Chapter 6 Facility Management

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Introduction

Over the next century, warming global temperatures will present many challenges for the National Park Service and public land managers. Rising sea level will be one of the most obvious and most challenging impacts of this warming. Even a minor increase in sea level will have significant effects on coastal hazards, natural resources, cultural resources, and assets within national parks (figure 6.1). While sea level change and storm impacts are likely to occur in the future in most coastal parks, the timing of those impacts is not well-defined. However, it is certain that over time, facilities that are iconic and irreplaceable cultural resources and key roads and bridges that provide access will be lost. Park managers should approach development in areas vulnerable to climate change and/or other natural hazards conservatively, understanding that current estimates of changes and impacts may well underestimate future risk. This chapter describes the regulatory, program, and technical framework that the National Park Service will use to respond to climate change impacts to facilities in coastal parks. Updated resources can be found at https://www.nps.gov/subjects/climatechange/coastalhandbook.htm.

Figure 6.1. Built facilities, also known as assets, including roads, parking lots, and buildings, such as these pictured before and after Hurricane Sandy at Sandy Hook unit of Gateway National Recreation Area in New Jersey, are vulnerable to rising water level. In the post Sandy image, sand covered the parking lots.

Guiding Policies, Regulations and Plans

There are a number of governmental guiding policies, regulations, and plans that require the National Park Service to address the impacts of climate change on assets, including the president's Executive Order (EO) 13653 Preparing the United States for the Impacts of Climate Change (2013) and EO 13690 on Federal Flood Risk Management (2015). Additionally, the Council on Environmental Quality's Guiding Principles for Sustainable Federal Buildings and Associated Instructions was updated in 2016 and is required by EO 13693 *Planning for Federal Sustainability in the Next Decade* (2015). EO 13693 requires federal agencies to assess impacts from climate change in designing new facilities and modernizing existing facilities.

From the Department of the Interior (DOI), the Climate Change Adaptation Plan (DOI 2014) incorporates "Guiding Principles," which requires the National Park Service to consider climate change impacts on infrastructure and equipment. Lastly, the National Park Service (NPS) Climate Action Plan (2012a) and Green Parks Plan (2012b) both have climate change adaptation as key emphasis areas and require the agency to evaluate parks for vulnerability to climate change stressors and to develop guidance for adapting these vulnerable structures.

Executive Order 13690 – Federal Flood Risk Management

Impacts like rising sea level, intensified storms, and heavy downpours are contributing to an increased risk of flooding. In January 2015, the president signed EO 13690, establishing a flood standard that will reduce the risk and cost of future flood disasters by requiring all federal investments in and affecting floodplains to meet higher flood-risk standards. These standards are higher than the 1% annual chance (100-year) flood level. By requiring that federally funded buildings, roads, and other infrastructure are constructed to better withstand the impacts of flooding, the new standard will help ensure federal projects last as long as intended. Implementation guidance will be forthcoming from the National Park Service and will build upon Reference Manual (RM) 77-2.

EO 13690 modified the flood resilience standard that had been required by EO 11988 since 1977 for federally funded structures and facilities. Another requirement is that federal agencies shall use, where possible, natural systems, ecosystem processes, and nature-based approaches in federal actions and alternatives. This policy change is highly supportive of NPS Management Policies (2006) that promote preservation of natural resources and use of natural approaches.

In 2013, the Hurricane Sandy Rebuilding Task Force adopted a higher flood standard for the Hurricane Sandy affected region to ensure that federally funded buildings, roads, and other projects were rebuilt to reduce vulnerability to future storms (see "Chapter 9 Lessons Learned from Hurricane Sandy"). While the new Federal Flood Risk Management Standard (FFRMS) gives agencies the flexibility to select one of three approaches for establishing the flood elevation and hazard area they use in siting, design, and construction, the Climate-Informed Science Approach (first option) is preferred where data are available:

1. Use data and methods informed by best-available, actionable climate science.
2. Build 2 ft (0.6 m) above the 100-year (1%-annual-chance) flood elevation for standard projects, and 3 ft (0.9 m) above for critical buildings like hospitals and evacuation centers.
3. Build to the 500-year (0.2%-annual-chance) flood elevation.

Note that the return periods determining the 1% annual-chance and 0.2% annual-chance flood zones are based on historical flood risks; exceeding this elevation is intended to account for potential increases where best-available, actionable climate science is not currently available.

Executive Order 13653 – Preparing the United States for the Impacts of Climate Change

In support of EO 13653 and in preparation for the impacts of climate change, the National Park Service needs to develop plans that integrate consideration of climate change into agency operations and overall mission objectives, including:

- identification and assessment of climate change related impacts on and risks to the agency's ability to accomplish its missions, operations, and programs;
- a description of how any identified climate change related risk impairs NPS statutory mission or operation;
- a description of how the National Park Service will improve resilience, including capital equipment purchases such as updating agency policies for leasing, building upgrades, relocation of existing facilities and equipment, and construction of new facilities; and
- a description of how the National Park Service will contribute to coordinated interagency efforts to support climate preparedness and resilience at all levels of government, including collaborative work across agencies.

The National Park Service is developing a number of policy and program initiatives to meet the mandates found above and assess, plan for, and implement projects that enhance climate preparedness and resilience. Additionally, the National Park Service has developed a Facilities Adaptation Roadmap that will guide its response to climate change.

NPS Policy Memorandum 15-01

In response to federal mandates, the National Park Service issued Policy Memorandum (PM) 15-01 (NPS 2015). This provides guidance on the design of facilities to incorporate impacts of climate change adaptation and natural hazards when making decisions in national parks. It is the third "policy pillar" of the NPS climate change response (table 2.1). It complements PM 12-02, "Applying NPS Management Policies in the Context of Climate Change" (NPS 2012c) and PM 14-02 "Climate Change and Stewardship of Cultural Resources" (NPS 2014a). PM 15-01 (NPS 2015) states:

> *"Facilities play a critical role in the mission of the Service: they house our employees, protect and store equipment and materials, demonstrate sustainable design to our visitors, provide context for periods significant to our history, and connect the Service with the public. The Service has the responsibility to invest wisely in these facilities for the long term. Unquestionably, climate change and natural hazards pose a significant threat to our investment in current and future NPS facilities."*
>
> *"This Policy Memorandum, in conjunction with the Level 3 guidance, Addressing Climate Change and Natural Hazards Handbook, will help park personnel in planning and designing facilities that are responsive to the existing and projected climate change and other natural hazards. Managers must apply the guidance in the Handbook. The Associate Director for Park Planning, Facilities and Lands has the authority to update the Handbook periodically as necessary."*

The Level 3 Handbook (*NPS internal access only*) that accompanies PM 15-01 (NPS 2015) "will help provide information and context so that park decision-making appropriately addresses risks associated with natural hazards and climate change. It will ensure that the National Park Service reduces those risks to facilities and fulfills its mission to conserve natural and cultural resources established by Congress in the Organic Act of 1916." The Handbook and Natural Hazards Checklist are designed to support parks in planning and designing facilities that evaluate and respond to existing and projected climate change impacts and natural hazards.

Specific Hazard Assessments include answering direct questions designed to guide decision makers through the range of alternatives that project teams could employ to maximize resiliency against certain risks. For example, coastal flooding can be a significant risk to park assets and functions, and climate change potentially amplifies this risk. To plan/design for a flooding risk, decision makers need resources to quantify the hazard now (baseline) and for the future, including resilient/adaptable construction alternatives (figure 6.2). One strategy is to elevate a building above the expected height of sea level rise and wave effects (figure 6.3). This strategy was used at Flamingo for visitor use facilities in Everglades National Park (see Schupp, Beavers, and Caffrey 2015, "Case Study 18: Developing Sustainable Visitor Facilities").

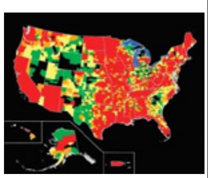
Potential Natural Hazard	Risk or Secondary Hazard	Sources of General Non-Site Specific Data	Sources for Site Specific Data	Best Professional Judgment
Coastal Storm Surge	• Rising Sea Levels • Rising Water – Wind Driven (i.e. hurricane, nor'easter)		• FEMA Map Service Center • NPS Technical Support	Potential Hazard ☐ Not applicable ☐
Tsunami	• Coastal area inundation associated with earthquakes or undersea landslides.		• State Tsunami Inundation Mapping e.g. OR Tsunami Clearinghouse • National Tsunami Watch Center	Potential Hazard ☐ Not applicable ☐

Figure 6.2. Excerpt from NPS Natural Hazards Checklist.

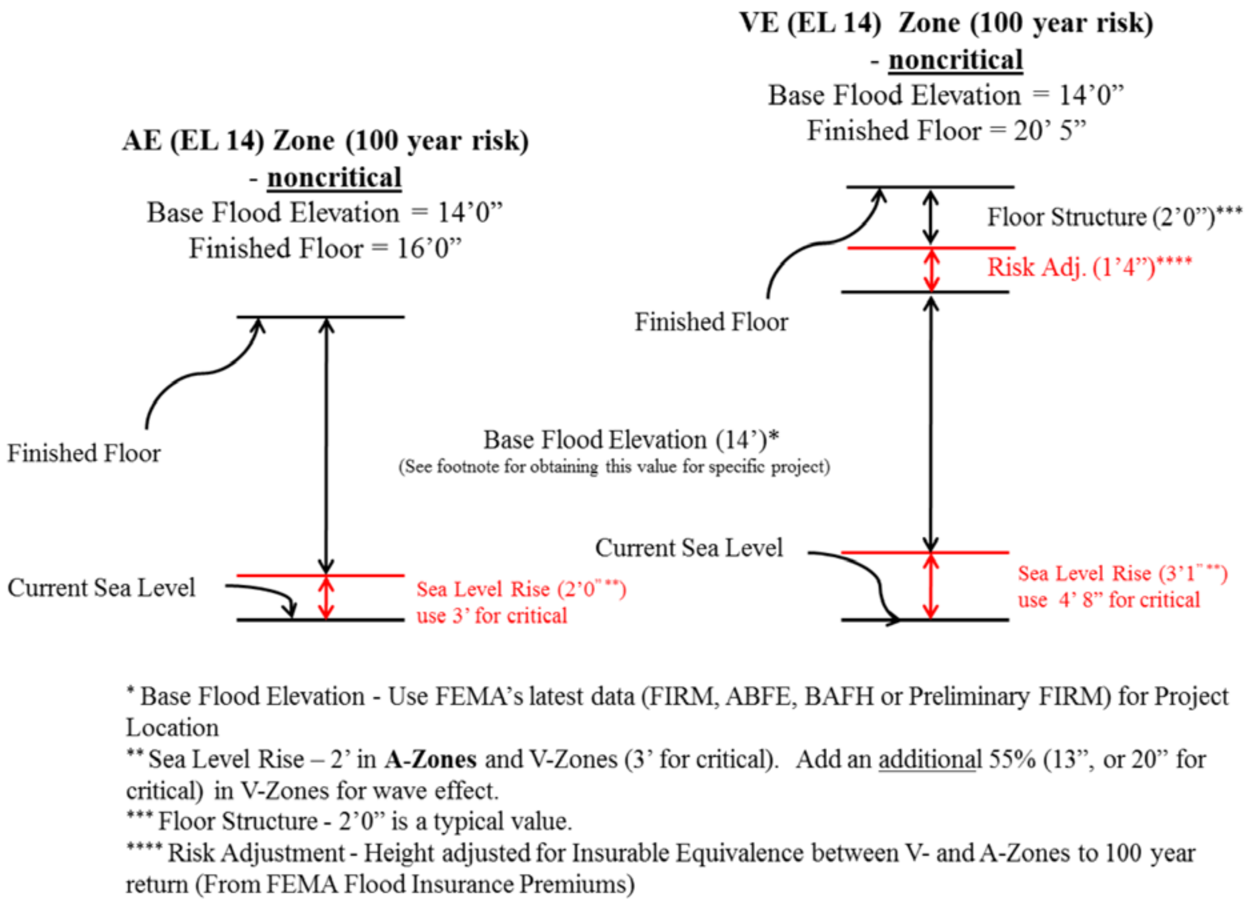


Figure 6.3. Illustration of flood zones relative to floor elevations. The illustration provides a process used to develop the finished floor elevation for projects within the floodplain for the case where the BFE is 14'. It incorporates adjustments to the finished floor elevation for both the A-Zone and the V-Zone. These adjustments account for sea level rise (A and V-Zones), and wave effects of sea level rise, floor structure depth, and insurance risk adjustment (V-Zone only). These adjustments will vary based on location and must be consistent with the requirements of EO 13960. Figure from NPS (2015).

Road Map for Planning for Climate Change Resilience and Sustainability of NPS Assets

The NPS Facilities Management community is working to implement an overarching process or "Road Map" to respond to the challenges of climate change and its impact on park facilities and assets. The Road Map will be used to guide the high level program actions that need to occur to meet both federal mandates and comprehensively track agency actions. The process will require all NPS stakeholder groups to collaborate on a wide-ranging set of actions across multiple components. Each of these Road Map components will have a series of milestones associated with them that will allow for a successful implementation of the Road Map.

The Road Map components are as follows:

- Policy/Guidance – Establish all necessary policies to focus investment in climate change facility adaptation. This may involve general management plans, risk management for facilities management, and cultural resources. Implement PM 15-01.
- Business Standards/Practices – Establish the framework for decision making. This may involve data elevation protocols (box 6.1) and the coastal hazards and climate change asset vulnerability assessment protocol. Apply *Addressing Climate Change and Natural Hazards for Facilities Handbook*.
- Stakeholder Engagement/Communication – Develop a process to involve and communicate with all stakeholders. Create communication materials and host stakeholder forums.

- Data Integration and Management – Develop systems for managing and storing integrated data. Identify systems of records, standardize data sources and protocols, and implement enterprise solutions. Identify key assets using flood mapping.
- Park Adaptation/Resiliency Management – Conduct vulnerability screenings and assessments and incorporate climate change adaptation in plans.
- Project Funding/Prioritization – Develop regional prioritization process and criteria for funding projects. Identify funding sources.
- Reporting and Evaluation – Monitor and evaluate performance of Road Map and projects. Track projects. Complete mandatory reporting.

Table 6.1. Overarching Climate Change Facility Adaptation Planning Framework

Step	Status	Planning
Step 1: Climate Change Adaptation Scoping (Business Standards/Practices; Data Integration & Management)	The Sustainable Operations and Climate Change (SOCC) Branch and the CCRP completed an inventory and assessment of parks vulnerable to 3.3 ft (1 m) of sea level rise. Top 100 parks identified.	SOCC and CCRP review other climate impact areas and identify affected parks.
Step 2: Vulnerability Assessments (Business Standards/Practices; Park Adaptation/ Resiliency Management)	SOCC is developing and piloting a vulnerability assessment protocol for park assets (structures and transportation) focused on sea level rise, storm surge, and coastal erosion.	SOCC, CCRP, and DOI to review the need for building out the protocol to address other climate stressors.
Step 3: Plan for Resilience and Sustainability in Capital Investments and Operations (Policy/Guidance; Project Funding/ Prioritization)	SOCC will pilot a climate change resiliency planning approach for sea level rise, storm surge, and coastal erosion during upcoming Climate Friendly Park workshops, webinars, and other training programs including collaborating with the Integrated Park Investment program.	SOCC to provide planning support to parks to address other climate impact areas through future Climate Friendly Park workshops, webinars, and other training programs.
Step 4: Implement and Monitor (Project funding/Prioritization; Reporting & Evaluation)	Parks, regions, and headquarters to assist with implementation and monitoring of project implementation as it relates to coastal hazards.	Parks, regions, and headquarters to assist with implementation and monitoring of other climate stressors.
Step 5: Communicate and Educate (Stakeholder engagement /Communication)	SOCC will prepare general communication materials (focused on sea level rise, storm surge, and coastal erosion) for parks to modify that communicate risks and adaptive strategies to park staff, visitors, and gateway communities.	SOCC will prepare general communication materials on other climate impact areas for parks to modify to communicate risks and adaptive strategies to park staff, visitors, and gateway communities.

In addition to the Facilities Management Climate Change Roadmap, the facilities management community has identified an Overarching Climate Change Facility Adaptation Planning and Implementation Framework that will be used to guide NPS response to climate change in coastal parks. This process, which includes the key steps in planning for climate change impacts at facilities in coastal parks, is summarized in table 6.1. Additionally, we have developed a *Coastal Hazards and Climate Change Asset Vulnerability Assessment Protocol*, which is described below.

Coastal Hazards and Climate Change Asset Vulnerability Assessment Protocol

The Sustainable Operations and Climate Change Branch (SOCC) of the Park Facility Management Division (PFMD) is providing various levels of support to parks to assist them in planning for park adaptation, including evaluating park assets for climate change vulnerability, assisting in the development of adaptation options, and training park staff on this topic. The National Park Service has partnered with the Program for the Study of Developed Shorelines (PSDS) at Western Carolina University (WCU) to create a C*oastal*

Hazards and Climate Change Asset Vulnerability Assessment Protocol. This protocol (NPS 2016) establishes a standard methodology and set of best practices for conducting vulnerability assessments in the built environment. Standardizing the methodologies and data used in these assessments allows managers to compare the vulnerability of coastal park assets across local, regional, and national levels. Additionally, the findings from these assessments can then be integrated into future decision-making and planning efforts (e.g., Choosing By Advantages [CBA]).

The assessments are currently focused on assets at risk to coastal hazards and sea level rise within coastal parks. Coastal vulnerability was chosen as a starting point in the development of vulnerability assessments because of digital data availability and a good understanding of the trends in the major climate stressors (e.g., sea level). Ultimately, the general methodology can be applied to additional natural hazards and climate stressors in non-coastal parks, as long as georeferenced hazard data exist or can be mapped.

A proposed standardized approach to assessing climate change vulnerability was described in a multiple agency – National Oceanic and Atmospheric Administration (NOAA), National Park Service, United States Geological Survey (USGS), Department of Defense (DOD), National Wildlife Federation (NWF), and United States Forest Service (USFS) – document titled "Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment" (Glick, Stein, and Edelson 2011). This document defines the vulnerability of natural resources to climate change as "the extent to which a species, habitat, or ecosystem is susceptible to harm from climate change impacts." Vulnerability under the Glick, Stein, and Edelson (2011) approach is composed of three equally weighted metrics or components: exposure, sensitivity, and adaptive capacity. However, for this infrastructure-specific protocol, vulnerability is comprised of only the first two metrics: Exposure and Sensitivity.

The adaptive capacity of an asset is evaluated separately and is not included in the vulnerability score. Note that this is different than how vulnerability is defined in "Chapter 3 Planning," "Chapter 4 Natural Resources," and the Glossary. This does not mean that understanding the adaptive capacity of an asset is not important. The range of adaptation strategies or options available for key vulnerable assets within a national park is the final and perhaps most important step in the overall analysis because any adaptation actions taken for an asset will help reduce its exposure or sensitivity, and, in turn, its vulnerability.

Vulnerability =
Exposure + Sensitivity

- ✓ **Exposure**—magnitude of change in climate and other stressors that a resource, asset, or process has already or may experience in the future.
- ✓ **Sensitivity**—degree to which a resource, asset, or process is or could be affected, either adversely or beneficially, by climate variability or change.

One of the primary goals of this protocol is to standardize methods for evaluating the exposure of NPS assets to coastal hazards and climate change. This includes the standardization of data inputs (i.e., widely available, established data) that will allow the application of a consistent methodology among units. Another goal is to create a complete and effective set of factors or indicators for assessing the sensitivity of assets to coastal hazards. The current focus for this methodology is on structures and transportation assets within the NPS asset database (Facilities Management Software System [FMSS]); however, other resources will likely be included in future work.

The protocol will benefit by having significantly more high accuracy building elevation data (see "Chapter 4 Natural Resources" for a discussion on accuracy of elevation data). The National Park Service has begun a process for collecting building elevation data (box 6.1). Once elevations (which will be related to the area's local tidal datum) are associated to the threshold of each structure, investment decisions can be based on location vulnerability (Smith and Gallagher 2011).

The Coastal Hazards and Climate Change Asset Vulnerability Assessment Protocol comprises four primary steps:

1. Exposure Analysis and Mapping
2. Sensitivity Analysis
3. Vulnerability Analysis
4. Adaptation Strategies Analysis

STEP 1 ASSET EXPOSURE ANALYSIS AND MAPPING

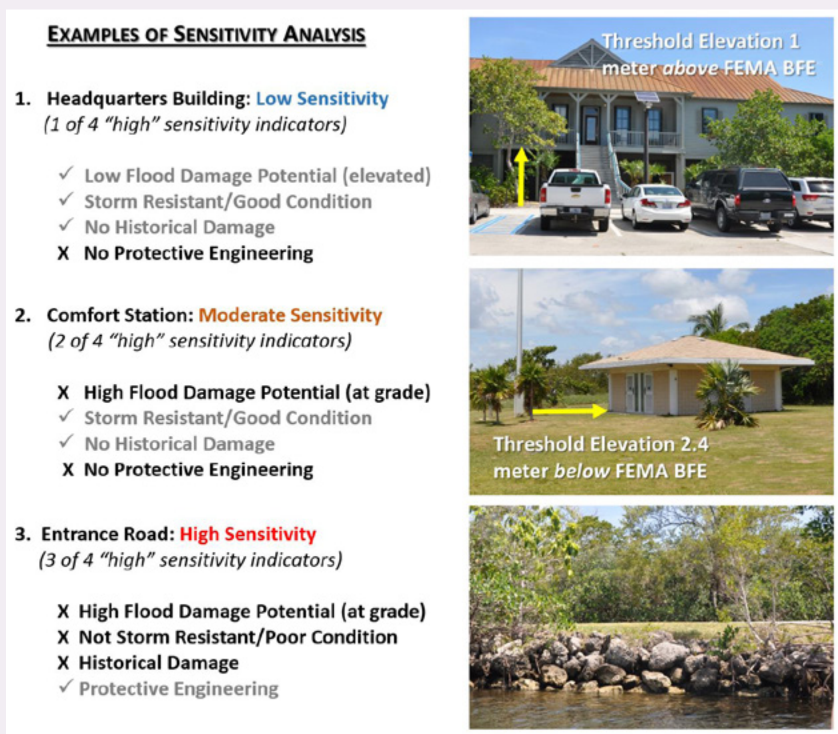
The first step in the protocol is to analyze the exposure of NPS assets to coastal hazards and climate change. The goal of this methodology is to standardize the data sources for exposure analysis, using widely available and regularly updated sources (when possible). Standard exposure indicators have also been determined; these indicators represent the primary factors or hazards that should be evaluated to assess an asset's exposure (over the short-term to the year 2050). The five factors are storm surge, sea level rise, erosion/coastal proximity, and historical flooding. The following is a summary of these indicators (as well as likely data sources for each):

- **Flooding** (Federal Emergency Management Agency (FEMA) Flood Maps; Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM) or other elevation model)
- **Storm Surge, Extreme Flooding, and Tsunamis** (NPS-specific Sea, Lake and Overland Surges from Hurricanes (SLOSH) model results; Tsunami models, LiDAR DEM or other elevation model)
- **Sea Level Rise** (NPS-specific sea level rise (SLR) modeling; LiDAR DEM or other elevation model)
- **Erosion, Coastal Proximity, and Cliff Retreat** (State/USGS erosion rate buffers; shoreline proximity buffers)
- **Historical Flooding** (Park surveys/interviews/questionnaire results; storm imagery/reconnaissance)

The exposure analysis utilizes data imported into Geographical Information Systems (GIS) format because exposure is directly dependent on location (whether the area experiences the hazard) and mapped hazard data. Digital hazard data are gathered for each of the exposure indicators, such as the online georeferenced FEMA flood map layers. The only dataset that does not come from a widely available, well-established source is the historical flooding layer, which is derived from storm imagery, reconnaissance, and direct communication with park personnel. Thus, each of these exposure data layers represents an exposure indicator hazard zone for a particular park. Each asset that falls within a particular zone (exposed) is assigned a higher score than assets outside the hazard zone (unexposed).

STEP 2 ASSET SENSITIVITY ANALYSIS

The second step in the protocol is to analyze the sensitivity of NPS assets to coastal hazards and climate change. Similar to exposure, a set of indicators was determined for asset sensitivity. Unlike exposure, sensitivity is evaluated independent of location (only exposure is location-dependent). Sensitivity refers to how that asset would fare when exposed to the hazard, which is a function of the inherent properties or characteristics of the asset. While the sensitivity indicators for structures and transportation assets are generally the same (see list below), how sensitivity is addressed during design and construction is very different. Below is a list of the sensitivity indicators (with data sources) on the following page:



- **Flood Damage Potential/Elevated** (asset questionnaire; direct measurements of threshold elevation)
- **Storm Resistance and Condition** (asset questionnaire; FMSS database)
- **Historical Damage** (asset questionnaire; discussion with park staff)
- **Protective Engineering** (asset questionnaire; field and aerial imagery analysis; Coastal Engineering Inventory)

Bridges are considered transportation assets but have additional factors that must be considered when analyzing sensitivity to coastal hazards and climate change. Additional bridge sensitivity indicators are listed below (with data sources):

- **Bridge Clearance** (National Bridge Inventory, item 39)
- **Scour Rating** (National Bridge Inventory, item 113)
- **Bridge Condition** (National Bridge Inventory, items 59 and 60)
- **Bridge Age** (National Bridge Inventory, item 27; FMSS database)

Because digital data are not generally available, the primary data source for much of the sensitivity analysis is an asset questionnaire. This questionnaire contains detailed questions related to the various sensitivity indicators (e.g., is the structure elevated above base flood elevation). It is distributed to appropriate personnel within each unit—typically individuals that possess long institutional memory and familiarity with park facilities. Where appropriate, sensitivity data are also obtained from FMSS, the National Bridge Inventory, aerial imagery, and site visits.

STEP 3

STEP 3: ASSET VULNERABILITY ANALYSIS

Upon completion of step 3, each asset will have been given a rating (and score) of low, moderate, or high vulnerability to coastal hazards and climate change (calculated as the sum of exposure and sensitivity). A subset of the assets from the completed vulnerability analysis will be chosen for development of adaptation strategies (step 4).

STEP 4

ADAPTATION STRATEGIES ANALYSIS

After the vulnerability assessment is complete, adaptation strategies will be analyzed for key assets within each park. FMSS data such as Asset Priority Index (API) and Optimizer Band (OB) can help prioritize the assets to analyze for adaptation strategies. These assets will likely include those with high vulnerability and high priority and/or high criticality (API/OB), as well as high vulnerability assets with low priority and/or criticality. If an asset is a historic asset, then its historic character should be considered in selecting and designing adaptation options (see "Chapter 5 Cultural Resources"). This adaptation analysis begins with discussions with the park or by way of a questionnaire. This portion of the analysis focuses on the options available to the park to reduce the overall vulnerability of key assets. An outline of potential adaptation strategies to reduce coastal hazards and climate change vulnerability has been compiled for both structures and transportation assets (NPS 2016). Below is a list of these strategies, including the potential effect on vulnerability.

- Elevate the asset: reduces the sensitivity of the asset; elevating a structure (and critical utilities) or transportation asset (i.e., a road) reduces the risk of flood damage. Conversely, planning for submersion of assets such as roadways may also provide added protection during storm inundation. See additional discussion in "Chapter 9 Lessons Learned from Hurricane Sandy."
- Relocate the asset: reduces the exposure of the asset; relocating the asset to a lower risk area reduces the likelihood it will experience impacts from coastal hazards/SLR.
- Protect/Engineer: protecting the asset with an engineered structure or landscape modifications (i.e., drainage) can reduce the likelihood that the asset will experience, or obtain damage from, coastal hazards/SLR. This reduces the exposure and/or sensitivity of the asset.
- Decommission and Remove: eliminates the vulnerable asset.
- Storm-Resistant Redesign: reduces the sensitivity of the asset; redesigning the asset to be more storm resistant can reduce the likelihood of damage from coastal hazards/SLR.

- Engineering Downgrade (transportation assets only): reduces the sensitivity of the asset; downgrading the amount of engineering (i.e., replacing paved parking lot with shell material lot) can reduce the cost of rebuilding after damage and gives more flexibility for replacement. An example from Assateague Island National Seashore is described in "Case Study 16: Relocating Visitor Facilities Threatened by Erosion" in Schupp, Beavers, and Caffrey (2015).

This protocol is designed solely to assess the vulnerability of physical infrastructure. However, there are other adaptation actions for vulnerable assets that would not reduce the vulnerability of the physical asset but instead its function. For example, a park might consider moving the critical contents within a building to a higher floor to reduce potential flood damages. Similarly, parks may decide to shift an asset's function to a less vulnerable asset. These adaptation actions do not change the vulnerability of the original asset (i.e., exposure and sensitivity remain the same); instead these actions change the criticality of the asset, potentially making it less of a concern to the park.

BOX 6.1. PROCESS FOR COLLECTING ELEVATIONS ON VULNERABLE ASSETS

Note: Locations of Vulnerable Asset Elevations procedure documentation https://www.nps.gov/orgs/socc/mitigation-and-adaptation.htm

PRE-FIELD:

1. Verify quality of Facility Management Software System (FMSS) data.
2. Coordinate with Regional and Washington Support Office staff so there will not be duplication of efforts. Your project may support existing efforts.
3. Asset data should be mapped in a GIS format (Shapefile or GeoDatabase) with FMSS Location IDs (FMSS primary key for assets) associated to the features. FMSS data can be accessed through Asset Management Record System. Location Hierarchy reports are recommended to be run to assist in attribution of spatial data.
4. Inventory, evaluate, and compile a list of existing local survey monumentation infrastructure as described in Accurate Elevation in Coastal National Parks (Smith and Gallagher 2011). Of particular interest are tidal benchmarks with published benchmark data sheets. If deep rod monumentation needs to be installed, this should be completed at least 30 days before data collection field work.
5. Determine the location of current and historic tide stations in the study area using the NOAA Tides and Currents website: http://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels.

FIELD:

6. Set up geodetic receiver on a backbone monument that will be tied to all of the survey points that you collect in a given area. If conventional surveying techniques are required, all points should be tied back to the backbone monumentation with traditional Real Time Kinematic (RTK) or static Global Navigation Satellite System (GNSS) surveying techniques.
7. Best approach is to have a 3-person field crew: two people using RTK rover devices and one person capturing photos and providing Locations ID's to be used as the RTK point name and photo names. This is done to later associate the photos to the survey horizontal and vertical data (figures 6.4 and 6.5).
8. For buildings, collect first floor elevations at the threshold of primary entrance if possible. Collect multiple points for linear transportation assets and parking lots.

POST-FIELD:

9. Process project static base control files through National Geodetic Survey OPUS (Online Positioning User Service) using the precise ephemeris. It can take up to 21 days for the precise ephemeris to be available, so static files should be first processed using the rapid ephemeris to confirm their quality before final processing when the precise ephemeris is available. After the base control files are processed with the precise ephemeris, all RTK and conventional surveyed points can be adjusted and processed for North American Vertical Datum of 1988 (NAVD88) heights using current geoid.

10. Relate the NAVD88 orthometric heights of the assets to the local tidal datums. These tidal datums are mean lower low, mean low, mean sea level, mean high, and mean higher high water. Tidal datums are determined by recording tidal observations at a tide station over a period of months or years and deriving the relevant statistics. NPS staff and partners should request assistance with this step, especially in areas with relative land movement (subsidence, isostatic rebound, etc.).
11. Relate horizontal and vertical positions to photos.
12. Post results to NPS Focus/FMSS, and produce data-sharing products such as CSV and File GeoDatabase files (figure 6.6).

LESSONS LEARNED:

1. Data quality in FMSS is important.
2. NPS staff with park knowledge is crucial.
3. Park-specific tidal data and permanent survey monumentation (backbone) are often lacking.
4. Proper planning and coordination with park and/or program staff prior to field work are critical.
5. Experience in surveying techniques, tidal datums, FMSS, and GeoJot is essential.
6. Where proper GNSS signal is obstructed, conventional survey methods will be necessary.
7. Specialized equipment and knowledge of how to use it is required for this type of data collection.

Stakeholder Involvement and Outreach

The success of the facilities management climate change adaptation response will require the involvement of many stakeholder groups. It will also require the development of communication materials that can be used by parks and programs to reach out to these core groups. Workgroups will need to be established to develop components of the road map that require subject matter expertise such as GIS. These will be identified and integrated as needed.

One of SOCC's main programmatic responsibilities is the Climate Friendly Parks (CFP) Program. The principle output of this program is a park climate change action plan. Through the NPS Green Parks Plan (GPP; NPS 2012b) the Director has required that, where feasible, all parks become CFP and develop a climate change action plan. These plans currently focus mostly on greenhouse gas mitigation in the energy, transportation, and waste areas as well as planning around climate change communications at the park (see "Chapter 7 Communication and Education"). CFP workshops now include adaptation discussions, and SOCC will modify the CFP initiative to add a climate change facility adaptation component (focused on assets) to the CFP plan as appropriate. This process is shown in box 6.2.

Strategies for Adapting Coastal Facilities and Operations

Visitor use areas in coastal environments are vulnerable to storm surges and future changes in sea level and lake level. With the projected changes in storm frequency and intensity, there are no "easy" answers to the design elements for coastal infrastructure. Certain engineering standards based on historic conditions are no longer accurate guides of future asset performance. More detailed examination of climate change impacts will be critical as actions envisioned in the general management plan and other planning documents are analyzed and implemented at site-specific levels. Factoring in changes in sea level and lake level, these analyses will influence the type, design, location, and ultimate feasibility of coastal facilities and developments.

When parks engage in development employing site-specific design, outstanding opportunities are created to demonstrate forward thinking, innovative designs, flexibility, and readiness for change in response to changes in sea level and lake level. Coastal resiliency will be incorporated into any new developed areas and adaptively reused structures and facilities. Multiple strategies and associated costs for protection and adaptation of infrastructure in the coastal zone are described in "Chapter 8 Protecting Infrastructure: Costs and Impacts."

These strategies propose a range of facility additions and renovations to expand recreational opportunities. Proposed facility investments will be evaluated using the following climate change overarching approach prior to project approvals to ensure the long-term sustainability of these investments. Future plans and studies will provide technical data and resource information to support the strategies. Creative solutions will be identified to limit impacts from future flooding, storm surge, and other impacts on existing visitor and operations facilities. When these facilities are no longer viable to retain and use, a transition to portable facilities or other means to continue to offer visitor services, as feasible, should be considered. This could include the following on page 82:

BOX 6.2. OVERARCHING PROCESS FOR FACILITIES CLIMATE CHANGE RESPONSE AND ADAPTATION

STEP 1 — PARK CLIMATE CHANGE SCOPING
(STEP 1 FROM ADDRESSING CLIMATE CHANGE AND NATURAL HAZARDS HANDBOOK)

- Review climate change impacts including
  - sea level rise, storm surge, coastal hazards.
  - blizzards, extreme cold, extreme heat.
  - hurricanes, heavy rains.
  - wildfires, drought, lightning, tornadoes.
  - permafrost depletion.
- Build working group and subcommittees.
- Characterize critical assets.

STEP 2 — VULNERABILITY ASSESSMENT
(STEP 2 FROM ADDRESSING CLIMATE CHANGE AND NATURAL HAZARDS HANDBOOK)

- Refine impacts assessment and conduct asset inventory.
- Conduct vulnerability assessment.
- Use Sustainable Buildings Checklist, Natural Hazards Checklist (figure 6.2), and other new standards.
- Establish vision and resiliency goals.
- Prioritize planning issues.

STEP 3 — PLAN FOR RESILIENCE AND SUSTAINABILITY IN CAPITAL INVESTMENTS AND OPERATIONS
(STEP 3 FROM ADDRESSING CLIMATE CHANGE AND NATURAL HAZARDS HANDBOOK)

- Identify, evaluate, and prioritize adaptation strategies.
  - Identify options that could reduce vulnerability; suggestions for eliciting additional options include:
    - Analyze past climate events that led to disaster; working backwards from a negative impact, at what points in the process could an intervention have improved the outcome?
    - Could existing or outdated technologies or resources be repurposed in ways that would reduce vulnerability or enhance resilience?
    - What newly available technologies have potential to improve resilience?
    - Review various levers for affecting change such as land use planning, codes and standards, inspection and enforcement, operations, maintenance and repair, and renewal and renovation.
- Create response plan or integrate strategies into other plans; plan and invest for resilience and sustainability at all scales including operations and capital investments.
- Develop and submit a funding request (PMIS).
  - Use Sustainable Buildings Checklist and other new standards and criteria to assess assets.
  - Use rating scores as they become available from the National Park Service.

STEP 4 — IMPLEMENT AND MONITOR

- Implement high-priority actions.
- Track progress and evaluate effectiveness.
- Assess new impacts information and conduct adaptive management.
- Revise strategies and priorities as needed.

STEP 5 — COMMUNICATE AND EDUCATE
(SEE "CHAPTER 7 COMMUNICATION AND EDUCATION")

- Share success stories.
- Develop a robust resource center.
- Provide user-friendly communication materials to parks and stakeholders.

- Removing existing facilities and discontinuing recreational uses where continued use is unsafe, infeasible, or undesirable because of changing environmental conditions.
- Avoiding or minimizing additions of new infrastructure, construction of high value assets, or major investments in facility renovations within coastal hazard or storm surge zones.
- Reflecting EO 13690's amendments to EO 11988 for substantial facility investments within the coastal zone, including an adjustment for projected sea level rise by year 2100; these investments should be avoided to the extent possible. Essential improvements within these flood-prone areas, such as rehabilitation of historic structures or provision of necessary facilities for beach access and recreation, will be carefully evaluated to determine whether facilities should be elevated, made portable, hardened, or otherwise made resilient to potential flooding. Any decision to proceed with substantial improvements within the flood zone as adjusted for sea level rise will be documented in a floodplain statement of findings according to DO-77 per EO 13690's amendments to EO 11988.
- Transitioning to systems and facilities that are more resistant to the effects of natural hazards and climate change effects on those hazards.
- Keeping susceptible elements of utilities, critical systems, and infrastructure out of flood zones (and away from the effects of other natural hazards) to the extent possible.

Visitor Experience, Transportation, and Access

Sea level rise and storm surge impacts will change the way that visitors experience park assets and resources. Perhaps one of the most notable of these changes will be the way visitors access the parks. Many park transportation assets have the highest exposure to SLR and coastal flooding making them the most vulnerable assets. For example, future visitors to Gulf Islands National Seashore may need to access the Fort Pickens unit via a ferry instead of driving in on the asphalt road, which is vulnerable to storm overwash (see Schupp, Beavers, and Caffrey 2015, "Case Study 19: Establishing Alternative Transportation to Fort Pickens to Supplement Vulnerable Road Access"). Alternate forms of transportation and access can benefit natural resources by reducing impacts to habitats of rare species such as the dune habitat used by the Santa Rosa beach mouse (Jackson et al. 2001). Although the park has implemented several strategies to maintain the road, including lowering road elevation, the value analysis should also consider the alternative of elevated causeways, which were once viewed as cost prohibitive. Existing roads may need to have larger culverts to address climate change impacts on drainage and local watershed precipitation (see Schupp, Beavers, and Caffrey 2015, "Case Study 15: Rehabilitating Stream Crossings on Historic Roads").

Some parks have already embraced more resilient design of parking lots. For example, Assateague Island National Seashore incorporates native materials so that asphalt debris will not litter the beach after storms (see Schupp, Beavers, and Caffrey 2015, "Case Study 16: Relocating Visitor Facilities Threatened by Erosion"). Other parks have considered the extent to which facilities should be replaced and elevated (see Schupp, Beavers, and Caffrey 2015, "Case Study 18: Developing Sustainable Visitor Facilities"). In the future, certain decisions and adaptation strategies may become more or less viable. It is important that parks document their process for planning and the rationale for which adaptation strategies are chosen.

While the loss of access can be a true loss, in some cases it will only be a change in traditional access to resources and assets. Although it may change the way that visitors experience a resource, the resource can persist. Some parks may have to consider acquiring land at higher or inland locations to properly provide for the safety of visitors and park staff. For example, Assateague Island National Seashore's general management plan (see Schupp, Beavers, and Caffrey 2015, "Case Study 23: Incorporating Climate Change Response into a General Management Plan") includes the potential for obtaining additional lands on the mainland for visitor contact stations, staff housing, maintenance, and headquarters. Recognizing these needs will help the park prioritize and plan for obtaining these lands even if the acquisition is many years into the future. A storm impact may accelerate the timeline for implementing such strategies.

Coastal landscapes that are allowed to evolve naturally can become more resilient and better able to withstand changes (see "Chapter 9 Lessons Learned from Hurricane Sandy"). At Cape Hatteras National Seashore on Hatteras Island, a breach during Hurricane Isabel in 2003 was artificially closed with dredged sediment. The inlet closure allowed State Highway 12 to be reestablished close to its pre-storm location, but that stretch of barrier island continues to be narrow and vulnerable to future breaches. The balance between the natural environment and the built environment must be considered when planning future actions. After later hurricanes (Hurricane Irene in 2011 and Hurricane Sandy in 2012) breached the same highway, some breaches were allowed to persist with temporary bridges put in place to allow access to communities without impeding natural coastal processes of overwash, breach closure, and wetland building.

Figure 6.4. Image of base station set up for RTK-GPS elevation data collection at Fort Sumter National Monument as part of the vulnerable asset elevation project in 2015.

Asset Management Plans and Incident Response

The goal of coastal adaptation is to implement strategies as soon as they can be acted upon and to prepare for opportunities. Without consideration and planning for a variety of strategies, parks may find it is easiest in the short-term to return to business as usual, such as conditions that existed prior to a storm (see "Chapter 3 Planning" for a discussion of pre-disaster planning). When vulnerable locations are identified through processes described earlier in this chapter, funding to relocate assets and resources away from vulnerable locations should be pursued.

Parks are required to maintain asset management plans that describe the condition and priority of investments at the park. Park asset management plans should include elements of climate change vulnerability assessment and coastal adaptation. For example, plans for assets in the maintenance backlog must align with park adaptation strategies. If a certain structure is no longer serving its intended function, the future of that asset should be reconsidered (see "Chapter 9 Lessons Learned from Hurricane Sandy" for additional discussion of deferred maintenance and prioritization of cultural resources).

The NPS Southeast Region has recognized the need to prepare for storms, and to have plans in place for post-storm recovery/adaptation. The Cape Lookout National Seashore Storm Recovery Plan sets an excellent example of preparing for post-storm assessments (see Schupp, Beavers, and Caffrey 2015, "Case Study 20: The Need for Storm Recovery Plans"). The plan lists the most important resources in several categories. These priority resource listings assist ordering of recovery efforts; provide justifications for the expertise recommended on each assessment team; and inform incident responders of the resources that drive visitation, operations, and the overall character of the park. Detailed checklists of major resources are included in the plan's appendix so that teams can assess their status such as presence/absence and immediate threats. These assessments help the incident command to assemble and dispatch resource assessment teams. For the purpose of resource damage assessment, the park is divided into multiple areas and the expertise and number of specialists needed in each of those assessment areas are specified. The park storm recovery plan also explains the need for immediate aerial photo overflights and specifies photograph needs (e.g., resolution and vantage points) and provides contact information for appropriate pilots.

Figure 6.5. Image of rover GPS data collection at the Sally Port of Fort Pickens at Gulf Islands National Seashore as part of the vulnerable asset elevation project in 2015.

For staff living in and near coastal parks, the realities of living in a changing environment can affect both participation at work and their ability to participate in incident response activities. When a major storm impacts a park, many of the park staff may be involved in addressing human health and safety concerns for themselves, their friends and family, and the local community, and may not be able to fully participate in park incident management activities. Therefore, it is very important that information about resources and facilities be stored in systems that can be easily accessed by incident management teams (IMT) deployed to or working remotely for the impacted site. The systems, such as park atlases and off-site web mapping services, should be accessible and understandable, and should use standard protocols. Backup copies of the systems must be maintained offsite to enable the IMT staff to work at that remote location or on-site at the park.

Figure 6.6. Coastal asset at Elliot Key in Biscayne National Park was documented as part of the vulnerable asset elevation project in 2015.

Coastal Fortifications and Lighthouses

Coastal fortifications and lighthouses are unique sets of cultural resources that are also assets. With a few exceptions (see Schupp, Beavers, and Caffrey 2015, "Case Study 8: Relocating the Lighthouse"), these structures are so large that they cannot or will not likely be relocated. Strategies to address these assets will have to consider the place-based nature of these cultural resources. Some assets may be protected in place for a limited period of time with coastal engineering methods such as seawalls or beach nourishment (see Schupp, Beavers, and Caffrey 2015, "Case Study 5: Strategic Planning and Responsible Investments for Threatened Historic Structures"). Data have shown that many forts and lighthouses along the southeast coast of the United States have high exposure to 3.3 ft (1 m) of sea level rise (Peek et al. 2015). Prioritizing funding of repairs, maintenance, and even improvements at the sites may be critical in deciding how to distribute limited funds (see Schupp, Beavers, and Caffrey 2015, "Case Study 5: Strategic Planning and Responsible Investments for Threatened Historic Structures"). It is important to place each of these assets in context of the system of cultural and historical resources managed along the coast (figure 6.7). Even when access is limited and structures are partially submerged, it is still possible to provide a visitor experience related to these resources. As "Chapter 5 Cultural Resources" discusses, unique compliance requirements and more complex decision-making processes are required for these irreplaceable cultural resources.

Opportunities for Adaptation

Mitigate Impacts of Coastal Engineering

When human actions impact natural coastal processes, such as when coastal engineering structures disrupt sediment supply and affect the evolution of a coastal landscape, the National Park Service can take actions to mitigate for those human-caused alterations (see "Chapter 2 Policy"). For a discussion of pre-disaster planning, see "Chapter 3 Planning." Some impacts are caused by actions that occur outside of NPS boundaries, such as an updrift jetty affecting sediment transport to a down-drift park. The National Park Service has begun a series of coastal engineering inventories (CEIs) (e.g., Coburn, Griffith, and Young 2010; Dallas, Ruggiero, and Berry 2013; Schupp and Coburn 2015; and other coastal engineering inventories available at http://www.nature.nps.gov/geology/coastal/monitoring.cfm that identify the locations and impacts of historic and current coastal engineering projects that affect coastal parks. These data exist for only 19 parks, so this work must be expanded to all coastal parks. The Northeast Region recognized that many coastal engineering structures are not comprehensively documented in FMSS, so post-Hurricane Sandy work has included incorporating data from available coastal engineering inventories into that database.

Remove, Restrict, and Redesign Structures

Aging coastal protection structures will become less effective as they deteriorate with age or their design elevations are exceeded. Building restrictions and structure removal can protect and promote open marine and estuarine shorelines and habitats such as wetlands (Nordstrom, Jackson, and Roman 2016). Coastlines respond differently to storm impacts and rising water level associated with coastal change depending on whether they are fixed or dynamic. Nature-based and hybrid infrastructure strategies can be an important component of coastal adaptation (see "Chapter 8 Protecting Infrastructure: Costs and Impacts"). Following the publication of the CEI reports and creation of the associated GIS datasets, projects by the US Naval Academy at Fort Raleigh National Historic Site have helped the park to consider the elements related to implementation of a living shoreline. "Chapter 9 Lessons Learned from Hurricane Sandy" identifies additional opportunities related to facilities and infrastructure, such as including architectural, engineering, and project management expertise on the post-storm assessment teams so that FMSS rebuilding estimates will consider the cost of newly designed sustainable buildings in addition or instead of the cost of rebuilding the damaged structure as it was.

Funding Opportunities

Funding opportunities for adaptation will vary depending on location, park resources, and temporal conditions, such as storm events. Parks with five-year project plans should review these plans in conjunction with climate change vulnerability information to determine how the use of any project funding can be used to reduce exposure or sensitivity using strategies and actions noted above. Many project specifications and plans can be modified to increase the overall resiliency of the asset. The opportunity to adapt following a large-scale incident such as Hurricane Sandy may also bring needed funds for implementation of recovery objectives. It is important to conceive and perhaps even design projects to be implemented on dynamic post-storm landscapes. While the funding process for the National Park Service may not currently be designed to intentionally incorporate these "adaptive" actions, the concept of incorporating adaptive designs and other adaptive planning efforts will be very useful to effect changes for asset management in coastal parks. Examples of how the Value Analysis (VA), CBA, Rapid Review Team, and Development Advisory Board processes and procedures were used to incorporate adaptive element of project design are discussed for Hurricane Sandy recovery in "Chapter 9 Lessons Learned from Hurricane Sandy."

Documentation

As the consequences of climate change increase, parks will need to evaluate and document vulnerable assets and resources. Adaptation strategies may include Historic American Buildings Survey (HABS), Historic American Engineering Record (HAER), or Historic American Landscapes Survey (HALS) documentation, 3D laser scanning surveys, digitizing hard copies of documents and artifacts, and interpretation. Parks should also recognize that loss of resources and assets will be part of this process, as recognized in the *Preserving Coastal Heritage Workshop Report* (NPS 2014b) and PM 14-02, and discussed further in "Chapter 5 Cultural Resources."

Storm Recovery Planning

The storm recovery plan for Cape Lookout National Seashore (CALO 2011; see Schupp, Beavers, and Caffrey 2015, "Case Study 20: The Need for Storm Recovery Plans") uses existing databases such as FMSS and the Archeological Sites Management Information System (ASMIS) for cultural resources. It is important that the incident management team has the ability to easily access this information and to know the intentions of the park management team for recovery. Incidents provide opportunities for climate change adaptation. Without prior planning, including consultation and coordination with National Historic Preservation Act section 106, it can be challenging to implement changes during the recovery process. Use of storm recovery plans for Fire Island and Assateague Island National Seashores are discussed in "Chapter 9 Lessons Learned from Hurricane Sandy."

Figure 6.7. Panorama of waterfront of Salem Maritime National Historic Site in Massachusetts. Photograph by Marcy Rockman, NPS.

Emerging Topics

In addition to managing and adapting to potential impacts to NPS facilities from climate change, the National Park Service must address potential impacts from non-NPS infrastructure development near and through its coastal parks. In particular, there is increasing pressure for rapid deployment of energy development projects and related infrastructure, including offshore wind, offshore oil and gas drilling, marine hydropower, marine electric transmission related onshore substations, and petroleum product pipelines and related onshore compressor stations.

Regarding renewable energy, the current administration has committed to a national, non-hydro renewable energy generation of 20% by 2030, with efforts to streamline and expedite permitting of offshore wind and related transmission infrastructure. In 2011, the Department of Energy and DOI formed a strategic partnership and issued a National Offshore Wind Strategy aimed at deploying generation projects. Likewise, DOI launched its "Smart from the Start" initiative to facilitate siting, leasing, and construction of new projects. In addition, a number of coastal states have Renewable Portfolio Standards requiring that a certain percentage of energy either used or produced in that state is from renewable energy sources. Generally, these efforts seek to reduce carbon emissions and reliance on fossil fuels, increase energy efficiency, and to use more renewable energy to generate electricity, pointing to the growing importance of these technologies.

Large-scale development projects have the potential to cause adverse, cross-boundary impacts to NPS units. Examples include: direct mortality of avian species; potential disruption to physiology and behavior of nocturnal species from night lighting of facilities such as wind turbines; interference with sand and gravel transport from submerged facilities and construction activities; destruction of submerged archaeological resources; and others. Many of these resources are already vulnerable to the stressors of sea level rise and climate change. As such, it is imperative that the National Park Service engage on such activities occurring near its boundaries to ensure protection of park resources and values.

Increasingly, coastal parks are called upon to permit third-party infrastructure development within and through park units or to provide access to near shore facilities through seashores and park coastal waters. For example, the formerly named Atlantic Wind Connection electric transmission project was designed to connect offshore wind facilities to the onshore grid and had proposed a route through Assateague Island National Seashore that would have required directionally drilling the marine transmission cable under the barrier island. NPS staff identified a number of potential resource impacts, including the possibility of piercing the freshwater lens under the island, interfering with sand transport along the seafloor, and creating a vulnerability point for a future island breach. Moreover, NPS staff raised concerns about the ongoing management and safety of such facilities in an area constantly in flux. Clearly, such facilities have the potential to compound adaptation and management needs for coastal parks.

Take Home Messages

- The National Park Service has the responsibility to invest wisely in facilities for the long term. Unquestionably, climate change and natural hazards pose a significant threat to our investment in current and future facilities.
- Vulnerability to climate change impacts needs to be understood at the asset level for parks to plan for these impacts. This includes an understanding of the risk of exposure and sensitivity of the asset to these impacts.
- Park asset management plans and five-year project plans should be evaluated to include elements of climate change vulnerability and coastal adaptation strategies.
- Climate Friendly Park workshops are opportunities to integrate climate change mitigation planning with coastal adaptation.

References

Cape Lookout National Seashore (CALO). 2011. Cape Lookout National Seashore Storm Recovery Plan 2011. Cape Lookout National Seashore, Harkers Island, NC. http://www.nature.nps.gov/geology/coastal/documents/CALO_Final_Storm_Recovery_Plan_2011.pdf (accessed 13 March 2015).

Coburn, A. S., A. D. Griffith, and R. S. Young. 2010. Inventory of Coastal Engineering Projects in Coastal National Parks. Natural Resource Technical Report. NPS/NRPC/GRD/NRTR—2010/373. NPS Natural Resource Program Center, Fort Collins, CO. https://irma.nps.gov/DataStore/Reference/Profile/2165163 (accessed 15 October 2014).

Council on Environmental Quality. 2016. Guiding Principles for Sustainable Federal Buildings and Associated Instructions. https://www.whitehouse.gov/sites/default/files/docs/guiding_principles_for_sustainable_federal_buildings_and_associated_instructions_february_2016.pdf (accessed 07 August 2016).

Dallas, K., P. Ruggiero, and M. Berry. 2013. Inventory of coastal engineering projects in Gateway National Recreation Area. Natural Resource Technical Report NPS/NRSS/GRD/NRTR—2013/738. National Park Service, Fort Collins, CO.

Department of the Interior (DOI). 2014. Department of the Interior Climate Adaptation Plan. https://www.doi.gov/sites/doi.gov/files/migrated/greening/sustainability_plan/upload/2014_DOI_Climate_Change_Adaptation_Plan.pdf (accessed 07 August 2016).

Executive Order 11988, "Federal Floodplain Management" 42 FR 26951. 4 February 2014. http://www.archives.gov/federal-register/codification/executive-order/11988.html.

Executive Order 13653, "Preparing the United States for the Impacts of Climate Change." 78 FR 66819. 6 November 2013. http://www.gpo.gov/fdsys/pkg/FR-2013-11-06/pdf/2013-26785.pdf (accessed 9 May 2016).

Executive Order 13690, "Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input." 30 January 2015. https://www.whitehouse.gov/the-press-office/2015/01/30/executive-order-establishing-federal-flood-risk-management-standard-and- (accessed 23 June 2016).

Executive Order 13693, "Planning for Federal Sustainability in the Next Decade." 19 March 2015. https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade (accessed 07 August 2016).

Glick, P., B. A. Stein, and N. A. Edelson [eds.]. 2011. Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment. National Wildlife Federation, Washington, DC.

Jackson, D. R., K. NeSmith, D. Printiss, K. Brandt, and D. Hipes 2001. 2001. Santa Rosa Beach Mouse Fact Sheet. Field Guide to the Rare Animals of Florida. Florida Natural Areas Inventory, Tallahassee, FL. http://fwcg.myfwc.com/docs/beach_mouse_santarosa.pdf (accessed 13 March 2015).

National Park Service (NPS). 2006. National Park Service Management Policies. U.S. Government Printing Office, Washington, DC.

NPS. 2012a. National Park Service Climate Change Action Plan 2012-2014. NPS Climate Change Response Program, Fort Collins, CO. http://www.nature.nps.gov/climatechange/docs/NPS_CCActionPlan.pdf (accessed 07 August 2016).

NPS. 2012b. Green Parks Plan. National Park Service, Washington, DC. https://www.nps.gov/greenparksplan/downloads/NPS_2012_Green_Parks_Plan.pdf (accessed 07 August 2016).

NPS. 2012c. Applying National Park Service Management Policies in the Context of Climate Change. US DOI National Park Service Policy Memorandum 12-02. March 6, 2012. https://www.nps.gov/policy/PolMemos/PM_12-02.pdf (accessed 28 April 2015).

NPS. 2014a. Climate Change and Stewardship of Cultural Resources. US DOI National Park Service Policy Memorandum 14-02. http://www.nps.gov/policy/PolMemos/PM-14-02.htm (accessed 28 April 2015).

NPS. 2014b. Preserving Coastal Heritage. Summary Report. April 3-4, 2014. Federal Hall, New York City, NY. Available at http://www.achp.gov/docs/preserve-coastal-heritage.pdf (accessed 7 October 2014).

NPS. 2015. Addressing Climate Change and Natural Hazards for Facilities. US DOI National Park Service Policy Memorandum 15-01. http://www.nps.gov/policy/PolMemos/PM_15-01.htm (accessed 28 April 2015).

NPS. 2016. Coastal Hazards and Climate Change Asset Vulnerability Protocol: Project Description and Methodology. NPS 999/132623. National Park Service, Washington, DC.

Nordstrom, K. F., N. L. Jackson, and C. T. Roman. 2016. Facilitating landform migration by removing shore protection structures in national coastal parks in the northeastern USA: opportunities and constraints. Environmental Science and Policy (in press). doi:10.1016/j.envsci.2016.07.012 (accessed 8 August 2016).

Peek, K. M., R. S. Young, R. L. Beavers, C. Hawkins Hoffman, B. T. Diethorn and S. Norton. 2015. Adapting to climate change in coastal national parks: Estimating the exposure of FMSS-listed park assets to 1 m of sea-level rise. Natural Resource Technical Report NPS/NRSS/GRD/NRTR—2015/961. National Park Service, Fort Collins, CO.

Schupp, C., and A. Coburn. 2015. Inventory of coastal engineering projects within Assateague Island National Seashore. Natural Resource Report NPS/NRPC/GRD/NRR—2015/914. National Park Service, Fort Collins, CO.

Schupp, C. A., R. L. Beavers, and M. Caffrey [eds.]. 2015. Coastal Adaptation Strategies: Case Studies. NPS 999/129700. National Park Service, Fort Collins, CO.

Smith, T. G., and C. Gallagher. 2011. Accurate Elevations in Coastal National Parks. 999/107779. National Park Service, Lakewood, CO.