



Climate Change Hazards Summary Report for Facility Investment Planning

North Cascades National 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 North Cascades National 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.

A robust warming trend of annual average daily minimum temperatures at North Cascades National Park is evident based on a historical analysis of a long term weather station at Stehekin (1895-2011, Hoffman et al. 2015). Annual average daily maximum temperature trends over the same period did not demonstrate a statistically significant trend, similar to observations from other stations in the region (Hoffman et al. 2015). This is also consistent with anticipated future warming, where the minimum temperatures are expected to rise more rapidly than maximum temperature due to the reduced effectiveness of nighttime cooling (Hoffman et al. 2015).

Comparing climate experienced during the past 10–30 years relative to the longer 1901–2012 historical range of variability, Monahan and Fisichelli (2014) found that North Cascades National Park has recently experienced extreme warm conditions (exceeding 95% of the historical range of conditions) during the driest quarter of the year and the coldest month of the year. Similar extreme warming trends were

found for the mean warmest quarter of the year and the mean coldest quarter, although the changes were not statistically significant (Monahan and Fisichelli 2014).

Future projected temperatures indicate warming at North Cascades National Park. Gonzalez et al. (2018) project a range of warming from 3.2 °F per century (+/- 1.3) to 8.8 °F per century (+/- 2.2), based on a low to high greenhouse gas emissions scenario, respectively. At the regional scale, modelling under a high emissions scenario projects 35 to 45 fewer days with a minimum temperature < 32 °F between the periods 1980-2000 and 2041-2070 (Kunkel et al. 2013).

Analyses of data from the broader western U.S. (including North Cascades National Park) detected statistically significant increased winter temperatures (Barnett et al. 2008, Bonfils et al. 2008), decreased snowpack (Barnett et al. 2008, Pierce et al. 2008), decreased ratio of snow to rain (Pierce et al. 2008), and earlier spring streamflow (Barnett et al. 2008) from 1950 to 1999 (Gonzalez 2013).

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, increase fire risk, and intensify 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.

Historical trends of total annual precipitation at North Cascades National Park trended weakly upwards based on an analysis of a long term weather station at Stehekin (1895-2011, Hoffman et al. 2014). Gonzalez et al. (2018) similarly found a non-statistically significant increasing total annual precipitation trend for North Cascades National Park over the period 1895-2010 (+7% per century, $p=0.16$; analysis at whole park scale).

Statistically significant declines in snow depth and snow water equivalent were observed at Beaver Pass, Thunder Basin, and Meadow Cabins over the last half century (Hoffman et al. 2015). Other snow monitoring stations within the park showed similar patterns, although they were not statistically significant (Hoffman et al. 2015). These snow trends are consistent with changes in freezing level observed by the U.S. Western Regional Climate Center (2013). Stoelinga et al. (2010) estimated global warming lead to a loss of 16% of snowpack in the Washington Cascades between 1930 and 2007, after accounting for the influence of natural variability. Casola et al. (2009) estimated a loss of 8-16% snowpack for the same region between 1977-2006.

Future snow water equivalent is projected to decline 30% by mid-century in the North Cascades, with changes concentrated at lower elevations near the snowline (Hoffman et al. 2015). Future estimates of

snow water equivalent decline for the western Cascades from other studies are smaller, ranging from -9% over the period 1985-2025 (Stoelinga et al. 2010) and -11-21% by 2050 (Casola et al. 2009).

Projected warming will raise the elevation of the snow line in the mountains of Washington state. This will increase the proportion of precipitation falling as rain instead of snow, leading to less snow accumulation during the winter. Watersheds in the North Cascades are projected to become increasingly rain dominated resulting in more autumn/winter flooding, higher peak flows and lower summer flows (Raymond et al. 2014). Higher stream flows will stress existing trails, roads, bridges, and culverts within the North Cascades National Park Service Complex, where roads are currently distributed evenly across snowmelt, mixed snow and rain, and rain dominant watersheds, but will likely transition to the latter (Strauch et al. 2018). This is anticipated to challenge the 16,000 km road network of the North Cascades, increasing the difficulty of maintaining access for recreational users and resource managers (Raymond et al. 2014). Rainfall is expected to be the dominant form of precipitation across the majority of Washington by the end of the 21st century (Frankson et al. 2017), although a transition from snow to rain is unlikely to occur at the park's highest elevations.

Projected increases in heavy rainfall events for Washington state by mid-century could further increase flood risk (Frankson et al. 2017). Heavier rains could also increase the likelihood of avalanches, and Lazar and Williams (2008) predicted the onset of wet avalanche activity is likely to begin earlier in the season, based on a climate change assessment of Aspen Mountain, Colorado. Furthermore, the intensity of extreme precipitation events increase with increasing temperatures (Easterling et al. 2017).

Park staff assessment – relevant to GFIP Project:

☐ Yes

☐ No

Increased drought frequency, intensity, magnitude, and duration

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 (Halofsky et al. 2020). The 2015 drought necessitated \$7 million of relief funds to be used for backup emergency water supplies in Washington (May et al. 2018).

As the climate changes future drought impacts may be severe. The recent 2015 event in the North Cascades was unprecedented in the context of the past 400 years (Harley et al. 2020), and droughts are projected to be more likely within this century as climates warm (Diffenbaugh et al. 2015). These threats are likely to impact the park by coinciding with increased park visitation (Fisichelli et al. 2015).

Droughts occur in the Pacific Northwest when warm or dry winters reduce snowpack or when hot, dry summers reduce soil moisture and streamflow (Dalton et al. 2013, Dello and Dalton 2015). A record warm 2015 winter led to historically low snowpack in much of the Northwestern mountains as winter

precipitation fell as rain instead of snow, resulting in drought, water scarcity, and wildfire throughout the region (Mote et al. 2016, May et al. 2018). Climate change-drive temperatures increases are expected to deepen droughts in this region, particularly in areas with snowpack. Declining snowpack is expected to amplify summer drought conditions, increasing vulnerability to typical droughts caused by inter-annual precipitation variability (Vose et al. 2016, May et al. 2018).

Glaciers found in North Cascades National Park provide storage and the slow release of cool waters during summer, especially during droughts. Approximately 56% of the park's ice cover has been lost since the late 1800s (Dick 2013).

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.

Wildfires during the drier summer months of the Pacific Northwest are of particular concern (Frankson et al. 2017). The wildfire season of 2015 was the most destructive in Washington's history, with over 1 million acres burned, more than 6 times the average (Frankson et al. 2017). Snowpack in the mountains provides an important source of water during the drier summer months. Drier summers, along with warmer temperatures and earlier melting of the snowpack, increases the frequency and extent of wildfires (Frankson et al. 2017). High tree density and ladder fuels resulting from fire exclusion will exacerbate climate-driven increases in area burned and severity of burns (Raymond et al. 2014).

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).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Lake and reservoir water level change

Water levels at Ross Dam and Ross Lake are impacted by changes in precipitation, which may result in low lake levels during dry periods due to diminished inputs and increased evaporation, or high water levels due to intense storms or consistent precipitation over a prolonged period. Ross Lake is a favorite destination of boaters and backpackers seeking access to North Cascades' remote mountains. Reservoirs and lakes with controls on inlet and outlet flows are used to manage surface water levels; however, climate change may result in extremes that limit the ability to meet water level requirements for user needs or overwhelm control systems resulting in flooding.

Ross Dam, a hydropower dam on the Skagit River reliant on snowpack, provides 20 percent of the hydropower capacity for Seattle. April 1st snowpack at Ross Dam and the Skagit River has already declined, and earlier melting, as well as transitions from snow to rain delivery in the winter are likely to heighten the risk of flooding as reservoirs overflow and place stress on the region's water supply in the drier summer months (Stewart et al. 2004). Climate change will create challenges for hydropower plants such as Ross Dam given the demand of electricity for cooling will continue to rise in the summer just as lowering water levels will reduce the capacity of dams to generate power (Casola et al. 2005). Competing demands for summer water also used for irrigation, fish habitat, reservoir recreation, and cities will likely increase tensions amongst users (Casola et al. 2005).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

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.

Extreme flooding is projected to increase throughout much of the North Cascades (Raymond et al. 2014). The 100 year flood is projected to more than double historical levels in some watersheds on the leeward side of the Cascade crest. Increasing cool season runoff will cause rivers to become more geomorphically dynamic, creating or enlarging channels, eroding banks, widening floodplains, and generating sediment that fills channels and cause water levels to increase. These effects will be enhanced by projected increases in winter soil moisture, which reduces soil infiltration capacity and increases runoff (Raymond et al. 2014).

Rain-on-snow events in the North Cascades are likely to also increase flooding, although generalities are complicated by the changing elevation of the freezing line, existing snowpack, and interannual variability

in the magnitude of precipitation (McCabe et al. 2007). Atmospheric rivers also contribute to extreme precipitation events and flooding, particularly along the west coast of the United States. Espinoza et al. (2018) found a pronounced increase in atmospheric river conditions under a high greenhouse gas emissions scenario, resulting in longer, wider atmospheric rivers.

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). Facilities may be impacted indirectly through forest insect pest invasions exacerbated by climate change leading to increased tree mortality, hazard trees, and treefall.

Across western North America climate change has caused bark beetle outbreaks leading to the most extensive tree mortality in the last 125 years (Raffa et al. 2015). Mountain pine beetle occurs primarily on the eastern side of North Cascades National Park (Hoffman et al. 2015), and although outbreaks have not been as large as in other parts of the western U.S. (Raymond et al. 2014), rising temperatures could lead high elevation habitats of the park to become more suitable for the beetle, which could, in turn, increase tree mortality (Logan and Powell 2001, Hoffman et al. 2015). Pest-related tree mortality can also increase erosion and landslides.

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 plant species, such as cheatgrass (*Bromus tectorum*), may invade burned areas, displace natives, and alter fuel and fire regime properties (e.g., increase fire frequency) (Brooks et al. 2004). North-central Washington may become more climatically suitable for cheatgrass as the climate changes and increased atmospheric CO₂ levels may increase cheatgrass productivity and biomass (Ziska et al. 2005).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

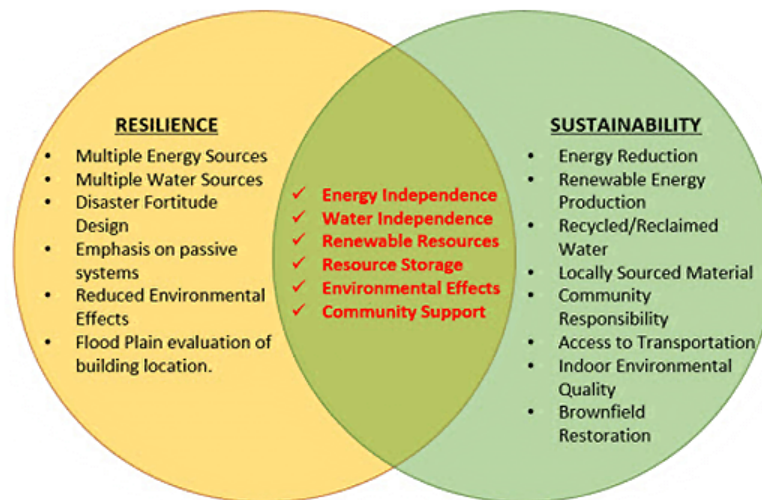
Step 2: Consider adaptation and resiliency strategies

- 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 based on climate-induced changes in hydrology related to road repair, damage to facilities in a floodplain, trail repair, or a water system project is provided below. This information was derived from Raymond et al. (2014).
- 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**; i.e., resilience strategies should be specific to your project type and the relevant climate change hazard.
- 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 from North Cascades National Park road repair, damage to facilities in a floodplain, trail repair, or a water system project

Several climate change related hazards have been identified that may affect projects in North Cascades National Park, including hotter average days, more extreme heat days, increased drought frequency and intensity, altered precipitation and flooding patterns, increased wildfire, and increased tree pests and invasive species abundance or distribution. The primary hazard affecting this project is related to climate change-induced alterations in hydrology. Possible adaptation strategies are provided below.

Vulnerability: Higher peak flows leading to increased road damage at stream crossings

- Replace existing or damaged culverts with higher capacity culverts
- Prioritize structure replacement in high-risk (mixed-rain-and-snow) watersheds
- Reroute roads out of floodplains
- Continue to decommission roads with high risk and low access

Vulnerability: Higher peak flows leading to increased damage and disrupted access to facilities and cultural and historical resources

- Restore natural function of the floodplain allowing waterways to migrate
- Remove or modify infrastructure allowing channels to migrate within the floodplain
- Consider increased use of engineered logjams to redirect flows
- Stabilize banks near resources with vegetation

Vulnerability: Higher peak flows and flood frequency may increase damage to trails and bridges, requiring more maintenance, replacements, or closures

- Upgrade trail bridges with stronger rot-resistant materials
- Relocate bridges to locations with stronger parent material if possible
- Reroute trails above waterways with highest flood risk
- Consider increasing the height of bridges above waterways
- Collaborate with hydrologists to consider future peak flows in design of new trails and trail bridges
- Abandon damaged trails with low use and high flood risk
- Reroute trails in locations that eliminate the need for trail bridges

Vulnerability: Decreased water and potable water availability with reduced snowpack, lower summer precipitation, and increased demand in the dry season

- Increase water conservation by installing waterless urinals and low-flow, solar, and composting toilets
- Institute gray water recycling
- Reduce campground capacity or close facilities when water is not available
- Investigate alternative water sources (e.g., ground water)
- Consider constructing new wells, cisterns, and reservoirs
- Increase water storage with artificial storage infrastructure (e.g., water towers)

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 **North Cascades National 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 **North Cascades National Park** is projected to change as a result of climate change (Fitzpatrick and Dunn 2019). Under a high greenhouse gas emission scenario, Bellingham, Washington's climate in 2080 may feel like today's climate near Seattle, Washington. The typical summer in Seattle, Washington is 3°F (1.7°C) warmer and 30.1% drier than summer in Bellingham, Washington. 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.