



Climate Change Hazards Summary Report for Facility Investment Planning

Joshua Tree 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 Joshua Tree 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 temperatures

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 Joshua Tree National Park, annual average temperature increased at the statistically significant rate of $1.5 \pm 0.1^{\circ}\text{C}$ ($2.7 \pm 0.2^{\circ}\text{F.}$) per century from 1895 to 2017 (Gonzalez et al. 2018). Under the highest greenhouse gas emissions scenario, climate models project additional heating of Joshua Tree National Park of $4.6 \pm 0.9^{\circ}\text{C}$ ($8.3 \pm 1.6^{\circ}\text{F.}$) by 2100. The temperature increase could be kept to $1.5 \pm 0.6^{\circ}\text{C}$ ($2.7 \pm 1.1^{\circ}\text{F.}$) 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 $>32^{\circ}\text{C}$ (90°F.) and an increase of $2\text{--}3^{\circ}\text{C}$ ($4\text{--}6^{\circ}\text{F.}$) in the hottest temperature of the year, from 1990 to 2050 (Vose et al. 2017). Extreme temperatures can increase weathering and stress on infrastructure and people.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
☐ No

Altered rainfall and snowfall

For the area within the boundaries of Joshua Tree National Park, total annual precipitation decreased at a statistically significant rate of $-32 \pm 12\%$ per century from 1895 to 2017 (Gonzalez et al. 2018). For projections under continued climate change, approximately half of the climate models project increases and half project decreases (Gonzalez et al. 2018). This lack of agreement exists for monthly, seasonal, and annual projections. Even if precipitation were to increase, higher temperatures would tend to increase aridity in the Mojave Desert through an increase in evapotranspiration (Byrne and O’Gorman 2015). The number of dry days per year and the number of extreme rainfall days could increase, leading to intense droughts alternating with intense wet periods (Polade et al. 2014, 2017; Swain et al. 2018). Under the highest emissions scenario, climate change would reduce the probability of snowfall in southern California mountains and high desert to zero (Klos et al. 2014). Changing rainfall and snowfall affect drought, wildfire, water scarcity, flash flooding, and wood decay

Climate change has contributed to a 10% increase in 100-year storms (a day with more precipitation than any other day, on average, in 100 years) for the southwestern U.S. as a whole from 1958 to 2016 (Easterling et al. 2017). Under the highest emissions scenario, continued climate change could, in southern California by 2100, double the frequency of extreme storms comparable to the storms that generated the 2016-2017 floods (Swain et al. 2018). Under the highest emissions scenario, climate change could increase the frequency and intensity of atmospheric rivers, narrow bands of highly concentrated storms that move from the Pacific Ocean into California, increasing rainfall in severe storms in southern California up to 28% by 2100 (Hagos et al. 2016, Huang et al. 2020). Extreme storms can cause flash flooding, damaging water and wastewater systems, drainage systems, roads, buildings, and other infrastructure.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Drought

Drought is an extended period of low precipitation, surface water, or soil moisture below a long-term average. A severe drought struck most of California from 2012 to 2016, with the hottest annual average temperatures and lowest 12-month precipitation total since 1895 (Diffenbaugh et al. 2015). From 2012 to 2015, soil moisture for California as a whole dropped to its driest level in the past 1200 years (Robeson 2015). For California as a whole, the high temperatures of human-caused climate change accounted for one-tenth to one-fifth of the 2012-2014 period of the drought (Williams et al. 2015). From 2000 to 2018, the increased heat of human-caused climate change has caused half the severity of the most severe drought for the southwestern U.S. as a whole since the 1500s (Williams et al. 2020).

Under the highest emissions scenario, climate change could increase the number of dry days in southern California by five to ten days per year (Polade et al. 2014). Under the highest emissions scenario, climate change increases drought risk in southern California by 2100 to the 1% driest drought severity

experienced currently (Cook et al. 2015), increasing the probability of a drought as severe as the 2012-2016 California drought to once a year by mid-century (Diffenbaugh et al. 2015). This could cause more frequent water shortages in southern California (Pagan et al. 2016). Drought can also affect and water and wastewater system operations, water quality (Mosley 2015), and soil stability (Fernandes et al. 2015).

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).

Under a medium emissions scenario, the increased heat of continued climate change could increase fire frequency in the Mojave Desert (Mann et al. 2016) and lengthen fire season up to three weeks by 2050 (Abatzoglou and Kolden 2011), mainly from increases in exotic grasses creating a fine fuel layer (Moloney et al. 2019). This depends on increases in precipitation, which would increase spread of exotic grasses. If aridity increases under continued climate change, invasive grasses would not tend to increase, causing a lack of fuel for wildfires.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Flash Floods

In southern California, increases in extreme rainstorms under climate change could increase probabilities of flash floods 30-40% (Modrick and Georgakakos 2015). Flood threats to infrastructure include erosion, structural damage from the force of floodwaters, damage to electrical systems, and post-flood physical deterioration of building materials.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Tornadoes

While tornadoes are very rare in southern California, residents reported a tornado in the town of Joshua Tree in 2001. Climate change can increase the frequency of severe thunderstorms, which generate tornadoes. Under the highest emissions scenario, continued climate change could slightly increase the number of severe thunderstorm days with tornado conditions in southern California (Diffenbaugh et al. 2013).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Insect Pests

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 southern California (Buczowski and Bertelsmeier 2017). Pests can directly infest buildings and other infrastructure and indirectly affect infrastructure by increasing risks of tree death and falling branches or trees.

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

Invasive species

Climate change can favor invasive alien plant species 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 could increase invasive red brome and Sahara mustard in the Mojave Desert (Curtis and Bradley 2015). Joshua Tree National Park is in a zone of medium to high risk of invasive alien plant and animal species under climate change (Early et al. 2016). Increases in invasive grasses would increase fire risks (Abatzoglou and Kolden 2011).

Park staff assessment – relevant to GFIP Project:

- ☐ Yes
- ☐ No

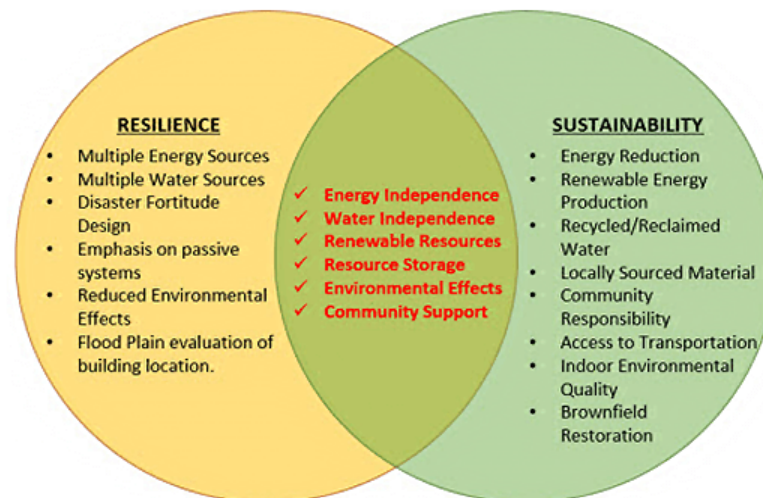
Step 2: Consider adaptation and resiliency strategies

- 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 (new building, historic building restoration, road repair, water system, other) project in Joshua Tree National Park, including hotter temperatures, drought, wildfire, and flash floods. Possible adaptation and resiliency strategies include:

- Clear any flammable vegetation or other material away from buildings.
- Avoid new infrastructure in or near intermittent water courses.
- Use site location, orientation, and design to take advantage of natural conditions such as breezes, shade, natural light, and sunshine for solar energy.
- Energy conservation and renewable energy systems to reduce fossil fuel energy use.
- Water conservation measures, including low-flow water fixtures, graywater recycling, and ground-coupled cooling systems.
- 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.
- Relocate any infrastructure from an area where a hazard cannot be avoided.
- Strengthen structures to prevent damage from extreme storms.
- 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.

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 Joshua Tree 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 ☐	• 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
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

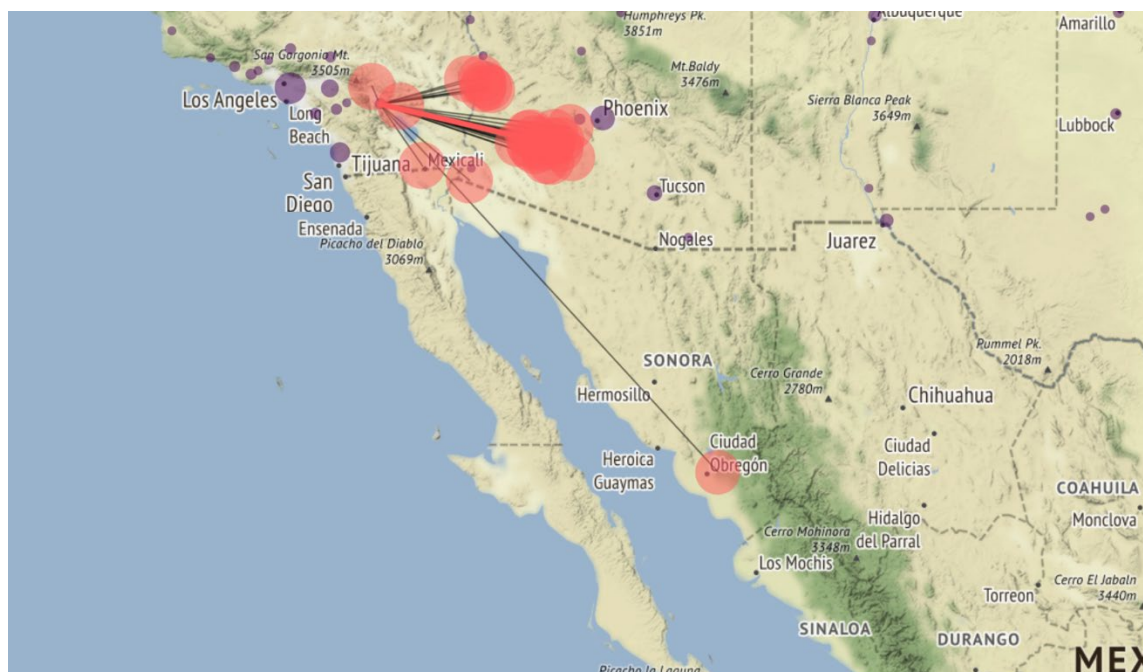
Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
Altered precipitation patterns, increased extreme precipitation, and changing humidity	Known Hazard ☒ Potential Hazard ☐ Not Applicable ☐	• 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 •
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

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
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

Potential Climate Hazard	Best Professional Judgment	Examples of risk or secondary hazard	Sources of General Non-site specific Data	Sources for Site Specific Data
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 Palm Springs 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, Palm Springs then could feel similar to Arizona today. The red line shows the average of the 27 climate models; the black lines show the 27 individual projections. Smaller 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?*

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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.