



June 2019

CLIMATE RESILIENCE

DOD Needs to Assess Risk and Provide Guidance on Use of Climate Projections in Installation Master Plans and Facilities Designs

Why GAO Did This Study

DOD manages a global real-estate portfolio with an almost \$1.2 trillion estimated replacement value. Since 2010, DOD has identified climate change as a threat to its operations and installations. In January 2019, DOD stated that the effects of a changing climate are a national security issue with potential impacts to the department's missions, operational plans, and installations. GAO was asked to assess DOD's progress in developing a means to account for potentially damaging weather in its facilities project designs.

GAO examined the extent to which DOD has taken steps to incorporate resilience to extreme weather and climate change effects into (1) selected installation master plans and related planning documents, and (2) selected individual installation facilities projects.

GAO reviewed DOD documents related to increasing climate resilience, conducting installation master planning, and designing facilities projects. GAO visited or contacted a non-generalizable sample of 23 installations that had been associated with one or more climate vulnerabilities.

What GAO Recommends

GAO is making eight recommendations, including that the military departments work together to update master planning criteria to require an assessment of extreme weather and climate change risks and to incorporate DOD guidance on the use of climate projections into facilities design standards. GAO also recommends that DOD issue guidance on incorporating climate projections into installation master planning and facilities project designs. DOD concurred with all eight of GAO's recommendations.

View [GAO-19-453](#). For more information, contact Diana Maurer at (202) 512-9627 or maured@gao.gov.

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What GAO Found

Department of Defense (DOD) installations have not consistently assessed risks from extreme weather and climate change effects or consistently used projections to anticipate future climate conditions. For example, DOD's 2018 preliminary assessment of extreme weather and climate effects at installations was based on the installations' reported past experiences with extreme weather rather than an analysis of future vulnerabilities based on climate projections. Fifteen of the 23 installations GAO visited or contacted had considered some extreme weather and climate change effects in their plans as required by DOD guidance, but 8 had not. For example, Fort Irwin, California, worked with the U.S. Army Corps of Engineers to improve stormwater drainage after intense flash flooding caused significant damage to base infrastructure. By contrast, Joint Base Pearl Harbor-Hickam, Hawaii, did not include such considerations in its plans, although it is located in an area subject to tropical storms and where further sea level rise is anticipated.

Flooding at Naval Station Norfolk, Virginia



Source: U.S. Navy. | GAO-19-453

GAO also found that most of the installations had not used climate projections, because they lack guidance on how to incorporate projections into their master plans. Not assessing risks or using climate projections in installation planning may expose DOD facilities to greater-than-anticipated damage or degradation as a result of extreme weather or climate-related effects.

Eleven of the 23 installations we reviewed had designed one or more individual facilities projects to increase the resilience of the facilities to extreme weather and climate change effects. However, project designs generally did not consider climate projections, according to installation officials. These officials told us that DOD lacks guidance on how to use climate projections that involve multiple future scenarios and different time periods. Until DOD updates its facilities design standards to require installations to consider climate projections in project designs, identify authoritative sources for them to use, and provide guidance on how to use projections, installation project designers may continue to exclude consideration of climate projections from facilities project designs, potentially making investments that are planned without consideration of climate-related risks.

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Abbreviations

DOD	Department of Defense
NOAA	National Oceanic and Atmospheric Administration
SERDP	Strategic Environmental Research and Development Program

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June 12, 2019

Congressional Addressees

The Department of Defense (DOD) manages a global real-estate portfolio with an estimated replacement value of almost \$1.2 trillion, including installations in all regions of the continental United States, Alaska, and Hawaii, as well as in foreign locations. These installations not only provide services and support to servicemembers and their families, but are critical to maintaining military readiness. Since 2010, DOD has identified climate change as a threat to its operations and installations and stated that the department needs to adapt its infrastructure to the risks posed by climate change.¹ In January 2019, DOD stated in a report to Congress that the effects of a changing climate are a national security issue with potential impacts to the department's missions, operational plans, and installations.²

The effects of climate change, such as sea level rise, may damage infrastructure and result in increased costs to the department. These costs are projected to increase as extreme weather events become more frequent and intense as a result of climate change—as observed and projected by the U.S. Global Change Research Program and the National Academies of Sciences, Engineering, and Medicine. According to the U.S. Global Change Research Program's *Fourth National Climate Assessment*, the effects of climate change are already being felt in the United States and are projected to intensify in the future. These effects will include increases in the incidence of extreme high temperatures, heavy precipitation events, high tide flooding events along the coastline, and forest fires in the western continental United States and Alaska. The assumption that current and future climate conditions will resemble those of the recent past is no longer valid, according to the report. For example,

¹DOD, *Quadrennial Defense Review Report* (February 2010).

²Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report on Effects of a Changing Climate to the Department of Defense* (January 2019).

sea levels are expected to continue to rise along almost all U.S. coastlines.³

We and others, such as the National Academies of Sciences, Engineering, and Medicine, have therefore recommended enhancing climate resilience as one strategy to help limit the federal government's fiscal exposure. Enhancing climate resilience means being able to plan and prepare for, absorb, recover from, and more successfully adapt to climate-related impacts, such as those identified by the U.S. Global Change Research Program in the 2018 *Fourth National Climate Assessment*.⁴ Examples of resilience measures to protect infrastructure include raising river or coastal dikes to reduce the risks to infrastructure from sea level rise, building higher bridges, and increasing the capacity of stormwater systems. Enhancing climate resilience can add additional costs up front, but could also reduce potential future costs incurred as a result of damage from climate-related events.

As a result of the significant risks posed by climate change, in February 2013, we placed *Limiting the Federal Government's Fiscal Exposure by*

³Jay, A., D.R. Reidmiller, C.W. Avery, D. Barrie, B.J. DeAngelo, A. Dave, M. Dzaugis, M. Kolian, K.L.M. Lewis, K. Reeves, and D. Winner, 2018: Overview. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, D.C.

⁴The National Academies of Sciences, Engineering, and Medicine defines resilience as the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. The National Academies, Committee on Increasing National Resilience to Hazards and Disasters and Committee on Science, Engineering, and Public Policy, *Disaster Resilience: A National Imperative* (Washington, D.C.: 2012). We reported in 2016 that two related sets of actions that can enhance climate resilience by reducing risk include climate change adaptation and hazard mitigation. Adaptation involves adjustments to natural or human systems in response to actual or expected climate change, including increases in the frequency or severity of weather-related disasters. Hazard mitigation refers to actions taken to reduce the loss of life and property by lessening the effects of adverse events and applies to all hazards, including terrorism and natural hazards such as health pandemics or weather-related disasters. For more information, see, for example, GAO, *Climate Change: Selected Governments Have Approached Adaptation through Laws and Long-Term Plans*, [GAO-16-454](#) (Washington, D.C.: May 12, 2016); and, Jay, A., D.R. Reidmiller, C.W. Avery, D. Barrie, B.J. DeAngelo, A. Dave, M. Dzaugis, M. Kolian, K.L.M. Lewis, K. Reeves, and D. Winner, 2018: Overview. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, D.C.

Better Managing Climate Change Risks on our High-Risk List.⁵ As part of our work in this high-risk area, in 2015 we reported that the climate information needs of federal, state, local, and private-sector decision makers were not being fully met and that a national climate information system could help them make more informed decisions about managing climate change risks. We made two recommendations, including that the Executive Office of the President develop a set of authoritative climate change projections for use in federal decision making, but as of May 2018, the Executive Office of the President had yet to take action in response.⁶ In 2016 we reported that improved federal coordination could facilitate the use of forward-looking climate information in facilities design standards and building codes, the technical guidelines that promote the safety, reliability, productivity, and efficiency of infrastructure.⁷ We made one recommendation—that the Director of the National Institute of Standards and Technology at the Department of Commerce convene an ongoing government-wide effort to provide the best available forward-looking climate information to standards-developing organizations for consideration in design standards and building codes. As of May 2018, our recommendation had not been implemented.

We have also previously reported on the risks of extreme weather and climate change effects to DOD installations.⁸ In 2014, we reported on the risks that climate change posed to DOD's domestic installations, and in 2017 we issued a related report on risks that climate change posed to

⁵GAO, *High-Risk Series: An Update*, [GAO-13-283](#) (Washington, D.C.: Feb. 14, 2013). See also GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, [GAO-19-157SP](#) (Washington, D.C.: Mar. 6, 2019).

⁶GAO, *Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information*, [GAO-16-37](#) (Washington, D.C.: Nov. 23, 2015).

⁷GAO, *Climate Change: Improved Federal Coordination Could Facilitate Use of Forward-Looking Climate Information in Design Standards, Building Codes, and Certifications*, [GAO-17-3](#) (Washington, D.C.: Nov. 30, 2016).

⁸Extreme weather and climate change effects refer to weather events observed and projected to become more common and intense because of climate change as well as the effects of such events, including loss of life, rising food and energy prices, increasing cost of disaster relief and insurance, fluctuations in property values, and concerns about national security. See our discussion in the Background section of this report for more information.

DOD's foreign installations.⁹ We discuss our findings and recommendations from these reports in more depth later in this report.

Senate Report 115-130, accompanying a bill for fiscal year 2018 appropriations for military construction, the Department of Veterans Affairs, and related agencies, cited concerns with the frequency and costs of extreme weather events and the potential effects of climate change and included a provision for us to review DOD's progress in developing a means to account for potentially damaging weather in its facilities project designs.¹⁰ This report examines the extent to which DOD has taken steps to incorporate resilience to extreme weather and climate change effects into (1) installation master plans and related planning documents, and (2) individual installation facilities projects.

For objective one, we reviewed DOD policies, guidance, and standards related to increasing climate resilience and conducting installation master planning. We interviewed officials in the Office of the Assistant Secretary of Defense for Sustainment, each of the military departments involved with installation policy, and the engineering organizations of each military department. We also visited or requested information from a non-generalizable sample of 23 domestic military installations, plus an Air Force unit with responsibility for certain facilities in Alaska because these facilities are affected by severe coastal erosion. To develop this sample we focused on domestic installations because our November 2017 report focused on foreign installations. We selected installations that had identified one or more climate-related vulnerabilities based on their past experiences in a DOD-administered survey of climate vulnerabilities at DOD installations or in a prior GAO report on weather and climate risks at DOD installations. We visited 10 of these installations, plus the Air Force unit in Alaska, and sent the remaining 13 installations a questionnaire.¹¹

⁹GAO, *Climate Change Adaptation: DOD Can Improve Infrastructure Planning and Processes to Better Account for Potential Impacts*, [GAO-14-446](#) (Washington, D.C.: May 30, 2014), and *Climate Change Adaptation: DOD Needs to Better Incorporate Adaptation into Planning and Collaboration at Overseas Installations*, [GAO-18-206](#) (Washington, D.C.: Nov. 13, 2017).

¹⁰S. Rep. No. 115-130, at 12-13 (2017).

¹¹One of these installations—Camp Lejeune—ultimately did not return the questionnaire because, according to officials, the installation had sustained significant damage in a hurricane and officials were fully engaged in clean-up and recovery activities. To reduce the use of installation officials' time in responding, we conducted a phone interview with installation officials as an alternative to the questionnaire and discussed the installation's responses to the questions in the questionnaire.

We then reviewed documents from all the installations in our sample, including master plans. We compared DOD's actions to take steps in installation planning to increase resilience with DOD guidance on climate change resilience, Unified Facilities Criteria standards, federal internal control standards, and best practices for enterprise risk management.

For objective two, we reviewed DOD guidance related to increasing climate resilience. We also reviewed DOD standards for facilities project design to determine the extent to which they require or give guidance on climate resilience measures and the extent to which they incorporate guidance on using climate projections. We obtained information from each of the installations in our sample on the extent to which they had incorporated climate resilience measures into specific projects and reviewed project design documents. We compared the extent to which DOD took steps in its facilities projects and its project design standards to increase resilience with DOD guidance on climate change resilience. See appendix I for more information on our objectives, scope, and methodology.

We conducted this performance audit from April 2018 to June 2019 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Extreme Weather and Climate Change Effects

According to the National Research Council, although the exact details cannot be predicted with certainty, climate change poses serious risks to many of the physical and ecological systems on which society depends.¹² Moreover, according to key scientific assessments, the effects and costs

¹²The National Research Council is the principal operating agency of the National Academies of Sciences, Engineering, and Medicine for furnishing scientific and technical advice to governmental and other organizations. See, National Research Council, Committee on America's Climate Choices, *America's Climate Choices* (Washington, D.C.: 2011); National Research Council, *Climate Change: Evidence, Impacts, and Choices* (Washington, D.C.: 2012).

of extreme weather events such as floods and droughts will increase in significance as what are considered rare events become more common and intense because of climate change.¹³ According to the National Academies of Sciences, Engineering, and Medicine, extreme weather events are directly traceable to loss of life, rising food and energy prices, increasing costs of disaster relief and insurance, fluctuations in property values, and concerns about national security. Table 1 shows seven effects commonly associated with climate change that DOD has documented.

Table 1: Seven Observed and Potential Effects of Climate Change on Weather Events and on Department of Defense (DOD) Infrastructure and Operations

Category	Potential effects of climate change on weather events	Observed and potential effects on DOD infrastructure and operations
Flooding due to storm surge	Increased severity and frequency of flooding caused by storm surge	Coastal erosion (e.g., shoreline facilities), damage to coastal infrastructure (e.g., piers and utilities)
Flooding due to non-storm surge	Increased severity and frequency of flooding not caused by storm surge	Inundation of inland sites, damage to infrastructure (e.g., training area facilities), encroachment on training lands (e.g., excessive damage to maneuver training lands), stormwater and wastewater disposal issues, shifting river flows
Extreme temperatures	Hot: Increased frequency of extremely hot days, thawing of permafrost, seasonal weather shifts	Strained electricity supply, changing demand for cooling of buildings (e.g., effects on an installation's energy intensity and operating costs), training encroachment (e.g., more red and black flag days), ^a erosion and facility damage from thawing permafrost, water supply shortages, increased maintenance requirements for runways or roads
	Cold: Increased frequency of extremely cold days, seasonal weather shifts	Strained electricity supply, changing demand for heating of buildings (e.g., effects on an installation's energy intensity and operating costs), training encroachment, increased maintenance requirements for runways or roads
Wind	Stronger and more frequent wind	Damage to above-ground electric/power infrastructure (e.g., power lines), roofs of buildings, and housing
Drought	Increased frequency of drought	Water supply shortages

¹³Jerry M. Melillo, Terese (T.C.) Richmond, and Gary W. Yohe, eds., *Climate Change Impacts in the United States: The Third National Climate Assessment*, (Washington, D.C.: U.S. Global Change Research Program, May 2014) and *Intergovernmental Panel on Climate Change, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Category	Potential effects of climate change on weather events	Observed and potential effects on DOD infrastructure and operations
Wildfire	Increased frequency of wildfires	Training encroachment (e.g., restrictions on types of ammunition used, halting or delaying of training activities)
Changes in mean sea level	Increased frequency and severity of coastal flooding	Coastal site damage from erosion and inundation, water supply interruptions, wastewater disposal issues

Source: GAO analysis of the 2010 Quadrennial Defense Review, 2012 DOD Climate Change Adaptation Roadmap (Roadmap), 2014 Roadmap, Fiscal Year 2015 DOD Strategic Sustainability Performance Plan (Sustainability Plan), Fiscal Year 2016 Sustainability Plan, and the December 2016 draft of the DOD Screening Level Vulnerability Assessment Survey Report. | GAO-19-453

^aAccording to the U.S. Navy, red flag days are days on which strenuous exercise must be curtailed in hot weather for all personnel with fewer than 12 weeks of training; black flag days are days on which non-mission essential physical training and strenuous exercise must be suspended for all personnel.

Sources of Climate Information and Projections

According to a 2010 National Research Council report on making informed decisions about climate change¹⁴ and our October 2009 report on climate change adaptation,¹⁵ most decision makers need a basic set of information to understand and make choices about how to adapt to the effects of climate change. This set of information includes information and analysis about observed climate conditions, information about observed climate effects and vulnerabilities, and projections of what climate change might mean for the local area. In November 2015, we found that in order for climate information to be useful, it must be tailored to meet the needs of each decision maker, such as an engineer responsible for building a bridge in a specific location, a county planner responsible for managing development over a larger region, or a federal official managing a national-scale program.¹⁶

Agencies across the federal government collect and manage many types of climate information, including observational records from satellites and weather monitoring stations on temperature and precipitation, among other things; projections from complex climate models; and tools to make this information more meaningful to decision makers. For example, the *Fourth National Climate Assessment*, completed in November 2018 by the U.S. Global Change Research Program, references various sources of climate information, including projected temperature and precipitation

¹⁴National Research Council, America's Climate Choices: Panel on Informing Effective Decisions and Actions Related to Climate Change, *Informing an Effective Response to Climate Change* (Washington, D.C.: 2010).

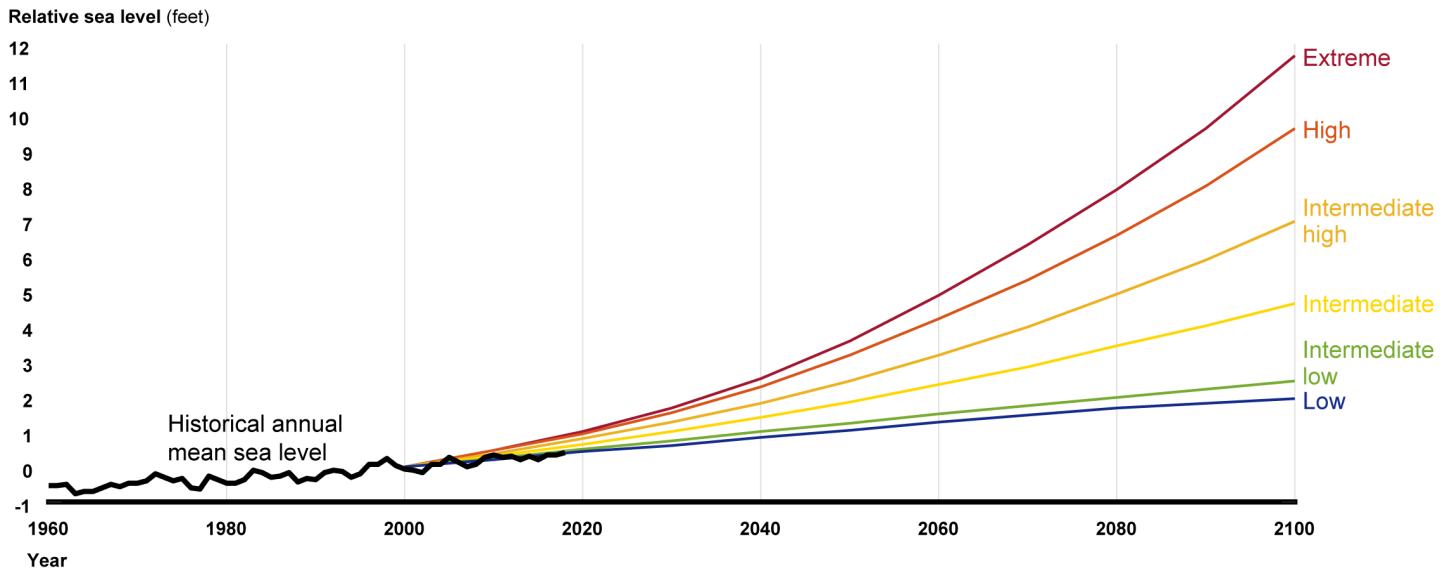
¹⁵GAO, *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*, [GAO-10-113](#) (Washington, D.C.: Oct. 7, 2009).

¹⁶GAO, *Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information*, [GAO-16-37](#) (Washington, D.C.: Nov. 23, 2015).

data. Likewise, in 2016, a multi-agency group led by the Strategic Environmental Research and Development Program (SERDP) developed a report and accompanying database of future sea level projections and extreme water levels, which as of May 2019 contained sea level change projections for 1,813 DOD sites worldwide.¹⁷

Climate projections are typically a range of possible future scenarios for particular time frames. Multiple future scenarios allow for planners and engineers to see a range of possible conditions that could occur at various points in time. For example, a planner or engineer could consider four different future scenarios occurring over the course of 20, 40, or 60 years or over the service life of the project being designed. Figure 1 shows an example of sea level change projections provided by the National Oceanic and Atmospheric Administration (NOAA). Specifically, the chart shows historical mean sea levels and multiple scenarios of projected relative sea level rise in Norfolk, Virginia.

Figure 1: Historical Mean Sea Levels and Projected Relative Sea Level Rise for Norfolk, Virginia

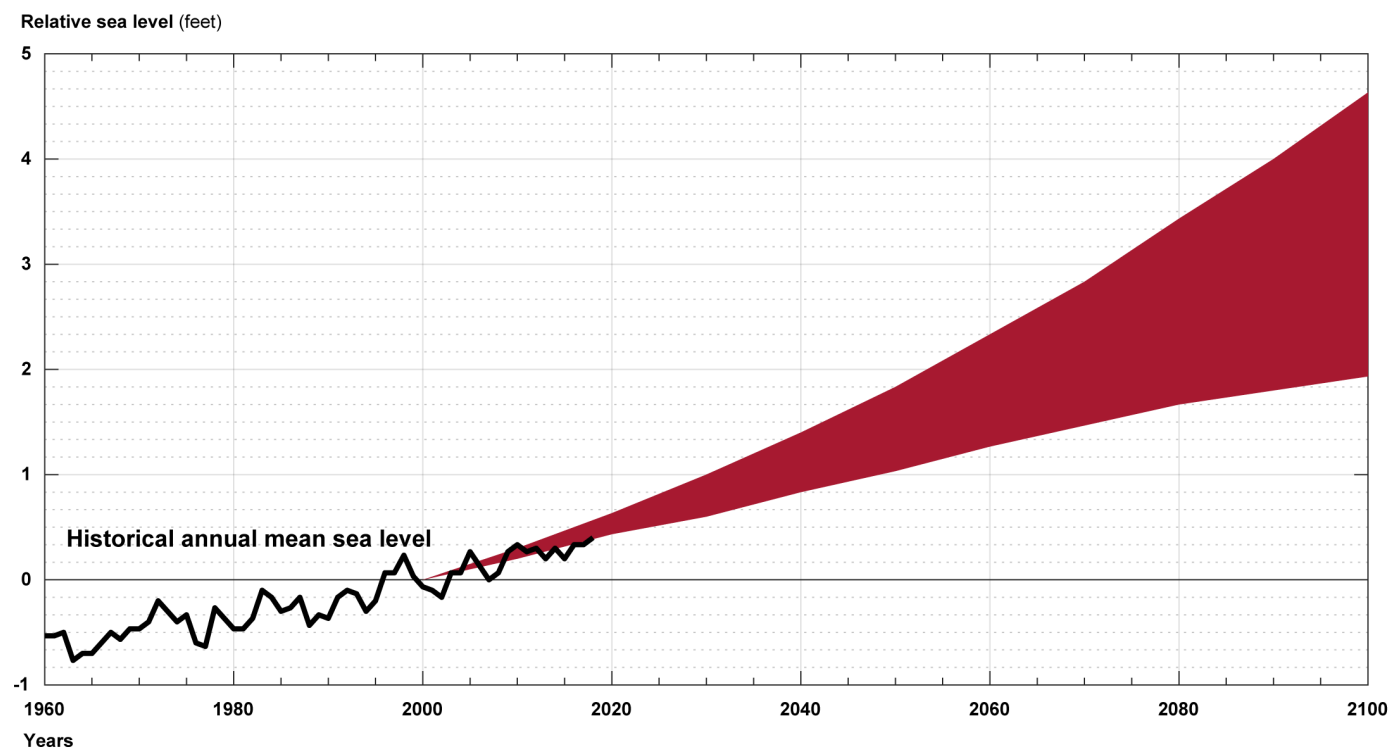


Source: National Oceanic and Atmospheric Administration National Ocean Service. | GAO-19-453

¹⁷The group consisted of SERDP, the National Oceanic and Atmospheric Administration, the U.S. Army Corps of Engineers, the Office of the Oceanographer of the Navy, and the South Florida Water Management District. Its report is *Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide* (April 2016).

The chart shows the historical annual mean sea level from 1960 to 2018 through the bold black line. The projections use 2000 as a starting point, and so overlap with the historical data. Relative sea level rise takes into account changes in land levels—in the Norfolk area the land is generally subsiding over time. Each scenario is based on different assumptions about future greenhouse gas emissions, according to an official from NOAA’s National Ocean Service. Planners and engineers can use the multiple scenarios to evaluate when potential effects could occur and determine their risk tolerances to inform their planning or design choices. Figure 2 similarly shows the same historical mean sea levels at Norfolk, Virginia, as well as the very likely range of projections of future relative sea levels, according to the National Ocean Service.

Figure 2: Historical Mean Sea Levels and Projected Relative Sea Level Rise for Norfolk, Virginia



Source: National Oceanic and Atmospheric Administration National Ocean Service. | GAO-19-453

This chart shows the range of possibilities considered very likely—those between the low and intermediate scenarios in figure 1—according to an official from NOAA’s National Ocean Service.

Installations' Processes for Master Planning and Project Design

Installation Master Planning Process

Master planning for military installations involves the evaluation of factors affecting the present and future physical development and operation of a military installation. DOD requires all installations to develop master plans. DOD's instruction on real property management states that plans must be based on a strategic assessment of the operational mission and expected use of the installation.¹⁸ The plans must cover at least a 10-year period and be updated every 5 years, or more often if necessary. The plans must include lists, by year, of all construction projects, major repair and sustainment projects, and restoration and modernization projects needed within the time period covered by the plan.

Design Standards for Individual Facilities Projects

Individual DOD facilities projects within installations must be designed in accordance with DOD's facilities design standards, which are defined in the Unified Facilities Criteria. Unified Facilities Criteria are technical manuals and specifications used for planning, design, construction, maintenance, and operations of all DOD facilities projects. The U.S. Army Corps of Engineers, Naval Facilities Engineering Command, and the Air Force Civil Engineer Center are responsible for administering and updating the Unified Facilities Criteria. The Unified Facilities Criteria include a core group of 27 standards that apply to building systems found in most DOD facility construction projects, and include standards such as architecture, roofing, and civil engineering.¹⁹ Engineers and planners apply the criteria that are most appropriate for their individual facilities projects to their project proposals and designs. Table 2 shows excerpts from requirements and guidance to project designers in the Unified Facilities Criteria relevant to the consideration of climate.

¹⁸DOD Instruction 4165.70, *Real Property Management* (Apr. 6, 2005) (incorporating change 1, Aug. 31, 2018).

¹⁹Unified Facilities Criteria, 1-200-01, *DOD Building Code (General Building Requirements)* (June 20, 2016) (change 2, Nov. 1, 2018), lists 28 core Unified Facilities Criteria. However, one of these, Unified Facilities Criteria 4-010-02, *DOD Minimum Antiterrorism Standoff Distances for Buildings* (Feb. 9, 2012) (FOUO) has been canceled by Unified Facilities Criteria 4-010-01, *DOD Minimum Antiterrorism Standards for Buildings* (Dec. 12, 2018), reducing the total from 28 to 27 core Unified Facilities Criteria.

Table 2. Excerpts from Unified Facilities Criteria Requirements and Guidance on Consideration of Climate

Unified Facilities Criteria	Excerpt
1-200-02, <i>High Performance Sustainable Building Requirements</i> (Dec. 1, 2016) (change 3, Sept. 7, 2018)	[In selecting a sustainable site,] consider site-specific, long-term, climate change impacts such as drought, flood, wind, and wildfire risks.
3-400-02, <i>Design: Engineering Weather Data</i> (Sept. 20, 2018)	Knowing the probable wind speed and direction in a particular month can be helpful in construction and mission planning as well as in designing structures that experience severe wind-driven rain or drifting snow.
3-230-01, <i>Water Storage and Distribution</i> (Sept. 1, 2018) (change 1, Oct. 1, 2018)	Pumps, piping, and equipment must be protected from the weather. In cold climates pumps and piping must be protected from freezing temperatures. The pump station building must comply with [UFC] 1-200-01 [DOD Building Code (General Building Requirements)], be constructed of noncombustible materials and meet applicable building standoff distances.
3-110-03, <i>Roofing</i> (May 1, 2012)(change 3, Mar.6, 2019)	In new construction, the roof system selection is an integral part of the overall building design and must take into account interior building usage and climate. For example, the building can be designed to prevent outward moisture drive, support heavy roof systems (such as garden roofs or paver systems), or sloped for the desired durability (life cycle cost benefit) and aesthetic considerations.
3-101-01, <i>Architecture</i> (Nov. 28, 2011) (change 4, Mar.6, 2019)	Building shape, orientation, and design must utilize the site seasonal environmental factors to minimize annual facility energy use and to optimize daylighting. Coordinate building and glazing orientation and architectural shading with seasonal solar angles and prevailing winds to enhance energy performance of the building within the site-specific micro climate.
3-201-02, <i>Landscape Architecture</i> (Feb.23, 2009) (change 1, Nov. 1, 2009)	Streets, paved parking lots, roofs, and other impermeable surfaces allow no infiltration of runoff and provide little resistance to flow. Runoff draining from these surfaces can be highly concentrated and move at a velocity greater than runoff flowing over an unpaved surface. Soils must be protected from this erosive force, particularly at the edges of impermeable surfaces and soils.
3-201-01, <i>Civil Engineering</i> (Apr. 1, 2018)(change 1, Mar.19, 2019)	[Executive Order] 11988 directs all Federal agencies to avoid floodplain development wherever there is a practicable alternative. When development within the floodplain is considered, evaluate alternative site locations to avoid or minimize adverse impacts to the floodplain. When mission needs require siting a building within or partially within the 100-year floodplain, indicate...the base flood elevation...and the minimum design flood elevation....

Source: Unified Facilities Criteria. | GAO-19-453

DOD Infrastructure Costs Associated with Extreme Weather and Climate Change Effects

Extreme weather and climate change effects can damage infrastructure, requiring repairs and resulting in budgetary risks (i.e., costs) to DOD.²⁰ While no individual weather event can be definitively linked to climate change, particular weather events can demonstrate the vulnerability of military facilities. For example, in October 2018, Hurricane Michael devastated Tyndall Air Force Base in Florida, shutting down most base operations until December; causing severe damage to the flight line,

²⁰Budgetary risks include the use of funding to prepare for, or recover from, climate impacts (e.g., the cost of overtime required to set up sandbags in anticipation of flooding or repair roofs destroyed during a severe wind storm).

drone runway, and other base facilities including family housing; and destroying the base's marina. The Air Force estimates that repairs at the base will cost about \$3 billion and take 5 or more years to complete. Camp Lejeune and Marine Corps Air Stations Cherry Point and New River in North Carolina sustained heavy damage to facilities, housing, and training locations from Hurricane Florence in September 2018. The Marine Corps estimates that the recovery from the hurricane damage will cost about \$3.6 billion and take years to complete.

In 2014, we reported that more frequent and more severe extreme weather events and climate change effects may result in increased fiscal exposure for DOD. In the same report, officials provided examples of costs associated with extreme weather and climate change effects at DOD facilities. For example, officials from a Navy shipyard we visited stated that the catastrophic damage that could result from the flooding of a submarine in dry dock could cause substantial repair costs. In 2017, we found that DOD installations overseas face operational and budgetary risks posed by weather events and climate change effects at the military services' installations in each of DOD's geographic combatant commands. We recommended that the Secretaries of the Army, Navy, and Air Force work with the Office of the Secretary of Defense to issue a requirement to their installations to systematically track the costs associated with extreme weather events and climate change effects. DOD did not concur with this recommendation. In its response, DOD stated that tracking impacts and costs associated with extreme weather is important, but that the science of attributing these events to a changing climate is not supported by previous GAO reports. DOD also stated that associating a single event with climate change is difficult and does not warrant the time and money expended in doing so. However, as we stated in our response to DOD's comments, installations generally have the capability to track the costs associated with extreme weather events, which are projected to become more frequent and intense as a result of climate change. There is substantial budgetary risk resulting from weather effects associated with climate change, and these types of repairs are neither budgeted for nor clearly represented in the federal budget process. As of April 2019, the military departments have not implemented this recommendation.

Some Installations
Have Integrated
Extreme Weather and
Climate
Considerations in
Master Plans or
Related Installation
Planning Documents,
but They Have Not
Consistently
Assessed Climate
Risks or Used
Climate Projections in
These Plans

Some Installations Have
Integrated Extreme
Weather and Climate
Considerations into Their
Master Plans or Related
Installation Planning
Documents

Fifteen of the 23 installations we visited or contacted had integrated some considerations of extreme weather or climate change effects into their plans. For example,

- Langley Air Force Base, Virginia, partnered with the City of Hampton, Virginia, to study the effects of sea level rise. A 2018 addendum to the installation's 2010 joint land use study with the City of Hampton outlined climate vulnerabilities and identified recommendations for actions to increase installation resilience. Separately, after sustaining damage from Hurricane Isabel in 2003, the installation required all new development to be constructed to a minimum elevation of 10.5 feet above sea level, higher than the flooding associated with the hurricane and one foot higher than the flooding anticipated from a storm with a 1-in-500 chance of occurring in any given year. As DOD noted in its January 2019 report to Congress on climate-related vulnerabilities, Joint Base Langley-Eustis, of which Langley Air Force Base is a part, has experienced 14 inches in relative sea level rise

since 1930, due in part to land subsidence, and has experienced more frequent and severe flooding as a result.²¹

- The 611th Civil Engineer Squadron, based at Joint Base Elmendorf-Richardson in Alaska, partnered with the University of Alaska, Anchorage, to develop site-specific predictive models of coastal erosion for two radar sites on the North Slope of Alaska.²² The squadron plans to use this information in the future to develop possible alternative facilities projects to address the erosion risks. Squadron officials told us they consulted with the military users of the radars to determine the length of time to plan for their continued use and that they intend to use this information to develop plans to address this coastal erosion. The North Slope radar sites are experiencing greater than anticipated coastal erosion rates, which have begun to threaten the infrastructure supporting the sites.
- Fort Irwin, California, in response to severe flash flooding in 2013 that caused loss of power and significant damage to base infrastructure, worked with the U.S. Army Corps of Engineers to develop a plan to improve stormwater drainage. The 2014 plan recommended a series of infrastructure projects, some of which Fort Irwin has implemented; others remain to be implemented, depending on the availability of funding. Figure 2 depicts flooding damage in 2013 at Fort Irwin and a stormwater diversion channel subsequently built by the installation. The flash flooding on the installation caused damage to roads and other facilities throughout the installation, according to officials. The installation subsequently raised berms and built other structures, such as the diversion channel shown in figure 3, to divert stormwater from installation facilities.

²¹Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report on Effects of a Changing Climate to the Department of Defense* (January 2019).

²²Officials of the 611th Civil Engineer Squadron said the unit is not an installation and therefore not required to produce a master plan. However, this example illustrates actions that can be taken to assess climate-related risks to facilities.

Figure 3: Flood Damage and Stormwater Diversion Channel at Fort Irwin, California



Source: U.S. Army (left) and GAO (right). | GAO-19-453

- Marine Corps Recruit Depot Parris Island, South Carolina, reported that the installation plans to award a contract to study sea level rise at the installation and incorporate the results into the next iteration of its master plan. The installation stated that incorporating the study's results is included in the scope of work for the contract that has been awarded for the master plan update.
- Naval Station Norfolk, Virginia, noted in its 2017 master plan that climate change and sea level rise are expected to exacerbate effects to the installation from tidal flooding and storm surge, increasing risks to installation assets and capabilities. The plan established a goal of identifying measures that could minimize the effect of sea level rise on the installation. With the majority of the installation near mean sea level, Naval Station Norfolk is vulnerable to frequent flooding that is disruptive to operations. Figure 4 depicts flooding at Naval Station Norfolk. Installation officials told us that such floods can interfere with traffic on base, thus reducing the ability of those working on the installation to transit within, to, and from the base.

Figure 4: Flooding at Naval Station Norfolk, Virginia



Source: U.S. Navy. | GAO-19-453

- Naval Base San Diego, California, noted in its most recent master plan that local climate change effects include water and energy shortages, loss of beaches and coastal property, and higher average temperatures, among others. The plan also stated that Naval Base San Diego should be funded to conduct a study to determine installation-specific effects of sea level rise. Navy Region Southwest subsequently partnered with the Port of San Diego to study local effects of sea level rise, which installation officials said will help them understand the effects of sea level rise on the base.
- Camp Lejeune, North Carolina, participated in a study of the effects of sea level rise on the installation and on certain other DOD installations in North Carolina and Florida.²³ An installation official stated that installation officials have used the results of the study to make planning decisions, in particular by feeding the study data into the installation's mapping of potential flood zones. The 10-year study, which concluded in 2017, was funded by SERDP and was based at

²³SERDP, *Defense Coastal/Estuarine Research Program (DCERP)*, SERDP Project RC-2245 (January 2018).

Camp Lejeune to, among other things, understand the effects of climate change at Camp Lejeune. Camp Lejeune officials and one of the scientists involved in the study told us that installation officials have used the study's results to make decisions about where to site buildings so as to take into account the possible future condition of marshes on the base.

However, 8 of the 23 installations we visited or contacted had not integrated considerations of extreme weather or climate change effects into their master plans or related installation planning documents. For example,

- Joint Base Pearl Harbor Hickam, Hawaii, did not consider extreme weather and climate change effects in its most recent master plan, although it is located in an area that has been subject to tropical storms and where, according to projections in the DOD database of sea level change scenarios, further sea level rise is anticipated. Specifically, under the highest scenario in the database, sea level at Naval Station Pearl Harbor, part of the joint base, could rise more than 3 feet by 2065. The lowest elevation point on the base is 0.6 feet below sea level. The installation stated that it plans to incorporate the effects of climate change into the next update to its facilities master plan.
- Pearl Harbor Naval Shipyard, Hawaii, did not consider extreme weather or climate change effects in its most recent master plan, although it is co-located with Joint Base Pearl Harbor Hickam and therefore shares the same weather and climate conditions noted previously.
- Fort Wainwright, Alaska, officials told us they had not considered climate change as part of the installation's master planning. Officials noted that the majority of the base is on thaw-stable permafrost that would be unlikely to be significantly affected by rising temperatures, but some areas of the base are on less stable permafrost. DOD noted in its January 2019 report to Congress that thawing permafrost can decrease the structural stability of buildings and other infrastructure that is built on it.²⁴
- Camp Pendleton, California, officials told us that although they are aware of a variety of climate-related challenges to their installation and have taken or plan to take some steps to address them, an

²⁴Office of the Under Secretary of Defense for Acquisition and Sustainment, *Report on Effects of a Changing Climate to the Department of Defense* (January 2019).

example of which we discuss later in this report, the installation has not yet considered extreme weather and climate change effects in its master plan. The officials stated that they are still planning based on historical conditions rather than considering possible future conditions.

DOD's Unified Facilities Criteria standard specific to master planning states that where changing external conditions affect planning decisions, master planners should seek to understand, monitor, and adapt to these changes, including changes in climatic conditions such as temperature, rainfall patterns, storm frequency and intensity, and water levels.²⁵ DOD's directive on climate change adaptation further states that military departments should integrate climate change considerations into their plans.²⁶ The directive also states that the Assistant Secretary of Defense for Energy, Installations, and Environment should consider climate change adaptation and resilience in the installation planning process, including the effects of climate change on both built and natural infrastructure.²⁷

Our findings based on the 23 installations we reviewed for this report are consistent with our prior reports on extreme weather and climate change effects at military installations. Specifically, installations have not consistently integrated these considerations into their master plans or related installation planning documents. In May 2014, we reported that some domestic installations had integrated considerations of changing climatic conditions into their installation planning documents, but DOD had not provided key information—such as how to use climate change projections—to help ensure that efficient and consistent actions would be taken across installations. We recommended that DOD further clarify the planning actions that should be taken in installation master plans to account for climate change, to include further information about changes in applicable building codes and design standards that account for potential climate change effects and further information about potential projected climate change effects on individual installations. However, as of January 2019, DOD had not fully implemented this recommendation.

²⁵DOD, Unified Facilities Criteria 2-100-01, *Installation Master Planning* (May 15, 2012) (change 1, Nov. 28, 2018).

²⁶DOD Directive 4715.21, *Climate Change Adaptation and Resilience* (Jan. 14, 2016) (change 1, Aug. 31, 2018).

²⁷Officials in the Office of the Secretary of Defense stated that following a reorganization, these responsibilities have been taken over by the Assistant Secretary of Defense for Sustainment.

For example, as we discuss later in this report, DOD's updates to its facilities design standards lacked guidance on the use of climate projections. DOD also had not provided information on a range of potential effects of climate change on individual installations. DOD has taken some positive steps in this area, such as making available to the military services a database of sea level change scenarios for 1,774 DOD sites worldwide. However, DOD has not provided other specific types of climate projections, which we discuss in more depth later in this report.

Moreover, in November 2017 we reported that about a third of the installations in our sample of overseas installations had integrated climate change adaptation into their installation plans, but the lack of key guidance and updated design standards to reflect climate change concerns hampered their ability to consistently incorporate climate change adaptation into their plans. We recommended, among other things, that the military departments integrate climate change data and projections into DOD's facilities criteria and periodically revise those standards based on any new projections, as appropriate. DOD partially concurred, and as of January 2019, an official from the Office of the Assistant Secretary of Defense for Sustainment stated that the office was continuing to work with the military departments to evaluate how to effectively translate the latest climate data into a form usable by installation planners and facilities project designers. Based on our findings for this review, we continue to believe that DOD should take all necessary steps to implement these recommendations.

Installations Have Not Fully Assessed Risks from Extreme Weather and Climate Change Effects in their Master Plans and Related Installation Planning Documents

While 15 of the 23 installations we visited or contacted had integrated some consideration of extreme weather or climate change effects into their planning documents, only two of these installations had taken steps to fully assess the weather and climate risks to the installation or develop plans to address identified risks. DOD has taken some broad actions to assess risk to installations from extreme weather and climate change effects. For example, in January 2018, DOD issued a report to Congress on the results of its survey of installations on the extent to which they faced a variety of extreme weather or climate effects. However, the survey responses constituted a preliminary assessment and were based on installations' reporting of negative effects they had already experienced from extreme weather effects, rather than assessments of all future vulnerabilities based on climate projections. DOD noted that the information in the survey responses is highly qualitative and is best used as an initial indicator of where a more in-depth assessment may be warranted.²⁸

However, except for two of the installations in our sample, the installations' master plans and related installation planning documents did not (1) identify a range of possible extreme weather events and climate change effects that could affect the installation, (2) assess the likelihood of each event occurring and the possible effect on the installation, and (3) identify potential responses to these events. For example, Naval Air Station Key West, Florida, included discussion of the effects of sea level rise and storm surge on the installation in its master plan, as well as steps it could take to mitigate these effects. However, although the installation experienced drought conditions rated severe in 2011 and extreme in 2015, its master plan does not discuss effects on the installation of drought, which, according to a DOD report to Congress, can pose significant risks to an installation, including implications for base infrastructure.²⁹ All of the Air Force installations in our sample rated their degree of vulnerability to a range of climatic conditions—such as flood, temperature rise, and precipitation pattern changes—in their master plans, thereby identifying a range of possible climate events and the

²⁸Office of the Under Secretary of Defense for Acquisition, Technology and Logistics, *Department of Defense Climate-Related Risk to DOD Infrastructure Initial Vulnerability Assessment Survey (SLVAS) Report* (January 2018).

²⁹At the time of this review, we were also separately reviewing how DOD installations were coping with water scarcity and drought. We expect to publish the final report for that review in late 2019.

likelihood of each event. However, of those installations that identified a range of possible extreme weather and climate change effects that could affect the installation, most did not consistently identify potential responses to these events. The two exceptions—Eglin Air Force Base, Florida, and Joint Base Langley-Eustis, Virginia—took the additional step of identifying possible actions to address these climate events. For example, Eglin Air Force Base rated itself as having a high vulnerability to storm surge, but a low vulnerability from rising temperatures, and identified steps the installation could take in facilities planning and design to mitigate the identified risks.

The DOD directive on climate adaptation states that military departments should assess and manage risks to both built and natural infrastructure, including changes as appropriate to installation master planning, and should assess, incorporate, and manage the risks and effects of altered operating environments on capabilities and capacity, including basing.³⁰ Moreover, *Standards for Internal Control in the Federal Government* states that management should identify, analyze, and respond to risks related to achieving defined objectives. Risk assessment is the identification and analysis of risks related to achieving defined objectives in order to form a basis for designing responses to these risks.³¹ Our prior work has shown that assessing risks includes assessing both the likelihood of an event occurring and the effect the event would have. Agency leaders and subject matter experts should assess each risk by assigning the likelihood of the event's occurrence and the potential effect if the event occurs.³²

Despite a DOD directive requiring that the military departments assess and manage risks to both built and natural infrastructure, DOD has not required in the Unified Facilities Criteria standard that guides master planning that installations assess risks posed by extreme weather and climate change effects as part of their master plans or develop plans to address identified risks. Officials in the Office of the Assistant Secretary of Defense for Sustainment acknowledged that the Unified Facilities Criteria

³⁰DOD Directive 4715.21, *Climate Change Adaptation and Resilience* (Jan. 14, 2016) (change 1, Aug. 31, 2018).

³¹GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: September 2014).

³²GAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, [GAO-17-63](#) (Washington, D.C.: Dec. 1, 2016).

standard on master planning does not explicitly require a risk assessment specifically for extreme weather or climate change as part of the master planning process. Because installations have not consistently assessed the risks from extreme weather and climate change effects as part of their master plans or identified potential responses to identified risks, they may formulate plans and make planning decisions without consideration of those risks. By assessing and developing actions to address these risks in their master plans, installations could better anticipate exposure of the facilities to greater than anticipated damage or degradation as a result of extreme weather events or climate change effects.

Installations Have Not Consistently Used Climate Projections in Developing Master Plans

Eight of the 23 installations we visited or contacted, as well as the Air Force unit responsible for the North Slope radar facilities, had made some use of climate projections to incorporate consideration of extreme weather and climate change effects into their master plans or related installation planning documents. For example, as noted previously, the 611th Civil Engineer Squadron was developing its own site-specific projections of coastal erosion affecting the North Slope radar sites in Alaska, and Norfolk Naval Shipyard considered local sea level rise projections in a study on mitigating flooding at its docks.³³ However, officials from 11 of the 23 installations in our sample—including some from installations that had made some use of climate projections—cited the need for additional guidance from DOD or their military department headquarters on which projections to use in planning or on how to use them.

This is consistent with our prior findings on DOD's installation-level efforts to increase climate resilience. Our May 2014 report noted that installation officials told us they did not have the installation-level climate data from their military departments or from other DOD sources that they would need to understand the potential effects of climate change on their installations.³⁴ We recommended, among other things, that DOD provide further direction on planning actions to account for climate change, including information about changes in applicable building codes and design standards and the projected effects of climate change on

³³As noted previously, officials of the 611th Civil Engineer Squadron said the unit is not an installation and therefore is not required to develop a master plan. However, this example illustrates actions that can be taken to incorporate climate projections into facilities planning.

³⁴[GAO-14-446](#).

individual installations. DOD concurred but as of January 2019 had not fully implemented this recommendation, as noted previously. In December 2018, an official in the Office of the Assistant Secretary of Defense for Sustainment stated that DOD plans to develop a policy on the use of sea level rise projections by some time in 2019 and eventually to incorporate these projections into the Unified Facilities Criteria. However, DOD has no current time table for incorporating guidance on the use of other types of climate projections into its Unified Facilities Criteria. The official stated that the department is working toward eventually incorporating the use of other types of climate projections into guidance but that these types of projections would have to be vetted by DOD subject matter experts and approved prior to adoption. DOD intends to move in this direction, according to the official, but DOD has not yet developed a defined process for evaluating and incorporating the use of additional climate projections into guidance.

Our prior work has found that using the best available climate information, including forward-looking projections, can help an organization to manage climate-related risks.³⁵ Until November 2018, DOD's Unified Facilities Criteria on master planning stated that changes in climate conditions are to be determined from reliable and authorized sources of existing data but that to anticipate conditions during the design life of existing or planned new facilities and infrastructure, installations could also consider climate projections from reliable and authorized sources, such as, among others, the U.S. Global Change Research Office and the National Climate Assessment. In November 2018, in response to a statutory requirement in the John S. McCain National Defense Authorization Act for Fiscal Year 2019, DOD updated the Unified Facilities Criteria on master planning to specify that climate projections from reliable and authorized sources, such the U.S. Global Change Research Office and the National Climate Assessment, shall be considered and incorporated into military construction designs and modifications.³⁶ DOD guidance states that the Assistant Secretary of Defense for Energy, Installations, and Environment provides guidance and direction on relevant technologies, engineering standards, tools, development and use of scenarios, and other

³⁵[GAO-16-37](#).

³⁶Pub. L. No. 115-232, § 2805 (2018); Unified Facilities Criteria 2-100-01, *Installation Master Planning* (May 15, 2012) (change 1, Nov. 28, 2018).

approaches to enable prudent climate change adaptation and resilience.³⁷ The guidance also states that military departments are to leverage authoritative environmental prediction sources for appropriate data and analysis products to assess the effects of weather and climate.³⁸

Installations have not consistently used climate projections in their master plans because DOD has not provided detailed guidance on how to do so. Simply updating the language of the Unified Facilities Criteria on master planning in November 2018 to require the use of climate projections does not provide guidance to installations on how to use climate projections, such as what future time periods to consider and how to incorporate projections involving multiple future scenarios, nor does it identify the specific types of projections to use. The absence of guidance has hindered the ability of some installations to effectively apply the best available climate projections to their installation master planning. If they do not use climate projections in their master plans, installations risk failing to plan for changing climate and weather conditions and, as a result, could expose their facilities to greater risk of damage or degradation from extreme weather events and climate change effects. Incorporating such data into planning would help installation master planners better anticipate changing climate and weather conditions and increase the effectiveness of the installation's long-term investments in its facilities.

³⁷Officials in the Office of the Secretary of Defense stated that following a reorganization, these responsibilities have been taken over by the Assistant Secretary of Defense for Sustainment.

³⁸DOD Directive 4715.21.

Installations Have Designed Some Individual Facilities Projects to Increase Resilience to Extreme Weather, but They Lack Guidance on Using Climate Projections

Some Installations Have Designed Individual Facilities Projects with Elements of Resilience to Extreme Weather or Climate Change Effects

Eleven of the 23 installations we visited or contacted had designed or constructed one or more individual facilities projects to increase the resilience of the facilities themselves, or to increase the resilience of the installation more broadly, to extreme weather and climate change effects. For example,

- *Joint Base Langley-Eustis, Virginia.* In 2018, officials designed a project to build a maintenance hangar with a special foundation that would elevate the floor to 10 feet above the average high-water level at the project site and protect it against coastal storm flooding. Joint Base Langley-Eustis has experienced severe flooding in the past because of its low-lying geographical elevations in the Chesapeake Bay. The installation stated in its draft encroachment management action plan that the effects of climate change may exacerbate flooding issues through sea level rise or the increasing frequency and severity of storms.
- *Norfolk Naval Shipyard, Virginia.* In 2018, shipyard officials designed a project to increase the installation's resilience to storm-induced flooding, including building a floodwall to protect the dry docks that are used to perform maintenance on ships and submarines. Norfolk Naval Shipyard experiences extreme high tides three to five times a year on average and a significant hurricane on average once a year, according to an installation presentation, and flooding has been increasing over time in the area as relative sea levels have risen. The floodwall will enclose the dry docks, providing protection to critical assets and electrical utilities while they are in dry dock, among other

things. Figure 5 depicts a flooded dry dock at Norfolk Naval Shipyard, Virginia. Installation officials told us that flooding into dry docks poses risks to the ships being serviced there and to the performance of the base's mission of servicing and maintaining Navy ships and submarines.

Figure 5: Flooding at Norfolk Naval Shipyard, Virginia



Source: U.S. Navy. | GAO-19-453

- *Camp Pendleton, California.* In 2018, as part of a project to construct a new aircraft landing zone, officials included protection of the nearby coastline, which had been rapidly eroding from the impact of ocean waves and rain storms. According to officials, the erosion has accelerated in recent years and has threatened not only landing zones along the coast, but also beaches that are used for amphibious assault training. Figure 6 depicts coastal erosion near a landing zone at Camp Pendleton, California. According to officials, the erosion leading to the gully shown in the photograph has accelerated in recent years and advances further inland every year; it is now within feet of the landing zone. The officials told us that the erosion can threaten the function of the landing zone if it reaches that site.

Figure 6: Coastal Erosion at Camp Pendleton, California



Source: GAO. | GAO-19-453

- *Fort Shafter, Hawaii.* In 2016, officials constructed flood mitigation structures, including a flood control levee, to protect maintenance facilities being built in a flood zone. At the time, there were no adequate permanent maintenance facilities for units stationed at the base, and the only available land big enough to support the proposed maintenance facilities was located within a flood zone.

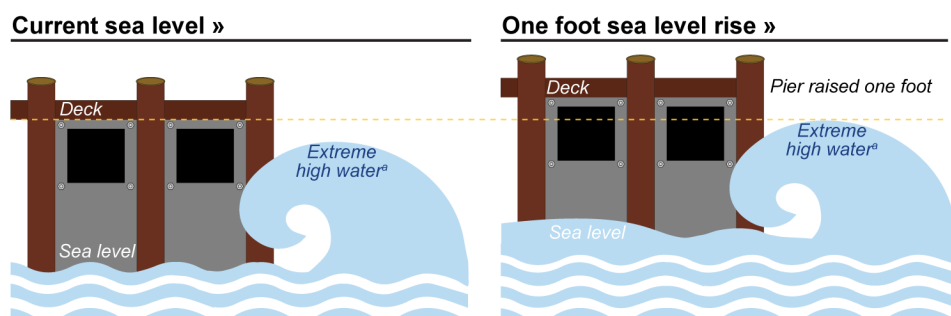
Most Installations Have Not Used Climate Projections in Designing Individual Facilities Projects

Despite limited efforts to increase the resilience of facilities to extreme weather and climate change effects, officials from 17 of the military installations in our sample said that their individual facilities project designs generally did not consider climate projections. Of the installations that stated that they considered climate projections in facilities project designs, one military installation said it uses a study on sea level rise at the installation as a tool that incorporates forward-looking projections, and another installation said it uses a NOAA web-based tool, Sea Level Rise Viewer, for graphical representations of projected sea level rise. One installation noted that it had considered sea level rise projections in a pier design, which we discuss further below. A fourth installation said it plans to use a draft Navy study on the vulnerability of coastal Navy installations to sea level rise to inform an upcoming facilities project design. However,

another installation said it has used energy consumption projections, which are not climate projections, and another installation cited a Navy climate adaptation handbook, which does not include climate projections for individual Navy installations.

Moreover, over the course of our review of 23 installations, we were able to identify only one project as having a design informed by climate projections. Specifically, in 2018, officials from Naval Base San Diego, California, designed a project to demolish and replace an existing pier. The project’s design was informed by the expectation of sea level rise over the 75-year lifespan of the pier. An installation official told us that the consideration of rising sea levels was not part of the original project proposal, but when a contractor provided the sea level rise projections, installation officials decided to raise the pier by one foot. Figure 7 depicts a notional example of a pier—not specific to San Diego or any other particular location—raised to account for sea level rise. The Unified Facilities Criteria on piers and wharves states that the bottom elevation of the deck slab should be kept at least one foot above the extreme high water level. In this notional example, the pier is raised to account for an anticipated one-foot sea level rise, so that the bottom of the deck slab remains one foot above the extreme high water level, as shown in the figure.

Figure 7: Notional Example of Pier Raised to Account for Sea Level Rise



Source: GAO. | GAO-19-453

^aExtreme high water is the highest elevation reached by the sea as recorded by a tide gauge during a given period, according to the National Oceanic and Atmospheric Administration’s Shoreline website.

DOD guidance requires the military departments to assess and manage risks to both built and natural infrastructure, including making changes, as appropriate, to design and construction standards. The guidance also requires the military departments to leverage authoritative environmental

prediction sources for appropriate data and analysis products to assess weather and climate effects.³⁹

However, DOD's Unified Facilities Criteria pertaining to project design, with the exception of the standard on high performance and sustainable building requirements, do not require consideration of climate projections as part of facilities project designs. The Unified Facilities Criteria standard on high performance and sustainable building requirements requires engineers to provide building design solutions that are responsive to any government-provided projections of climate change and determination of acceptable risk.⁴⁰ We analyzed 27 core Unified Facilities Criteria, as well as 3 other Unified Facilities Criteria, *Installation Master Planning, Design: Engineering Weather Data, DOD Building Code (General Building Requirements)*, and one facility criteria standard on *Navy and Marine Corps Design Procedures*. Our analysis showed that as of March 2019 these criteria, other than the Unified Facilities Criteria standard on installation master planning, do not identify authoritative sources of climate projections for use in facilities project designs. The Unified Facilities Criteria standard on installation master planning states that climate projections from the U.S. Global Change Research Program and the National Climate Assessment as well as the National Academy of Sciences shall be considered and incorporated into military construction designs and modifications. However, an official in the Office of the Assistant Secretary of Defense for Sustainment acknowledged that this requirement in the standard on installation master planning is not sufficient on its own to apply to all facility project designs. Additionally, the standard on installation master planning does not identify the specific types of climate projections to use or how to locate them. Our analysis showed that the Unified Facilities Criteria do not provide guidance on how to incorporate projections into facilities project designs, such as how to use projections involving multiple future scenarios and what future time periods to consider.

We found that while some Unified Facilities Criteria direct project designers to climate data, these are historical climate data rather than projections. For example, the following standards do not direct project designers to sources of climate projections:

³⁹DOD Directive 4715.21.

⁴⁰Unified Facilities Criteria 1-200-02, *High Performance and Sustainable Building Requirements* (Dec. 1, 2016) (change 3, Sept. 7, 2018).

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- Unified Facilities Criteria 3-210-10, *Low Impact Development* (June 1, 2015) (change 1, Feb. 1, 2016). This guidance directs project designers to use long-term rainfall records, such as those from regional weather stations, and directs engineers toward a table that provides rainfall data for selected locations. However, information included in the guidance is historical and does not include or refer to projections.
 - Unified Facilities Criteria 3-400-02, *Design: Engineering Weather Data* (Sept. 20, 2018). This guidance directs project designers toward instructions for accessing climate data for use in designing facilities and in mission planning. However, the guidance does not discuss the use of or specifically reference climate projections.
 - Unified Facilities Criteria 3-201-01, *Civil Engineering* (Apr. 1, 2018) (change 1, Mar. 19, 2019). This guidance requires project designers to plan for flood hazard areas and, if the project is constructed within the 100-year floodplain, requires that the project design document include flood mitigation measures as part of the project's scope of work.⁴¹ However, the guidance does not include or reference projections that would help engineers design for various potential flooding scenarios.

As previously noted, in response to a statutory requirement, DOD updated its Unified Facilities Criteria on master planning in November 2018 to require installations to consider and incorporate reliable and authorized sources of data on changing environmental conditions. However, simply including this language does not provide guidance to installations on what sources of climate projections to consider and how to use them in designing facilities projects, such as what future time periods to consider and how to incorporate projections involving multiple future scenarios. In addition, the Unified Facilities Criteria standard on master planning provides requirements and guidance for installation master planning but not for the design of individual facilities projects. An official of the Office of the Assistant Secretary of Defense for Sustainment stated that his office plans to develop a policy on the use of sea level rise projections by some time in 2019 and eventually to incorporate guidance on how to use sea level rise projections into the Unified Facilities Criteria or other guidance. This official added that there is currently no defined DOD process for vetting authoritative sources of climate projections, but

⁴¹The 100-year floodplain is a land area covered by a flood that has a 1 percent chance of occurring in any given year, also known as the base flood.

that DOD plans to continue vetting sources for possible use, as appropriate.

Furthermore, officials of 10 of the 23 military installations we reviewed stated that in order to incorporate such projections into project designs, they would need additional guidance from DOD or their military departments identifying authoritative sources of such projections or how to use climate projections that involve multiple future scenarios and different time periods. Ultimately, installations that do not consider climate projections in the design of their facilities projects may be investing in facilities projects without considering potential risks, such as potential future damage and degradation, which are associated with additional costs and reductions in capability. If DOD does not provide guidance on the use of climate projections in facilities designs, including what sources of climate projections to use, how to use projections involving multiple future scenarios, and what future time periods to consider, installation project designers will continue to lack direction on how to use climate projections. Further, if DOD does not update the Unified Facilities Criteria to require installations to consider climate projections in project designs and incorporate the department's guidance on how to use climate projections in project designs, installation project designers may continue to exclude consideration of climate projections from facilities project designs. Considering climate projections in facilities projects would help DOD to reduce the climate-related risks to its facilities investments.

Conclusions

DOD has a global real estate portfolio that supports the department's global workforce and its readiness to execute its national security missions. The department has repeatedly acknowledged the threats of extreme weather and climate change effects to its installations, and as we have previously reported, has begun taking steps to increase the resilience of its infrastructure to these threats. We found that 15 of the 23 the installations we visited or contacted had considered some type of extreme weather or climate change effects in their plans, a positive step toward increasing resilience to these climate risks. However, not all had done so and most of the installations we visited or contacted did not fully assess the risks associated with extreme weather and climate change effects—including the likelihood of the threat, potential effects on the installation, and possible responses to mitigate such effects. Likewise, many of the installations did not consider climate projections in planning. Without fully assessing the risks of extreme weather and climate change effects, and without considering climate projections as part of the planning process, installations may make planning decisions that do not

fully anticipate future climate conditions. By seeking to anticipate future climate conditions, DOD may be able to reduce climate-related risks to its facilities and the corresponding budgetary risks.

Eleven of the 23 installations we visited or contacted had designed or implemented one or more construction projects that incorporated resilience to extreme weather or climate change effects. These projects illustrate some of the steps that can be taken to increase an installation's resilience to climate risks. However, most of the installations had not considered climate projections in project design. Considering climate projections in facilities projects would help DOD to reduce the climate-related risks to its facilities investments. By updating its facilities project design standards to require installations to consider climate projections in project designs, identifying authoritative sources of climate projections, and providing guidance on how to use climate projections, DOD can aid installations to better position themselves to be resilient to the risks of extreme weather and climate change effects.

Recommendations for Executive Action

We are making eight recommendations, including two to DOD and two to each of the military departments. Specifically,

The Secretary of the Army should ensure that the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers works with the Assistant Secretary of Defense for Sustainment; the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command; and the Director of the Air Force Civil Engineer Center to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installation and (2) plans to address those risks as appropriate. (Recommendation 1)

The Secretary of the Navy should ensure that the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command works with the Assistant Secretary of Defense for Sustainment, the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers, and the Director of the Air Force Civil Engineer Center to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installation and (2) plans to address those risks as appropriate. (Recommendation 2)

The Secretary of the Air Force should ensure that the Director of the Air Force Civil Engineer Center works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installation and (2) plans to address those risks as appropriate. (Recommendation 3)

The Secretary of Defense should issue guidance on incorporating climate projections into installation master planning, including—at a minimum—what sources of climate projections to use, how to use projections involving multiple future scenarios, and what future time periods to consider. (Recommendation 4)

The Secretary of Defense should issue guidance on incorporating climate projections into facilities project designs, including—at a minimum—what sources of climate projections to use, how to use projections involving multiple future scenarios, and what future time periods to consider. (Recommendation 5)

The Secretary of the Army should ensure that the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers works with the Assistant Secretary of Defense for Sustainment; the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command; and the Director of the Air Force Civil Engineer Center to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects and incorporate, as appropriate, DOD guidance on the use of climate projections in facilities project designs—including identification of authoritative sources of such projections, use of projections involving multiple future scenarios, and what future time periods to consider. (Recommendation 6)

The Secretary of the Navy should ensure that the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command works with the Assistant Secretary of Defense for Sustainment, the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers, and the Director of the Air Force Civil Engineer Center to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects and incorporate, as appropriate, DOD guidance on the use of climate projections in facilities project designs—

including identification of authoritative sources of such projections, use of projections involving multiple future scenarios, and what future time periods to consider. (Recommendation 7)

The Secretary of the Air Force should ensure that the Director of the Air Force Civil Engineer Center works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects and incorporate, as appropriate, DOD guidance on the use of climate projections in facilities project designs—including identification of authoritative sources of such projections, use of projections involving multiple future scenarios, and what future time periods to consider. (Recommendation 8)

Agency Comments and Our Evaluation

We provided a draft of this report for review and comment to DOD and NOAA. In written comments, DOD concurred with all eight of our recommendations and identified actions it plans to take to address two of them. DOD's comments are reprinted in their entirety in appendix II. DOD also provided technical comments, which we incorporated as appropriate. NOAA did not provide any comments on the draft.

We are sending copies of this report to the appropriate congressional addressees; the Secretary of Defense; the Secretaries of the Departments of the Army, Navy, and Air Force; and the Secretary of Commerce (for NOAA). In addition, this report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff have any questions about this report, please contact Diana Maurer at (202) 512-9627 or at maurerd@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.

A handwritten signature in black ink that reads "Diana Maurer". The signature is written in a cursive style with a large, prominent "D" and "M".

Diana Maurer,
Director
Defense Capabilities and Management

List of Addressees

The Honorable John Boozman
Chairman
The Honorable Brian Schatz
Ranking Member
Subcommittee on Military Construction, Veterans Affairs, and Related
Agencies
Committee on Appropriations
United States Senate

The Honorable Debbie Wasserman Schultz
Chairwoman
The Honorable John Carter
Ranking Member
Subcommittee on Military Construction, Veterans Affairs, and Related
Agencies
Committee on Appropriations
House of Representatives

The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

Appendix I: Scope and Methodology

Senate Report 115-130, accompanying a bill for fiscal year 2018 appropriations for military construction, the Department of Veterans Affairs, and related agencies, cited concerns with the frequency and costs of extreme weather events and the potential effects of climate change, and included a provision for us to review the Department of Defense's (DOD) progress in developing a means to account for potentially damaging weather in its project designs.¹ In response to this provision, we examined the extent to which DOD has taken steps to incorporate resilience to extreme weather and climate change effects into (1) installation master plans and related planning documents, and (2) individual installation facilities projects.

For both of our objectives, we visited or requested information from a sample of domestic military installations. We focused on domestic installations because our November 2017 report focused on foreign installations.² To develop this sample, we selected installations in the continental United States, Alaska, Hawaii, and U.S. territories that had identified one or more climate-related vulnerabilities, based on their past experiences, in a DOD-administered survey of climate vulnerabilities, or installations that were referenced in a prior GAO report on weather and climate risks at DOD installations. In addition to these criteria, we selected sites that represented both a diversity in types of climate vulnerabilities and geographic diversity among the military services, as well as installations involved in any climate change-related pilot studies.³ From these criteria, we developed a non-generalizable sample of 23 installations. We also included in the sample one Air Force unit (not an installation) with responsibilities for particular facilities of interest in Alaska, because these facilities presented a climatic vulnerability (accelerating coastal erosion) that was not necessarily included elsewhere in the sample.

We visited 10 of these installations, as well as the Air Force unit in Alaska, in person. Within the sample, we selected installations to visit

¹S. Rep. No. 115-130, at 12-13 (2017).

²GAO, *Climate Change Adaptation: DOD Needs to Better Incorporate Adaptation into Planning and Collaboration at Overseas Installations*, [GAO-18-206](#) (Washington, D.C.: Nov. 13, 2017).

³We considered climate vulnerabilities as identified by DOD in its survey of climate vulnerabilities. These included flooding due to storm surge, flooding due to non-storm surge, extreme temperatures, wind, drought, wildfire, and changes in mean sea level.

based on geographic diversity and installations in proximity to each other, allowing us to visit multiple installations on each trip. For the remaining 13 installations, we developed and administered a questionnaire and document request. We received responses from 12 of these installations. One installation—Camp Lejeune—sustained significant damage from Hurricane Florence in September 2018, and to minimize the burden on installation officials' time to respond, we met with them by phone. Results from our nongeneralizable sample cannot be used to make inferences about all DOD locations. However, the information from these installations provides valuable insights. We asked similar questions to installations on our site visits and in the questionnaires, and we collected similar documents—such as installation master plans and individual facilities project documents—allowing us to report on similar information, such as the extent to which extreme weather and climate change considerations were integrated into installation master plans and individual facilities projects.

For objective one, we reviewed DOD policies, guidance, and standards related to increasing climate resilience and conducting installation master planning. These documents included, among others, DOD Directive 4715.21, which establishes policy and assigns responsibilities for DOD to assess and manage risks associated with climate change; DOD's Unified Facilities Criteria standard on installation master planning, which establishes the requirements for installation master plans; and a memorandum from the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics on floodplain management on DOD installations.⁴ We interviewed officials in the Office of the Assistant Secretary of Defense for Sustainment and the Strategic Environmental Research and Development Program. We also interviewed officials in each of the military departments, including officials involved with installation policy, as well as officials from the engineering organizations of each military department and officials in the National Oceanic and Atmospheric Administration to discuss climate science and the data potentially available for planners to use. We reviewed documents from each of the 23 installations and the one Air Force unit in our sample, including master plans, and used interviews with installation officials and

⁴DOD Directive 4715.21, *Climate Change Adaptation Resilience* (Jan. 14, 2016) (change 1, Aug. 31, 2018); DOD, Unified Facilities Criteria 2-100-01, *Installation Master Planning* (May 15, 2012) (change 1, Nov. 28, 2018); Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, *Floodplain Management on Department of Defense Installations* (Feb. 11, 2014).

questionnaires received from installations to determine the extent to which the installations had incorporated consideration of extreme weather and climate change effects into their installation plans. We compared DOD's actions to take steps in installation planning to increase resilience to extreme weather and climate change effects with DOD guidance on climate change adaptation and resilience, Unified Facilities Criteria standards, federal internal control standards, and best practices for enterprise risk management.⁵

For objective two, we reviewed DOD guidance, including DOD Directive 4715.21, requiring DOD components to integrate climate change considerations into DOD plans. We also reviewed DOD's facilities project design standards—the Unified Facilities Criteria—to determine the extent to which installations incorporated requirements for climate resilience and to identify any required or recommended climate data sources for facilities project design. Specifically, we reviewed the 27 core Unified Facilities Criteria standards, as well as 3 other Unified Facilities Criteria standards outside of the core 27—because of their broad relevance to project design—and one facility criteria on Navy and Marine Corps design procedures. Additionally, we performed a content analysis of these criteria for references to climate, weather, environment, and any climate data to be used as a basis for facilities design. We also identified any required or recommended climate data sources or tools for facilities design by searching for references, web links, or tables related to climate data within the criteria. Where climate data sources were identified, we reviewed them to determine the extent to which the sources and tools involved historical data or climate projections that anticipate future climate conditions. We interviewed officials from the U.S. Army Corps of Engineers, Naval Facilities Engineering Command, and the Air Force Civil Engineer Center to understand the extent to which the Unified Facilities Criteria include guidance or data sources for adapting DOD facilities to extreme weather and climate change effects.

In addition, we used interviews with installation officials and questionnaires we received from installations to determine the extent to which the installations had planned or executed any military construction or sustainment, restoration, and modernization facilities projects since

⁵DOD Directive 4715.21; Unified Facilities Criteria 2-100-01; GAO, *Standards for Internal Control in the Federal Government*, [GAO-14-704G](#) (Washington, D.C.: September 2014); GAO, *Enterprise Risk Management: Selected Agencies' Experiences Illustrate Good Practices in Managing Risk*, [GAO-17-63](#) (Washington, D.C.: Dec. 1, 2016).

2013 that included any elements for building resilience to extreme weather or climate change effects. We then reviewed project documentation for proposed or approved facilities projects to identify the resilience measures taken. We also observed some facilities-related climate resilience measures adopted by these installations. In addition, we interviewed officials from the Office of the Assistant Secretary of Defense for Sustainment to determine what plans, if any, the office had to update Unified Facilities Criteria with climate resilience requirements. We also interviewed officials from the Office of the Assistant Secretary of the Army for Installations, Energy and Environment; the Office of the Assistant Secretary of the Navy for Energy, Installations and Environment; and the Office of the Assistant Secretary of the Air Force, Installations, Environment and Energy to identify any actions, policies, or processes related to adapting facilities to extreme weather and climate change effects. Moreover, we interviewed officials from the American Society of Civil Engineers to understand what efforts, if any, had been made to incorporate climate projections into industry standards. Finally, we compared the extent to which DOD took steps in its facilities projects and its project design standards to increase resilience with DOD guidance on climate change resilience.

Table 3 lists the locations we visited or contacted during this review, including the installations receiving our questionnaire.

Table 3: Department of Defense Installations and one Air Force Unit We Visited or Contacted during this Review

Military Department	Location
Department of the Army	Fort Wainwright, Alaska
	Fort Irwin, California
	Fort Shafter, Hawaii
	Corpus Christi Army Depot, Texas
Department of the Navy	Camp Pendleton, California
	Naval Base San Diego, California
	Naval Air Station Key West, Florida
	Naval Base Guam, Guam
	Joint Base Pearl Harbor-Hickam, Hawaii
	Marine Corps Base Hawaii, Hawaii
	Pearl Harbor Naval Shipyard, Hawaii
	Camp Lejeune, North Carolina
Parris Island, South Carolina	
Naval Air Station Corpus Christi, Texas	

Appendix I: Scope and Methodology

Military Department	Location
	Naval Air Station Oceana, Virginia
	Naval Station Norfolk, Virginia
	Norfolk Naval Shipyard, Virginia
	Naval Base Kitsap, Washington
Department of the Air Force	611th Civil Engineer Squadron, Alaska
	Joint Base Elmendorf-Richardson, Alaska
	Luke Air Force Base, Arizona
	Edwards Air Force Base, California
	Eglin Air Force Base, Florida
	Joint Base Langley-Eustis, Virginia

Source: GAO. | GAO-19-453

Appendix II: Comments from the Department of Defense



SUSTAINMENT

ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

MAY 28 2019

Ms. Diana Maurer
Director, Defense Capabilities and Management
U.S. Government Accountability Office
441 G Street, N.W.
Washington, DC 20548

Dear Ms. Maurer:

This is the Department of Defense (DoD) response to the Government Accountability Office (GAO) Draft Report, GAO-19-453, "CLIMATE RESILIENCE: DoD Needs to Assess Risk and Provide Guidance on Use of Climate Projections in Installation Master Plans and Facilities Designs," dated April 18, 2019 (GAO Code 102741). Detailed comments on the report recommendations are enclosed.

Sincerely,

A handwritten signature in black ink, appearing to read "R. McMahon", is written over a horizontal line.

Robert McMahon

Enclosure:
As stated

**GAO Draft Report Dated April 18, 2019
GAO-19-453 (GAO CODE 102741)**

**“CLIMATE RESILIENCE: DOD NEEDS TO ASSESS RISK AND PROVIDE
GUIDANCE ON USE OF CLIMATE PROJECTIONS IN INSTALLATION MASTER
PLANS AND FACILITIES DESIGNS”**

**DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATIONS**

RECOMMENDATION 1: The Secretary of the Army should ensure that the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers works with the Assistant Secretary of Defense for Sustainment; the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command; and the Director of the Air Force Civil Engineer Center to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installation, and (2) plans to address those risks as appropriate.

DoD RESPONSE: Concur.

RECOMMENDATION 2: The Secretary of the Navy should ensure that the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and the Director of the Air Force Civil Engineer Center to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installations, and (2) plans to address those risks as appropriate.

DoD RESPONSE: Concur.

RECOMMENDATION 3: The Secretary of the Air Force should ensure that the Director of the Air Force Civil Engineer Center works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and Chief of Civil Engineers and Commander, Naval Facilities Engineering Command to update the Unified Facilities Criteria standard on installation master planning to require that master plans include (1) an assessment of the risks from extreme weather and climate change effects that are specific to the installations, and (2) plans to address those risks as appropriate.

DoD RESPONSE: Concur.

RECOMMENDATION 4: The Secretary of Defense should issue guidance on incorporating climate projections into installation master planning, including—at a minimum—what sources of climate projections to use, how to use projections involving multiple future scenarios, and what future time periods to consider.

**GAO Draft Report Dated April 18, 2019
GAO-19-453 (GAO CODE 102741)**

DoD RESPONSE: Concur. The Department is in the process of developing guidance to incorporate projections for sea level change into Unified Facilities Criteria for installation master planning, using a Department-vetted source of data. The Department will continue to tailor additional sources of climate projection data to other planning requirements, and integrate these projections into our criteria as appropriate.

RECOMMENDATION 5: The Secretary of Defense should issue guidance on incorporating climate projections into facilities project designs, including—at a minimum—what sources of climate projections to use, how to use projections involving multiple future scenarios, and what future time periods to consider.

DoD RESPONSE: Concur. The Department is in the process of developing guidance to incorporate projections for sea level change into Unified Facilities Criteria for design of facilities, using a Department-vetted source of data. The Department will continue to tailor additional sources of climate projection data to other engineering requirements, and integrate these projections into our criteria as appropriate.

RECOMMENDATION 6: The Secretary of the Army should ensure that the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers works with the Assistant Secretary of Defense for Sustainment; the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command; and the Director of the Air Force Civil Engineer Center to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects, and incorporate, as appropriate, DoD guidance on the use of climate projections in facilities project designs, including identification of the authoritative sources of such projections; use of projections involving multiple future scenarios, and what future time periods to consider.

DoD RESPONSE: Concur.

RECOMMENDATION 7: The Secretary of the Navy should ensure that the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and the Director of the Air Force Civil Engineer Center to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects, and incorporate, as appropriate, DoD guidance on the use of climate projections in facilities project designs, including identification of the authoritative sources of such projections; use of projections involving multiple future scenarios, and what future time periods to consider.

DoD RESPONSE: Concur.

**GAO Draft Report Dated April 18, 2019
GAO-19-453 (GAO CODE 102741)**

RECOMMENDATION 8: The Secretary of the Air Force should ensure that the Director of the Air Force Civil Engineer Center works with the Assistant Secretary of Defense for Sustainment; the Chief of Engineers and Commanding General of the U.S. Army Corps of Engineers; and the Chief of Civil Engineers and Commander, Naval Facilities Engineering Command to update relevant Unified Facilities Criteria to require that installations consider climate projections in designing facilities projects, and incorporate, as appropriate, DoD guidance on the use of climate projections in facilities project designs, including identification of the authoritative sources of such projections; use of projections involving multiple future scenarios, and what future time periods to consider.

DoD RESPONSE: Concur.

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Diana Maurer at (202) 512-9627 or maurerd@gao.gov.

Staff Acknowledgments

In addition to the contact named above, Brian J. Lepore (Director, retired), Kristy Williams (Assistant Director), Michael Armes, Kendall Childers, Simon Hirschfeld, Joanne Landesman, Amie Lesser, Grace Meany, Shahrzad Nikoo, Samantha Piercy, Monica Savoy, Benjamin Sclafani, Joseph Dean Thompson, and Jack Wang made key contributions to this report.

Related GAO Products

High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas. [GAO-19-157SP](#). Washington, D.C.: March 6, 2019.

Climate Change: Analysis of Reported Federal Funding. [GAO-18-223](#). Washington, D.C.: April 30, 2018.

Climate Change Adaptation: DOD Needs to Better Incorporate Adaptation into Planning and Collaboration at Overseas Installations. [GAO-18-206](#). Washington, D.C.: November 13, 2017.

Climate Change: Information on Potential Economic Effects Could Help Guide Federal Efforts to Reduce Fiscal Exposure. [GAO-17-720](#). Washington, D.C.: September 28, 2017.

High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others. [GAO-17-317](#). Washington, D.C.: February 15, 2017.

Climate Change: Improved Federal Coordination Could Facilitate Use of Forward-Looking Climate Information in Design Standards, Building Codes, and Certifications. [GAO-17-3](#). Washington, D.C.: November 30, 2016.

Defense Infrastructure: DOD Efforts to Prevent and Mitigate Encroachment at Its Installations. [GAO-17-86](#). Washington, D.C.: November 14, 2016.

Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information. [GAO-16-37](#). Washington, D.C.: November 23, 2015.

High-Risk Series: An Update. [GAO-15-290](#). Washington, D.C.: February 11, 2015.

Budget Issues: Opportunities to Reduce Federal Fiscal Exposures Through Greater Resilience to Climate Change and Extreme Weather. [GAO-14-504T](#). Washington, D.C.: July 29, 2014.

Climate Change Adaptation: DOD Can Improve Infrastructure Planning and Processes to Better Account for Potential Impacts. [GAO-14-446](#). Washington, D.C.: May 30, 2014.

Extreme Weather Events: Limiting Federal Fiscal Exposure and Increasing the Nation's Resilience. [GAO-14-364T](#). Washington, D.C.: February 12, 2014.

Climate Change: Energy Infrastructure Risks and Adaptation Efforts. [GAO-14-74](#). Washington, D.C.: January 31, 2014.

Climate Change: Federal Efforts Under Way to Assess Water Infrastructure Vulnerabilities and Address Adaptation Challenges. [GAO-14-23](#). Washington, D.C.: November 14, 2013.

Climate Change: State Should Further Improve Its Reporting on Financial Support to Developing Countries to Meet Future Requirements and Guidelines. [GAO-13-829](#). Washington, D.C.: September 19, 2013.

Climate Change: Various Adaptation Efforts Are Under Way at Key Natural Resource Management Agencies. [GAO-13-253](#). Washington, D.C.: May 31, 2013.

Climate Change: Future Federal Adaptation Efforts Could Better Support Local Infrastructure Decision Makers. [GAO-13-242](#). Washington, D.C.: April 12, 2013.

High-Risk Series: An Update. [GAO-13-283](#). Washington, D.C.: February 14, 2013.

International Climate Change Assessments: Federal Agencies Should Improve Reporting and Oversight of U.S. Funding. [GAO-12-43](#). Washington, D.C.: November 17, 2011.

Climate Change Adaptation: Federal Efforts to Provide Information Could Help Government Decision Making. [GAO-12-238T](#). Washington, D.C.: November 16, 2011.

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