



Climate Change Hazards Summary Report for Facility Investment Planning

Glen Canyon National Recreation Area 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 Glen Canyon National Recreation Area

- 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.

Temperature at GLCA are already shifting beyond the historical range of variability (Monahan and Fisichelli 2014). Mean annual temperature increased about 1.26 °F from 1901-2002 (Gonzalez 2014). Warming is particularly evident as an increase in very warm nights and a below-average occurrence of very cold nights over the last three decades (Frankson et al. 2017). Average estimates for the Colorado River Basin indicate a projected 9 to 10.8°F increase during the 21st century, with slightly higher increases projected in the upper Colorado Basin (Reclamation 2011).

The early 21st century has been the warmest period on record for Utah. The period from 2000 to 2004 was particularly warm, with the state seeing the largest number of extremely hot days (temperature 100°F or greater) in the historical record (Frankson et al. 2017). Garfin et al. (2013) report, with high confidence, a greater number of heat waves occurred across the southwest U.S. from 2001-2010 relative to 1901-2000. Future projections indicate the number and intensity of heat waves will continue to increase (Garfin et al. 2013). There is high confidence that the length of freeze-free days has increased, with regional analyses indicating a 7% increase (+17 days) during the period 2001-2010 compared to 1901-2000 (Garfin et al. 2013). Future projections suggest most of the Southwest U.S. will

experience a minimum of another 17 frost-free days by mid-century under a high greenhouse gas emissions scenario (Garfin et al. 2013).

Warming temperatures are projected to lead to changes in visitation based on the relationship between air temperature number of visitors. Fisichelli et al. (2015) projected a 9-32% increase in annual visitation; 4-22% increase in peak season visitation (3 busiest contiguous months); 13-34% increase in shoulder season visitation (2 months prior and 2 months after peak season); and 13-69% increase in low season visitation (3 contiguous months with least visitation).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Altered precipitation patterns, extreme precipitation, and changing humidity

Changing precipitation and humidity conditions can result in local flooding, wood decay, increased fire risk, and intensified drought conditions, 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, erosion of supporting ground around structures, among many other effects.

There has been no change in annual precipitation for GLCA from 1895-2010 (Gonzalez et al. 2018); precipitation projections vary between slight decreases to slight increases, without a statistically significant trend up or down. Spring precipitation, however, is projected to decrease across the Southwest U.S., with models projecting a 9-29% decline by 2070-2099, depending on the greenhouse gas emissions scenario (Garfin et al. 2013).

Reduced snow delivery due to warmer temperatures and more frost-free days means precipitation received by the region may runoff more quickly, potentially generating flooding, erosion, and drought as well as decreased aquifer recharge (Stortz et al. 2018). Spring snowpack in the upper Colorado Basin and southern Rocky Mountains has declined since the 1980's due to warmer temperatures (Pederson et al. 2013) There is high confidence that mountain snowpack will continue to decline, and this is already being observed in parts of the Southwest U.S. (Fleishman et al. 2019). Decreases in late winter and spring snowpack across mountains of the Southwest U.S. through the next century will be driven by increasing temperatures, rather than precipitation declines. Snowmelt and peak streamflow are expected to occur earlier in the year as 21st century warming progresses, and this will have direct implications for reservoirs on the Colorado River, including Lake Mead and Mohave (Fleishman et al. 2019). Garfin et al. (2013) note there is medium-high confidence that climate change will further limit water availability across most of the Southwest U.S.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Increased drought frequency, intensity, magnitude, and duration

Rising air temperatures and changing precipitation patterns are exacerbating drought risk in many parts of the United States (Wehner et al. 2017). Changing drought conditions (frequency, severity, duration) can challenge a variety of infrastructure and operations (Department of Homeland Security 2015) in the NPS (e.g., water supply and wastewater systems), impair water quality (Mosley 2015), affect soil heaves and shrinkages (Fernandes et al. 2015), and will enhance other related risks such as wildfire.

Droughts, a natural part of Utah's climate, are expected to become more intense. Higher temperatures increase evaporation and amplify the effects of naturally occurring dry spells by increasing the rate of loss of soil moisture. Robust projections of drought include substantial increases of very dry conditions throughout the soil column and sustained very hot droughts (Bradford et al. 2020). Most of Utah's water is supplied by the snowpack, and changes to the snow/rain ratio could result in less water storage. Additionally, higher spring temperatures can cause early melting of the snowpack, decreasing water availability during the already dry summer months. The projected increase in the intensity of naturally occurring droughts will increase the occurrence and severity of wildfires (Frankson et. al. 2017).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Increased wildfire frequency, intensity, magnitude, and duration

Wildfire is a natural part of many forest, woodland, and grassland ecosystems. Excessive fire, however, can damage ecosystems, kill people, and damage infrastructure. Climate change is intensifying the heat that drives wildfire (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). The effects of climate change on wildfire vary across landscapes. For areas where projected climate change increases fire risk, buildings, cultural landscapes, or other infrastructure located under or near tree canopies or dense grasslands are vulnerable to burning and destruction.

Fire potential is expected to increase in the Southwest (Liu et.al. 2013). Additionally, fire season could become a few months longer in the southern portion of the US. The increased future fire potential and longer fire seasons mean increased possibility for more intense wildfire activity (Liu et.al. 2013). In the western U.S., analyses of causal factors have found that human-caused climate change has doubled the area burned by wildfire since 1984 above natural levels, mainly through drying of vegetation (Abatzoglou and Williams 2016). Under the highest greenhouse gas emissions scenario, projected climate change could increase the frequency of large fires (>50 km², 20 sq. mi.) up to three times across the forests of the western U.S. by 2050 (Barbero et al. 2015). This trend of increasing numbers of very large fires is expected to continue as the fire risk projections show a continued increase in aridity,

increases in spring and early summer wildfires, an increase in the Keetch-Byram Drought Index, and increasing wind speeds for the southwest (Barbero et. al 2015, USGCRP 2017).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Lake and reservoir water level change

Lake Powell is the largest man-made lake in North America and is widely recognized by boating enthusiasts as one of the premier water-based recreation destinations in the world (NPS 2014). Lake Powell impounds waters of the Colorado River above the Glen Canyon Dam. It is the best known and most visited feature at Glen Canyon National Recreation Area. The Bureau of Reclamation manages the Glen Canyon Dam.

Approximately 95% of Lake Powell's inflow originates from the mainstream of the Colorado River and two major tributaries, the San Juan and Green Rivers (Stanford and Ward 1991; Reclamation 1995, 2007; Wildman et al. 2011). The majority of the inflow into Lake Powell, around 60%, occurs in late spring and early summer as a result of snowmelt in the Rocky Mountains and Upper Colorado River Basin (Iorns et al. 1965; Evans and Paulson 1983; Vernieu et al. 2005). Lake Powell water storage is very sensitive to changes in mean inflows and to sequences of wet and dry years (DOI 2016).

Since 2000, the Colorado River Basin has been in an extended drought. During the period 2000–2018, the inflow of water into Lake Powell was above average in only 4 years. This drought has reduced the overall system storage from nearly full to about half of capacity (Reclamation 2019).

Projected climate change impacts to Colorado River Basin include (a) decreased inflow to the reservoir system (due to higher temperatures and potentially lower precipitation); (b) greater evaporation and evapotranspiration losses (due to higher temperatures); and (c) increased demand (due to increased population size) (Reclamation 2012). For example, Milly and Dunne (2020) estimated that the warming effect alone (ignoring changes in precipitation) would, by the year 2050, reduce the flow in the Upper Colorado River Basin by 14-31 percent (low to high emissions scenario), relative to historical 1913-2017 flows. They estimate that for each 1.8 °F increase in warming, annual runoff into the Colorado system will drop 9.5 percent. Modeling under medium to high emissions scenarios projects a 9% decrease in mean natural flow at Lees Ferry by 2060 (Reclamation 2012).

Combined, these factors increase the probability of lower lake levels and likely duration of delivery shortages in coming decades. The Bureau of Reclamation has estimated that the shortfall created only by future supply and demand imbalances could range from 2.3 to 4.1 million acre feet (maf) per year, during any given deficit period (Reclamation 2012). Accounting for climate change, this value increases to around 7.4 maf per year during the deficit period (Reclamation 2012).

Riverine flood/Flash flood

Extreme precipitation events and the risk of flooding are 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, structural collapse from force of floodwaters, sewage backup, and damage to utilities, generators, and electrical systems. Post-flooding effects include increased rot, fungal/insect attack, mold and mildew, and physical deterioration of wood, brick and stone building materials.

Despite a decade of sustained Southwest U.S. drought, large storm events and flash flooding frequency has increased, resulting in increased flood damages (Batker et al. 2014; Dethier et al. 2020). Flash flood events within or near Glen Canyon National Recreation Area have caused significant damages to park infrastructure, economic loss, and loss of human life. Viscous, sediment-laden floods (debris flows) have repeatedly destroyed or damaged roads near Lees Ferry, where several short, steep drainages have headwaters in the easily eroded, clay-rich Chinle Formation. Since 1961, 15 people have died in GCNRA due to canyon floods. Eleven deaths occurred on August 12, 1997, when a severe thunderstorm caused a flash flood that swept 11 tourists and a tour guide down Antelope Canyon near Page, Arizona—the tour guide alone survived. The increasing popularity of canyoneering—hiking, climbing, and swimming through slot canyons with the aid of technical climbing equipment—will likely cause an increase in flood-related incidents within GLCA (Knudsen et al. 2017). Future projections include higher intensity summer rainfall and more frequent storm events are likely to increase the intensity and frequency of flash floods at Lake Mead and Mohave (Brekke et al. 2009).

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).

Non-native quagga mussels (*Dreissena bugensis*) were first found in Lake Powell in 2013, and have since been present in Lake Mead, Mohave and Havasu since 2007 (Reclamation 2020, Ryan et al. 2019). Quagga mussels are known to cause significant impacts to lake ecosystem function as well as biofouling of facilities. In Glen Canyon National Recreation Area, quagga mussels impact on Glen Canyon Dam water operations has been significant and led to increased operational costs.

In other lakes, quagga mussels have changed the composition of phytoplankton communities, altered nutrient dynamics, and potentially favor the growth cyanobacteria (especially those that produce

harmful toxins, Ryan et al. 2019). Although more information is needed, these kinds of ecological impacts may have implications for municipal water use and recreation of Lake Powell (Ryan et al. 2019).

We did not find studies evaluating the influence of climate change on quagga mussel populations in Lake Mead National Recreation Area, but studies from other lakes suggest intense storms may mix up stratified lake layers, delivering more phytoplankton that the mussels feed on and encourage their growth and reproduction (Schwalb et al. 2015). More work is needed to evaluate this potential climate nexus at Lake Mead National Recreation Area.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

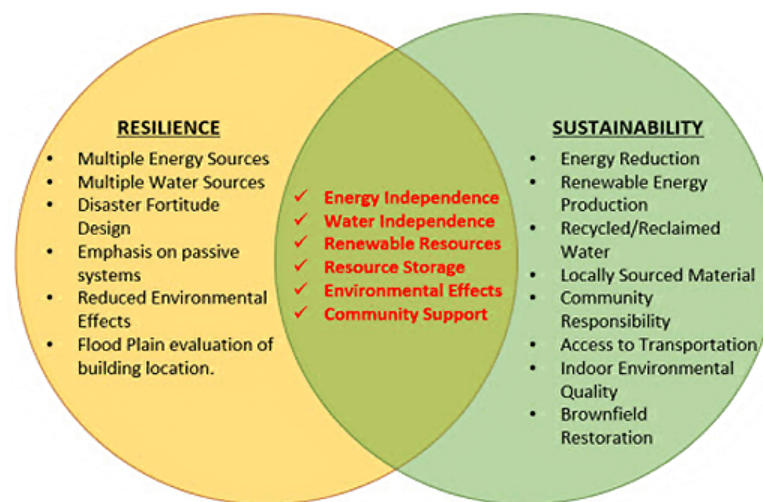
Step 2: Consider adaptation and resiliency strategies

- 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

- 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?

Examples for Glen Canyon National Recreation Area:

Several climate change hazards may affect building-related projects at GLCA, including hotter average days, more extreme heat days, increased impacts from wind and flooding, altered precipitation patterns (i.e. drought), increased extreme precipitation (e.g. flash flooding), and potential wildfire. Adaptation and resiliency strategies for the expected hazards are described below:

- Changes in building design or building systems may allow maintenance of appropriate temperatures and humidity without increasing energy use (which would increase greenhouse gas emissions and exacerbate climate change). Energy conservation and renewable energy systems can prevent any increase in fossil fuel energy use.
- 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.
- Water source needs and availability have been identified and water conservation measures will be prioritized. New restroom facilities will use water efficient fixtures.
- As water levels change, NPS must update and adjust infrastructure, like boat ramps, to accommodate those changes and continue boaters access to water. GLCA has made adjustments and will continue to make adjustments to keep boating recreation open to the public after the adjustments. For example, at Lake Powell, the Hite boat ramp was closed several years ago and replaced by a relocated ramp that works at a lower water elevation.
- Winter and spring precipitation is projected to increasingly fall in the form of heavier precipitation events with earlier spring snow melt, which can increase flooding and runoff. Road construction may require larger culverts to accommodate heavy runoff. Buildings, infrastructure, and roads in existing flood zones may need additional mitigation.

- Increased temperatures and crack/heave damage in drier soils, which may contribute to pavement degradation.
- Hotter and drier conditions will likely lead to an increase in wildfires. It will be important to maintain or increase the park's prescribed fire program and design any structures susceptible to wildfire damage with fire-resistant materials.
- Clearing any flammable vegetation, hazard trees, or other material away from buildings.
- The potential for increased invasive species should be mitigated. Measures include mitigation during construction (e.g., using weed-free gravel and cleaning construction equipment) and increased weed monitoring and treatment post construction.
- Use native and/or local landscape plants and materials that ameliorate harsh environmental conditions, fit into the landscape, and require little special care.
- Implement noxious weed and pest management programs that include early detection, monitoring, and eradication efforts, as well as construction mitigation to avoid new introductions.

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 **Glen Canyon National Recreation Area** 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 Judgment' 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

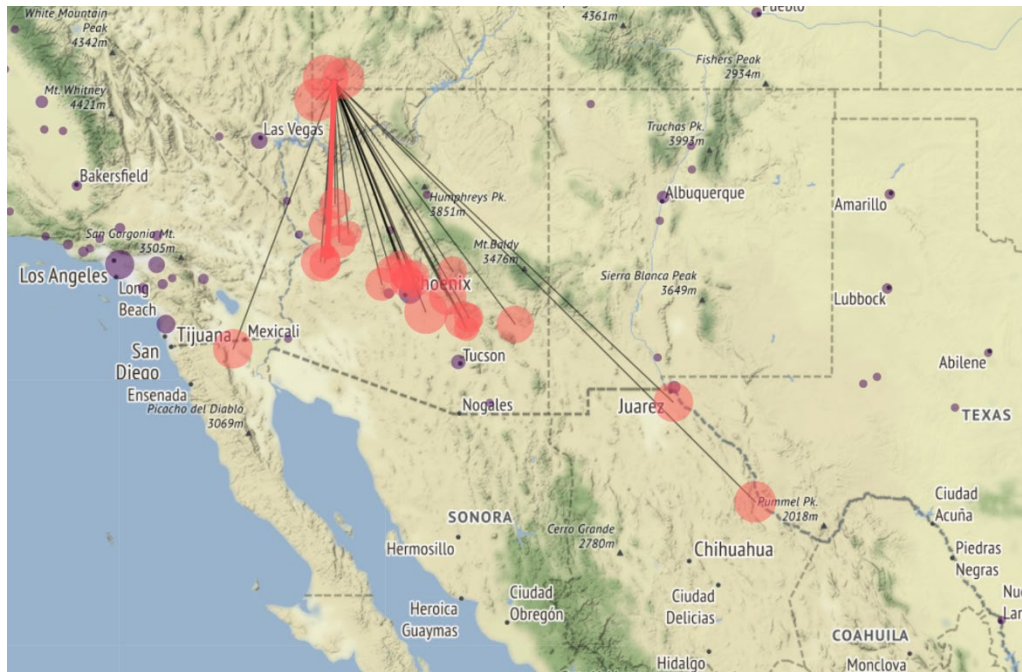
Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Sea level change and coastal storm surge	Known Hazard ☐ Potential Hazard ☐ Not Applicable ☒	• Rising sea and lake levels • Rising water – wind 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 Advisory System	• 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 **Glen Canyon National Recreation Area** is projected to change as a result of climate change (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, St. George, Utah's climate in 2080 may feel like today's climate near Lake Havasu City, Arizona. The typical summer in Lake Havasu City, Arizona is 10.6°F (5.9°C) warmer and 23.6% drier than summer in St. George, Utah. 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.