (2-3 ft.) above Federal Emergency Management Agency 100-year flood zones, depending on building criteria. Hurricanes also threaten structures from damage from wind, wind-blown rain, and debris. Large temperature swings stress buildings through sudden thermal expansion and can crack pipes. Tornadoes can result in catastrophic damage to infrastructure from high winds, and associated debris, hail, and flash flooding.

While climate change contributes to hurricane formation by warming sea surface temperatures (IPCC 2013), changes in historical monitoring methods have prevented definitive attribution of past hurricanes trends to climate change (IPCC 2013, USGCRP 2017). For the future, climate models project increases in North Atlantic hurricane intensities and precipitation amounts in the mid-Atlantic region (Kossin et al. 2017, Ting et al. 2019, Stansfield et al. 2020).

Climate change can increase the frequency of severe thunderstorms, which generate tornadoes, with analyses of historical records from 1979 to 2017 showing increases in the midwestern and southeastern

U.S., but no statistically significant trend for the mid-Atlantic region (Gensini and Brooks 2018). For the U.S. as a whole, the number of days with over 30 tornadoes (Brooks et al. 2014, Elsner et al. 2015) and the number of tornadoes per tornado outbreak have increased (Moore 2017, Tippett and Cohen 2016). Moreover, tornado power, a function of wind speed, tornado path area, and air density, has increased 5% ± 1% per year from 1994 to 2016 (Elsner et al. 2019).

Under the highest emissions scenario, continued climate change could increase the number of severe thunderstorm days with tornado conditions by 40% in the Washington, DC, area (Diffenbaugh et al. 2013, Gensini and Mote 2015).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Insect Pests

Pests can directly infest buildings and other infrastructure and indirectly affect infrastructure by increasing risks of tree death and falling branches or trees.

Warmer and moister conditions, which may increase under climate change, tend to favor numerous insect pests, including termites, ants, and hornets (Sims and Appel 2017). Continued climate change under low to high emissions could increase the number of invasive termite species in the Washington, DC, area (Buczkowski and Bertelsmeier 2017).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Invasive species

Terrestrial and aquatic invasive species can damage buildings and water systems. The use of pesticides to combat expanding invasive species may also threaten structures.

Climate change can favor invasive alien plant species, such as kudzu, in temperate zone ecosystems due to increased warmth, humidity, vegetation disturbances, and atmospheric carbon dioxide (Davidson et al. 2011, Hellmann et al. 2008, Liu et al. 2017). Climate change can also exacerbate aquatic invasive species, favored by warmer waters and other altered conditions in freshwater ecosystems (Havel et al. 2015).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

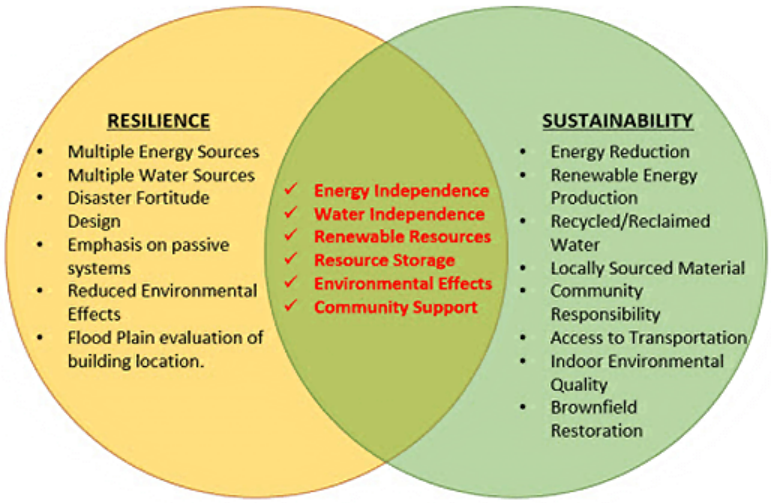
Step 2: Consider adaptation and resiliency strategies

- 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.

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

- An example response to Question 16 is provided below.
- You will need to identify the general type of project and modify the text below 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?

Several climate change hazards may affect a (shoreline repair, new building, historic building restoration, road repair, water system, other) project in Rock Creek Park, including sea level rise, storm surge, more frequent storms, Potomac River flooding, increased street stormwater runoff, hotter temperatures, and increased insect pests. Possible adaptation and resiliency strategies include:

- Avoid new infrastructure in the floodplain of Rock Creek.
- Natural shoreline features in Georgetown to handle some inundation from sea level rise.
- Vegetated catch basins for urban street stormwater runoff.
- Drainage systems and culverts that could handle greater water flows.
- Relocation of any infrastructure from an area where a hazard cannot be avoided.
- Water conservation measures, including low-flow water fixtures, graywater recycling, and ground-coupled cooling systems, for effective use of an essential natural resource.
- Strengthening structures to prevent damage from extreme storms or treefall.
- Clearing any flammable vegetation or other material away from buildings.
- Early detection and removal of termites or other pests or hazards.
- Weed and pest management measures to prevent new introductions from construction equipment and materials.
- Energy conservation and renewable energy systems to reduce fossil fuel energy use.

- Use site location, orientation, and design to take advantage of natural conditions such as breezes, shade, natural light, and sunshine for solar energy.
- Changes in building design or building systems to maintain appropriate temperatures and humidity without increasing energy use, which would increase greenhouse gas emissions and exacerbate climate change.
- Changes in building design or post-flooding dehumidification systems, coordinating with the NPS Historic Architecture, Conservation and Engineering Center or Historic Preservation Training Center and avoiding any increase in energy use, which would increase greenhouse gas emissions and exacerbate climate change.

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 Rock Creek 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 ☐	• 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
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

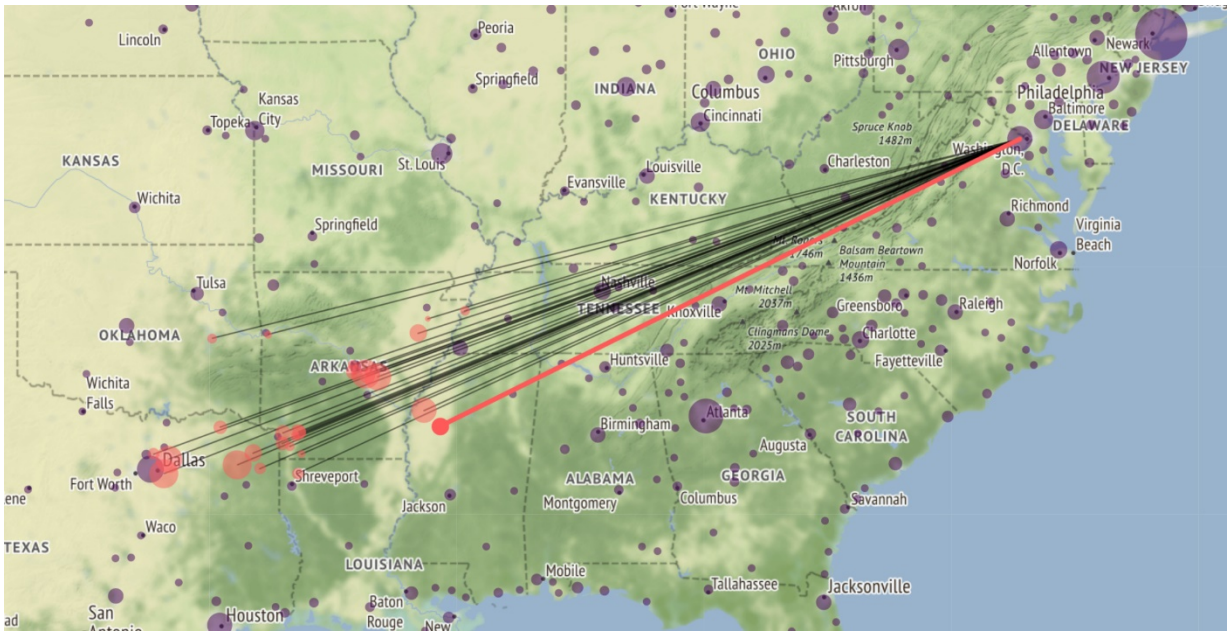
Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Increased wildfire frequency, intensity, magnitude, and duration	Known Hazard ☐ Potential Hazard ☒ Not Applicable ☐	• Damage to facilities 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
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 •

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
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 • Runoff projections (for select parks) • May require a special flood study
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

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
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
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 • Forest pests in eastern parks • 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 Could the Park Climate Feel Like in 60 Years?

The map below can help visualize how the climate around Washington, DC, could feel with continued climate change under high emissions by 2080, based on an analysis of climate model projections (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, Washington, DC, then could feel similar to Arkansas, Mississippi, or Texas today. The red line shows the average of the 27 climate models; the black lines show the 27 individual projections. Smaller red circles indicating closer 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 at 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.