Albemarle-Pamlico
National Estuary Partnership

Albemarle-Pamlico National Estuary Partnership (APNEP) Risk-Based Assessment and Adaptation Plan

Draft Report






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Acronyms

APES	Albemarle-Pamlico Estuarine System
APNEP	Albemarle-Pamlico National Estuary Partnership
CCMP	Comprehensive Conservation and Management Plan
COG	Council of Governments
C/P	Consequence/Probability
DCM	Division of Coastal Management
DMF	Division of Marine Fisheries
DWR	Division of Water Resources
EPA	U.S. Environmental Protection Agency
NC DACS	North Carolina Department of Agriculture and Consumer Services
NC DEQ	North Carolina Department of Environmental Quality
NC WRC	North Carolina Wildlife Resources Commission
NEP	National Estuary Program
NGO	Non-Government Organization
SAV	Submerged Aquatic Vegetation
SEO	State Energy Office
SSO	Sanitary Sewer Overflow
VA DEQ	Virginia Department of Environmental Quality

1 Executive Summary

The Albemarle-Pamlico National Estuary Partnership (APNEP) developed this risk-based adaptation plan to assess how recurring extreme weather events and other stressors may affect implementation of its Comprehensive Conservation and Management Plan (CCMP) and to identify actions for managing those risks. Following the U.S. Environmental Protection Agency's risk-based adaptation planning framework, the plan consists of a vulnerability assessment and an action plan. The vulnerability assessment identifies risks to APNEP's management objectives and evaluates their consequence, likelihood, spatial extent, and time horizon, while the action plan determines how those risks should be managed and identifies potential adaptation actions.

The assessment considered seven stressor categories: warmer summers, warmer winters, warmer water, increasing drought, increasing storminess, sea level rise, and ocean acidification. APNEP identified 54 risks across its CCMP objectives using existing regional assessments, consultation with EPA collaborators, and APNEP staff knowledge. Each risk was evaluated qualitatively based on consequence, likelihood, spatial extent, and time horizon, and then compared using a consequence/probability matrix to distinguish risks of low, moderate, and high concern.

The assessment identifies several high-consequence and high-likelihood risks affecting habitat, water quality, and hydrologic processes. These include harmful algal blooms associated with warmer temperatures; reduced water clarity from runoff; loss of wetlands and changes to estuarine communities associated with sea level rise and saltwater intrusion; and increased surface inundation as soils become more saturated. Other significant risks are associated with increasing storminess, including nutrient and pollutant runoff, wastewater-system inflow and infiltration, and impacts to waterways, shorelines, and aquatic habitats. The assessment also identifies risks to fisheries, freshwater supplies, recreation and stewardship activities, environmental education, and APNEP's monitoring activities.

APNEP evaluated the identified risks against organizational constraints and opportunities and assigned risk-management approaches of mitigate, transfer, accept, or avoid. Risks selected for mitigation were carried forward to identify potential adaptation actions. The resulting strategies emphasize supporting stormwater best management practices and other nature-based approaches; installing living shorelines; protecting and restoring wetlands; supporting wastewater treatment plant and system upgrades; adjusting environmental education and training activities; and repairing, restoring, or realigning research and education activities when access to natural areas is affected.

APNEP subsequently evaluated candidate adaptation actions for risk-reduction potential, feasibility and effectiveness, cost and cost-effectiveness, ancillary costs and benefits, equity and fairness, and robustness, using a 5-point scale for each category (1=low, 5=high). The highest-scoring actions were adjustments to training activities (23), repair or restoration or realignment of research and education efforts (22), and wastewater treatment plant or system upgrades addressing treatment-system overloading and sewage releases (20 each). Stormwater BMPs addressing nutrient loads and wetland protection and restoration each scored 19, while living shorelines and wastewater upgrades addressing sewer inflow and infiltration each scored 18. These results provide a basis for

prioritizing actions that offer achievable risk reduction while accounting for APNEP's resources, partnerships, and organizational constraints.

Implementation is intended to build on APNEP's existing partnerships with state and local governments, universities, non-governmental organizations, councils of governments, Tribal partners, and other organizations. The plan identifies potential development of complementary "action tracking" and "risk tracking" systems to document actions, responsible parties, milestones, implementation status, associated risks, and progress. Following implementation, APNEP may monitor whether adaptation actions are reducing risks as intended, reassess risks as conditions and scientific understanding change, identify emerging vulnerabilities and opportunities, and revise adaptation actions when more effective approaches become available.

The plan therefore establishes an iterative framework rather than a one-time assessment. APNEP intends for the adaptation plan to remain a living document, with updates occurring periodically (typically on a 5–10-year basis), and with earlier revisions possible when significant changes occur in science, environmental conditions, organizational priorities, or risk profiles. Monitoring and review can also inform future updates to APNEP's vulnerability assessment, adaptation strategy, and CCMPs, helping the Partnership maintain progress toward organizational and watershed resilience goals.

2 Purpose

Amendments (2021) to the Clean Water Act Section 320 (Public Law 116-337) require individual National Estuary Programs (NEPs) to address "the effects of recurring extreme weather events on the estuary, including the identification and assessment of vulnerabilities in the estuary and the development and implementation of adaptation strategies." This process involves evaluating each major goal established in the NEP's Comprehensive Conservation and Management Plan (CCMP) for risks associated with recurring extreme weather events and other relevant stressors, including the likelihood and consequences of those risks. Findings from the vulnerability assessment inform an action plan for managing identified risks and may inform updates or adjustments to CCMP goals (U.S. EPA, 2025).

The U.S. Environmental Protection Agency (EPA) workbook for developing risk-based adaptation plans (hereinafter "the workbook") presents a guide to risk mitigation and adaptation planning based on EPA's experience with watershed management, the NEP, and the Climate Ready Estuaries program (U.S. EPA, 2014). The workbook outlines a two-part process for developing an adaptation plan consisting of (1) a vulnerability assessment and (2) an action plan, which the Albemarle-Pamlico National Estuary Partnership (APNEP) followed in the creation of this report. This step-by-step process is described in Sections 4 (vulnerability assessment) and 5 (action plan).

Within this framework, a vulnerability assessment represents an understanding of how recurring extreme weather events may uniquely affect a National Estuary Program, with its CCMP goals serving as the primary focus. The vulnerability assessment evaluates identified impacts in the context of organizational goals to determine whether they will help, hinder, or have no effect on achieving those goals. In applying this process, individual NEPs take a broad look at potential risks, qualitatively assess their likelihood and consequences, and consult with key stakeholders to support coordination and agreement.

The action plan builds on the vulnerability assessment by identifying actions to manage and reduce prioritized risks and to improve the sustainability of the program and goals. After completing the vulnerability assessment, individual NEPs identify the most significant risks to achieving organizational goals and evaluate potential actions to decrease those risks. Because resources are often limited, the process emphasizes selecting actions that most effectively reduce risk, including "no-regrets" or win-win strategies where appropriate. The later steps in the workbook also establish a process to track the status of risks and identify responsible parties for implementing risk mitigation strategies. This planning-level process is intended to identify options, and additional detailed work is typically needed before actions are implemented.

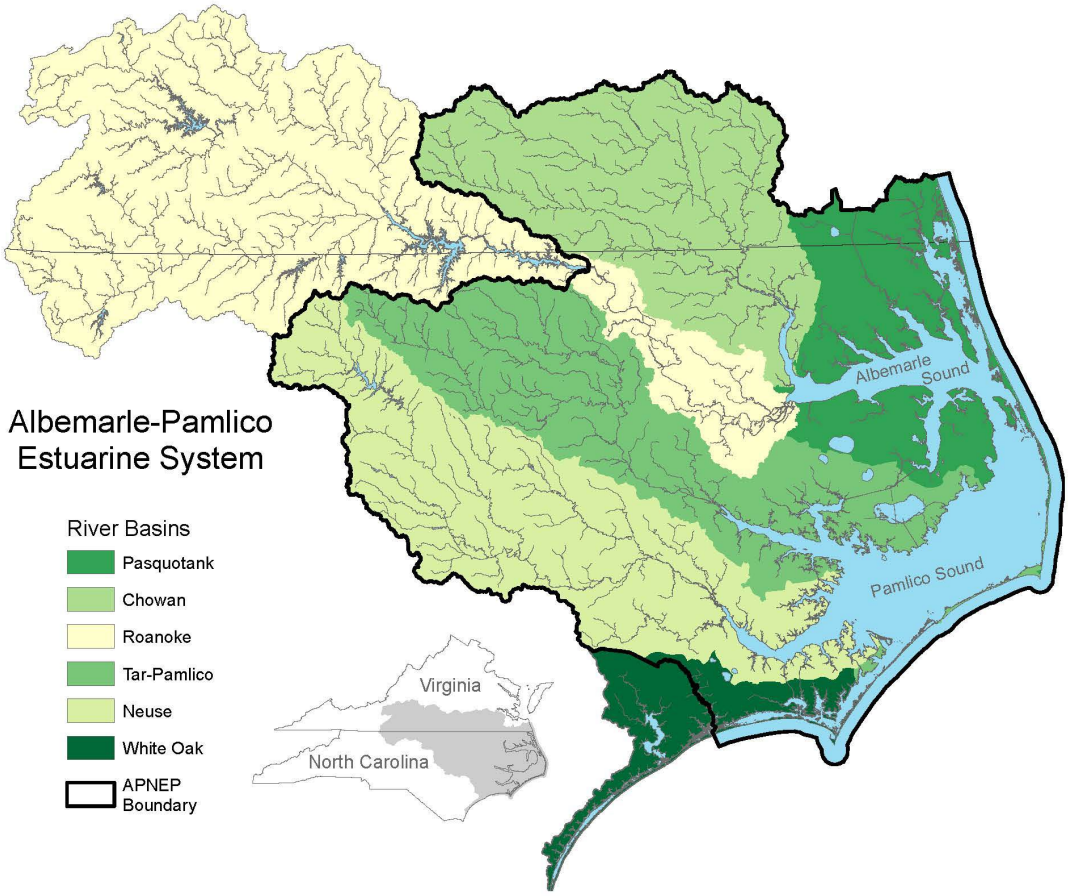
3 Background

3.1 Albemarle-Pamlico Watershed

The Albemarle-Pamlico watershed spans over 31,000 square miles. APNEP's management area, which is the largest among the individual NEPs, includes 23,803 square miles (76% of the total basin, excluding portions of the Roanoke and White Oak basins, NC) and encompasses over 3,000 square miles of estuarine waters and 10,000 miles of streams and rivers. Its headwaters extend from the Appalachian Mountains of Virginia to the North Carolina Piedmont, encompassing wetlands, forests, farms, and cities downstream to the estuary and the ocean. Land uses such as forestry, farming, industry, mining, and urban development dominate the region.

The Albemarle-Pamlico Estuarine System (APES; Figure 3-1) comprises nine major bodies of relatively shallow water known as "sounds" in coastal North Carolina and Virginia. The two largest, Albemarle Sound and Pamlico Sound, are complemented by smaller yet significant waterbodies: Back Sound, Bogue Sound, Croatan Sound, Currituck Sound, Core Sound, Roanoke Sound, and Back Bay.

Figure 3-1: APNEP Region River Basins



The sounds support both North Carolina's commercial and non-commercial fishing industries. Beyond these more recognizable benefits, the sounds provide other essential ecosystem services as well. Coastal wetlands filter water and buffer against storms, while submerged aquatic vegetation offers habitat for fish and shellfish, produces oxygen, and removes excess nutrients. Fish and shellfish supported by the sounds include shad, herring, blue crabs, oysters, and clams. Overall, the sounds contribute billions of dollars in economic activity and natural services each year.

Yet because of the greater frequency of tropical depressions and northeasters, the Albemarle-Pamlico region is particularly susceptible to environmental degradation and vulnerable to impacts associated with recurring extreme weather from a variety of stressors. For example, Hurricanes Matthew (2016) and Florence (2018) caused extensive flooding across the Albemarle–Pamlico watershed, delivering large pulses of freshwater, sediment, and nutrients to the estuary, degrading water quality, altering salinity and ecosystem processes, and damaging coastal habitats and infrastructure (North Carolina Department of Environmental Protection, 2020). To safeguard the estuarine system for future generations, this example is a stark reminder that it is essential to manage the entire watershed, including across state lines, rather than just the sounds themselves.

3.2 Albemarle-Pamlico National Estuary Partnership

APNEP was among the first of the NEPs established by the Clean Water Act in the late 1980s. This Partnership is a cooperative effort hosted by the North Carolina Department of Environmental Quality under a cooperative agreement with the EPA that works closely with the Commonwealth of Virginia. The program area extends across both states, from headwaters and Piedmont, through a broad coastal plain, and out to the string of barrier islands bordering the sounds.

APNEP's staff works closely with diverse stakeholder committees whose members include citizens, local business leaders, environmental organizations, educational institutions, Tribal communities, and local, state, regional, and federal agencies. Through these committees, APNEP engages stakeholders to ensure a coordinated approach to APES management. By facilitating communication and collaboration among organizations throughout the region, APNEP seeks to leverage its resources and those of its partners to accomplish more together than any individual organization could separately. This, combined with an ecosystem-based management approach, positions APNEP to identify and fill regional gaps and to address pressing issues confronting the region.

This collaborative, science-based approach is formalized through the 2025 CCMP, the strategic framework that guides the Partnership's priorities and actions. Developed as part of the NEP, a CCMP outlines priorities for activities, research, and funding to protect and restore designated estuaries of national significance and their watersheds and serves as a blueprint for future decision-making. Each CCMP is based on a scientific assessment of the estuary and is developed with input from a broad coalition of stakeholders, including community members, addressing issues such as water quality, habitat protection, and restoration.

Since the adoption of APNEP's original 1994 CCMP, many scientific and management developments have occurred. The third and most recent update (hereinafter "the CCMP") covers the 2025–2030 management horizon and documents APNEP's efforts to (1) characterize priority issues in the estuaries and supporting watersheds, (2) list and describe actions to address those problems, and

(3) identify partners and entities to implement those actions (Albemarle-Pamlico National Estuary Partnership, 2025a). The CCMP is crafted to meet the specific and often unique needs within the watershed and provides a guide for governments, businesses, non-governmental organizations, and community members in collaboration for APES stewardship. The CCMP aims to sustain these vital resources and ecosystem functions for future generations (Albemarle-Pamlico National Estuary Partnership, 2025a).

4 Vulnerability Assessment

A vulnerability assessment documents how recurring extreme weather events and other stressors uniquely affect APNEP's purpose, mission, and goals or objectives. The process of developing a vulnerability assessment involves five cumulative steps:

- **Step 1. Communication and Consultation**
- **Step 2: Establish Context**
- **Step 3: Risk Identification**
- **Step 4: Risk Analysis**
- **Step 5: Compare Risks**

The following subsections describe Steps 1–5 in greater detail.

4.1 Step 1—Communication and Consultation

The objective of Step 1 is to list the key stakeholders in the vulnerability assessment and understand their interests or concerns regarding the effects of recurring extreme weather events and other stressors on the estuary and the adaptation planning process. Consulting with stakeholders in general helps build support for adaptation and is essential for developing agreement on the outcomes of this process. It also provides an opportunity to incorporate stakeholder knowledge and information.

As authorized in N.C. Governor's Executive Order #29 (2025), APNEP staff is advised by a Management Conference composed of a Leadership Council, Science and Technical Advisory Committee, and Citizen Advisory Committee. APNEP's advisory committees provide direction and oversight for the Partnership, and all three committees are comprised of representatives from across the two-state region. APNEP staff involved in the creation of this vulnerability assessment were advised by members of the Management Conference. In addition, APNEP relied heavily on existing assessments developed within the region and with substantial stakeholder involvement, as described in Table 4-1.

APNEP will also work with the Management Conference to review and refine the draft and final adaptation plan reports. APNEP will review the draft report with the Management Conference and post the approved draft to the website for public review and comment for a minimum of 60 days. APNEP will also post links to the draft report in the newsletter and social media and share the report with targeted interested parties. For the final report, APNEP will review with the Management Conference, post the final document to the website, and post links to the final report in the newsletter and social media. APNEP will only reopen the final report for public review and comment if significant changes were made following the public comment period for the draft report.

4.2 Step 2—Establishing the Context for the Vulnerability Assessment

The purpose of Step 2 is to identify and list the CCMP management goals/objectives or actions that could be compromised by recurring extreme weather events and other stressors. The management approach establishes the scope and boundaries for the vulnerability assessment, as any stressors that do not affect APNEP's outcomes need not be included.

The APNEP CCMP has a tri-level management hierarchy: the first level has 3 broad goals, followed nine management objectives in the second level, and the third level has a great articulation of objectives into 32 management actions, thus averaging approximately 3.5 actions per objective. APNEP identified objectives as providing the most appropriate foundation for this organizational strategic review. These objectives are listed below:

- A1: Assess the condition of and potential impacts to targeted ecosystems.[1]
- B1: Protect and restore areas containing significant natural communities and habitats.
- B2: Protect and restore water quality by minimizing or eliminating targeted sources of water pollution.
- B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions.
- B4: Restore spawning areas for diadromous fish.
- C1: Foster watershed stewardship.
- C2: Conduct targeted environmental education efforts regarding estuarine habitats, water quality, and ecosystem services.
- C3: Provide tools and training to support ecosystem-based management.
- D1: Develop and maintain an integrated monitoring network to collect and disseminate information for assessment of ecosystem outcomes and management actions associated with CCMP implementation.

4.3 Step 3—Risk Identification

The objective of Step 3 is to develop a broad list of risks, defined as reasonably foreseeable ways that recurring extreme weather events and other stressors could hinder APNEP's ability to achieve the management objectives outlined in the CCMP. Since this list of risks is carried through the subsequent steps of analysis and evaluation, it is important to identify all potential risks at this stage.

The workbook presents a framework for identifying these risks. Within this framework, each of the nine objectives outlined in Step 2 has the potential to intersect with each of the following seven stressor categories:

- Warmer summers
- Warmer winters
- Warmer water
- Increasing drought
- Increasing storminess
- Sea level rise
- Ocean acidification

[1] During the risk identification step (see Section 4.3), APNEP identified similar risks for objectives A1 and D1 and ultimately decided to list all risks under D1 only.

To identify these intersections, the existing state and local resources addressing recurring extreme weather events and other stressors in the region (Table 4-1) were reviewed. Bolded entries provided particularly valuable insight.

Table 4-1: Resources reviewed

Scope	Type	Citation	Report Name
APNEP	Strategic Plan & Report	Albemarle-Pamlico National Estuary Partnership (2025b)	Cumulative FY 2022-27 Workplan & Budget for CCMP Implementation under the 2021 Infrastructure Investment and Jobs Act & FY 2026-27 Workplan and Budget (July 2025 Update)
APNEP	Report	Roach et al. (2023)	Tribal Coastal Resilience Connections Phase I Report
APNEP	Climate Assessment	Albemarle-Pamlico National Estuary Partnership (2019)	Initial Assessment of Climate Change Impacts to Implementation to 2012 - 2022 Comprehensive Conservation and Management Plan
North Carolina	**Climate Assessment**	**North Carolina Department of Environmental Protection (2020)**	**North Carolina Climate Risk Assessment and Resilience Plan**
North Carolina	Action Plan	North Carolina Department of Natural and Cultural Resources (2025)	2025-2030 North Carolina Natural and Working Lands Action Plan
North Carolina	Executive Order	State of North Carolina Office of Governor Roy Cooper (2024)	Executive Order No. 305
North Carolina	Executive Order	State of North Carolina Office of Governor Roy Cooper (2018)	Executive Order No. 80
Virginia	**Climate Assessment**	**Ruess et al. (2025)**	**The First Virginia Climate Assessment**
Virginia	**Action Plan**	**Virginia Department of Conservation and Recreation (2021)**	**Virginia Coastal Resilience Master Plan Phase 1**

During a series of meetings with EPA collaborators, APNEP staff asked clarifying questions about the goals and structure of the risk identification effort and applied their local knowledge to adapt risks identified in state-level resources to the specific context of the APNEP region and the risk identification framework. The resulting list of 54 risks that may impact APNEP's ability to achieve CCMP objectives is presented in Table 4-2.

Table 4-2: Risks

CCMP Objective	Risks	Opportunities
Warmer summers		
B1	• Plants and animals may be weakened by heat and become outcompeted by heat-tolerant species • Warmer waters may remove suitable habitat for species at the southern limit of their range (e.g., eelgrass) or at the edge of their thermal tolerance, causing declines • Native species may struggle with rising temperatures, and new species may thrive in the new environmental conditions	• Some species may benefit from heat • Habitat suitability may increase for some fish species, such as spotted seatrout; however, this may occur without corresponding increases in habitat suitability for their prey
C1	• Hotter summers and more frequent heatwaves make outdoor travel less appealing or even dangerous, especially for hiking or beachgoing • Peak seasons for fall foliage, spring blooms, and wildlife watching may shift, creating confusion and lower visitor satisfaction	
Warmer winters		
B1	• Mild winters are expected to promote the expansion of invasive exotic species including cogon grass, Chinese tallowtree, and fire ants	
Warmer water		
B1	• Desired fish species may shift their migration route to occur further offshore or deeper in the water column, affecting catchability, as has been observed in spot fish • Flora and fauna population ranges may move northward, as has been observed in submerged aquatic vegetation (SAV), black sea bass, summer flounder, and white shrimp • As water temperatures increase, fish species may experience more frequent and extended periods of low dissolved oxygen, causing physiological stress that can interfere with feeding and reproduction • Nonnative fishes which may prey on and compete with native fishes are likely to increase in numbers and distribution	• New species may become available; however, these species may be less desirable • Some native species may benefit from warmer water
B2	• Warmer water temperatures may increase frequency and extent of harmful algal bloom	

CCMP Objective	Risks	Opportunities
B4	• Warm water can harm underwater grasses and reduce refuge, spawning, forage, and nursery areas for fish species	• Some underwater grass species (i.e., Halodule) may expand their distributions due to warming waters
Increasing drought		
B1	• Water shortages due to drought increase the risk of catastrophic wildfires, temporarily reduce availability of suitable habitat for wetland and aquatic animal populations, and can cause outright mortality for individual animals and plants that are unable to migrate to a suitable habitat	
B2	• For municipal and industrial water supplies that use surface waters as their primary source, low stream flows resulting from drought can result in poor water quality, high turbidity, and even an inability for water intakes to function properly	• Reduced runoff may improve estuarine water quality or clarity
B3	• During drought, saltwater may reach upstream and impact freshwater intakes • Increased temperatures can reduce availability of water during times of drought	
C1	• Inland wetlands that provide essential habitats for birding and hunting may shrink or dry out due to heat and drought	
Increasing storminess		
B1	• Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality of aquatic fauna • Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries • Storm surge flooding may overtop, breach, or even drown barrier islands • Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring • Canopy gaps created by wind damage provide places for invasive exotic and/or shade-intolerant plant species to become established • More intense hurricanes may damage wetlands and natural barriers which help to protect infrastructure and communities from storm surge, increasing the vulnerability to subsequent storms	• Some native species may benefit from new canopy gaps

CCMP Objective	Risks	Opportunities
B2	• Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life • Flooding can directly contaminate source waters, resulting in drinking water service interruptions and the potential for adverse public health outcomes • Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season • Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding • Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines • Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a sanitary sewer overflow (SSO) at manholes or treatment plants • Runoff can reduce water clarity, thus reducing light availability for SAV	• Hurricanes can recharge soil moisture and groundwater aquifers
B4	• Heavy precipitation events and associated flooding can cause significant damage to infrastructure such as utility services, dams, and fish ladders	
C1	• Disruption of tourist amenities due to access issues • Closure of sites due to flooding or damage from extreme weather • Trail washouts due to flooding • Damage to boardwalks, downed trees blocking trails, increased marine debris and vessel groundings, and erosion create hazards for staff and visitors	
C2	• Training and education programs may be affected by delays or cancellations • Storm impacts increase workload for staff during the immediate response and long-term recovery process • Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas	
C3	• Localized events can threaten government functions, for example by shutting down arterial roadways and temporarily closing government buildings	

CCMP Objective	Risks	Opportunities
Sea Level Rise		
B1	• Coastal erosion may reduce habitat for freshwater tidal wetlands, maritime uplands, and maritime wetlands • Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities • Increased saltwater intrusion due to sea level rise is expected to change the salinity of estuarine communities and to convert lower coastal floodplains from swamp forest to wetlands • Saltwater intrusion may shift plant communities from freshwater-adapted to salt-tolerant species, degrading freshwater wetland habitats that serve as critical nurseries for many species and ultimately transforming productive coastal ecosystems into less diverse salt marshes or open water areas • If the amount of sediment input cannot offset the sea level rise, marshes can eventually drown	• Erosion may add new opportunities for habitat creation • Sparsely developed bayfront areas may allow some habitats, like tidal marshes, to migrate upland and hold their own • May open opportunities for other beneficial habitat (e.g., salt marshes move inland into low-lying forests or grasslands)
B3	• Groundwater may become more saline, contaminating freshwater aquifers and altering soil chemistry • Saltwater intrusion may make drinking water from both groundwater and surface waters more vulnerable to contamination and/or expensive to treat and secure • Areas relying on sole-source aquifers may increasingly face challenges with saltwater intrusion of drinking water supplies • The combined forces of higher baseline water levels and more frequent storm surge events may remove protective barriers and expose previously stable inland areas to direct marine influence • As subsurface soil becomes more saturated, its capacity to absorb additional waters from rainfall or flooding declines, raising the risk for surface inundation by interrupting flow directions	
C1	• Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity	• Potential increase in sedimentation may build up wetland elevation, help keep pace with sea-level rise, and protect coastal areas from erosion
Ocean acidification		

CCMP Objective	Risks	Opportunities
B1	• Ocean acidification may cause oysters and other shelled organisms to be unable to grow their shells, affecting the fishery and the marine organisms that rely on them for habitat and food	
All		
D1	• Monitoring program sampling schedules may be delayed • Uncertainty of system-wide model forecasts may be greater • Uncertainty of net ecosystem services forecast estimates may be greater	

4.4 Step 4—Risk Analysis

The purpose of Step 4 is to evaluate the likelihood and consequences of each risk identified in Step 3 so they may later be sorted into high, medium, and low qualitative impact categories.

APNEP staff reviewed each risk identified in Table 4-2 to make a high-level determination of its consequence, likelihood, spatial scale, and time horizon and rated each risk on a scale of A to C for each of these four criteria. Table 4-3 defines each criterion and describes the rating scale used.

Table 4-3: Risk evaluation criteria

Criterion	Definition and Scale
Consequence	Effect the risk would have on APNEP's goal were it to occur Low – life will go on; not as important as many other things; could adjust Medium High – major disruption; goal is out of reach or not attainable
Likelihood	Chance of the risk occurring (*i.e.*, probability) Low Medium High
Spatial extent	Proportion of APNEP's geographic area the risk would affect Low – limited scale; *e.g.*, a few waterfront lots, a bridge, a sewage treatment plant Medium – regional; *e.g.*, community, state park, wildlife refuge, sub-watershed High – widespread; *i.e.,* most of the watershed or estuary
Time horizon	Time horizon until the problem begins Low: More than 30 years Medium: 10–30 years High: Already occurring or 0–10 years

The risk evaluation criteria summarized in Table 4-3 was used to evaluate the likelihood and consequences of the 54 risks identified in Table 4-2. Table 4-4 presents the resulting designations for each risk.

Table 4-4: Risk Analysis

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
Warmer Summers					
B1	Plants and animals may be weakened by heat and become outcompeted by heat-tolerant species	High	Medium	High	Medium
	Warmer waters may remove suitable habitat for species at the southern limit of their range (e.g., eelgrass) or at the edge of their thermal tolerance, causing declines	High	Medium	High	Medium
	Native species may struggle with rising temperatures, and new species may thrive in the new environmental conditions	High	Medium	High	Medium
C1	Hotter summers and more frequent heatwaves make outdoor travel less appealing or even dangerous, especially for hiking or beachgoing	Medium	Medium	Medium	Medium
	Peak seasons for fall foliage, spring blooms, and wildlife watching may shift, creating confusion and lower visitor satisfaction	Low	Medium	Medium	Medium
Warmer winters					
B1	Mild winters are expected to promote the expansion of invasive exotic species including cogon grass, Chinese tallowtree, and fire ants	Medium	Medium	High	Medium
Warmer water					
B1	Desired fish species may shift their migration route to occur further offshore or deeper in the water column, affecting catchability, as has been observed in spot fish	Medium	Medium	Medium	Medium
	Flora and fauna population ranges may move northward, as has been observed in SAV, black sea bass, summer flounder, and white shrimp	High	Medium	High	Medium
	As water temperatures increase, fish species may experience more frequent and extended periods of low dissolved oxygen, causing physiological stress that can interfere with feeding and reproduction	High	High	High	Medium

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
	Nonnative fishes which may prey on and compete with native fishes are likely to increase in numbers and distribution	High	Medium	High	Medium
B2	Warmer water temperatures may increase frequency and extent of harmful algal bloom	High	High	Medium	High
B4	Warm water can harm underwater grasses and reduce refuge, spawning, forage, and nursery areas for fish species	Medium	Medium	Medium	Medium
Increasing drought					
B1	Water shortages due to drought increase the risk of catastrophic wildfires, temporarily reduce availability of suitable habitat for wetland and aquatic animal populations, and can cause outright mortality for individual animals and plants that are unable to migrate to a suitable habitat	High	Medium	Medium	High
B2	For municipal and industrial water supplies that use surface waters as their primary source, low stream flows resulting from drought can result in poor water quality, high turbidity, and even an inability for water intakes to function properly	High	Medium	Medium	High
B3	During drought, saltwater may reach upstream and impact freshwater intakes	Medium	Medium	Low	High
	Increased temperatures can reduce availability of water during times of drought	Low	Low	Low	Medium
C1	Inland wetlands that provide essential habitats for birding and hunting may shrink or dry out due to heat and drought	Low	Low	Medium	Medium
Increasing storminess					
B1	Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality aquatic fauna	Medium	High	Medium	High

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
	Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries	Medium	Medium	Medium	High
	Storm surge flooding may overtop, breach, or even drown barrier islands	Medium	Medium	Medium	High
	Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring	Medium	Medium	Medium	High
	Canopy gaps created by wind damage provide places for invasive exotic and/or shade-intolerant plant species to become established	Low	Medium	Low	High
	More intense hurricanes may damage wetlands and natural barriers which help to protect infrastructure and communities from storm surge, increasing the vulnerability to subsequent storms	Medium	Low	Medium	High
B2	Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life	High	Medium	Medium	High
	Flooding can directly contaminate source waters, resulting in drinking water service interruptions and the potential for adverse public health outcomes	High	Medium	Medium	High
	Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season	High	Medium	Medium	High
	Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding	Medium	High	High	High
	Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines	Medium	High	High	High

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
	Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a SSO at manholes or treatment plants	Medium	High	High	High
	Runoff can reduce water clarity, thus reducing light availability for SAV	High	High	Medium	High
B4	Heavy precipitation events and associated flooding can cause significant damage to infrastructure such as utility services, dams, and fish ladders	Low	Low	Medium	Medium
C1	Disruption of tourist amenities due to access issues	Low	Low	Medium	Medium
	Closure of sites due to flooding or damage from extreme weather	Low	Medium	Low	High
	Trail washouts due to flooding	Low	Medium	Low	High
	Damage to boardwalks, downed trees blocking trails, increased marine debris and vessel groundings, and erosion create hazards for staff and visitors	Low	Medium	Low	High
C2	Training and education programs may be affected by delays or cancellations	Low	Medium	Low	High
	Storm impacts increase workload for staff during the immediate response and long-term recovery process	Low	Low	Low	High
	Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas	Low	Medium	Low	High
C3	Localized events can threaten government functions, for example by shutting down arterial roadways and temporarily closing government buildings	Low	Low	Low	High
Sea Level Rise					
B1	Coastal erosion may reduce habitat for freshwater tidal wetlands, maritime uplands, and maritime wetlands	High	Medium	Medium	High

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
	Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities	High	High	Medium	High
	Increased saltwater intrusion due to sea level rise is expected to change the salinity of estuarine communities and to convert lower coastal floodplains from swamp forest to wetlands	High	High	Low	Medium
	Saltwater intrusion may shift plant communities from freshwater-adapted to salt-tolerant species, degrading freshwater wetland habitats that serve as critical nurseries for many species and ultimately transforming productive coastal ecosystems into less diverse salt marshes or open water areas	High	High	Low	Medium
	If the amount of sediment input cannot offset the sea level rise, marshes can eventually drown	High	High	Low	Medium
B3	Groundwater may become more saline, contaminating freshwater aquifers and altering soil chemistry	High	Low	Medium	Low
	Saltwater intrusion may make drinking water from both groundwater and surface waters more vulnerable to contamination and/or expensive to treat and secure	High	Low	Medium	Low
	Areas relying on sole-source aquifers may increasingly face challenges with saltwater intrusion of drinking water supplies	High	Low	Medium	Low
	The combined forces of higher baseline water levels and more frequent storm surge events may remove protective barriers and expose previously stable inland areas to direct marine influence	High	Low	Low	High
	As subsurface soil becomes more saturated, its capacity to absorb additional waters from rainfall or flooding declines, raising the risk for surface inundation by interrupting flow directions	High	High	Low	Medium

CCMP Objective	Risk	Consequence	Likelihood	Spatial Scale	Time Horizon
C1	Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity	Low	Low	Low	Medium
Ocean acidification					
B1	Ocean acidification may cause oysters and other shelled organisms to be unable to grow their shells, affecting the fishery and the marine organisms that rely on them for habitat and food	High	Low	Low	Medium
All					
D1	Monitoring program sampling schedules may be delayed	Medium	Medium	Low	High
	Uncertainty of system-wide model forecasts may be greater	Low	Low	High	Medium
	Uncertainty of net ecosystem services forecast estimates may be greater	Low	Medium	High	Low

4.5 Step 5—Risk Evaluation: Comparing Risks

Step 5 is intended to support individual NEPs in reaching agreement on the assessment of risks. This step involves comparing the risks identified in Step 3 based on the criteria and designations established in Step 4. Specifically, risks are sorted into a consequence/probability matrix for stakeholder review.

For this step, risks were categorized as low, moderate, or high concern based on their likelihood and consequence designations from Step 4. When both likelihood and consequence were low, moderate, or high, the risk was assigned to the corresponding category. For risks with mixed designations, the matrix approach was used to assign an overall concern category based on the intersection of consequence and likelihood. In general, risks with one low and one medium rating were categorized as low concern; risks with one low and one high rating were categorized as moderate concern; and risks with one medium and one high rating were categorized as high concern. Figure 4-1 shows the resulting designations.

Figure 4-1: Consequence/Probability Matrix

		Consequence of Impact		
		Low	**Medium**	**High**
Likelihood of Occurrence	**High**	None Identified	**B1: Protect and restore areas containing significant natural communities and habitats** 1. Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality of aquatic fauna **B2: Protect and restore water quality by minimizing or eliminating targeted sources of water pollution** 2. Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding 3. Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines 4. Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a SSO at manholes or treatment plants	**B1: Protect and restore areas containing significant natural communities and habitats** 1. As water temperatures increase, fish species may experience more frequent and extended periods of low dissolved oxygen, causing physiological stress that can interfere with feeding and reproduction 2. Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities 3. Increased saltwater intrusion due to sea level rise is expected to change the salinity of estuarine communities and to convert lower coastal floodplains from swamp forest to wetlands 4. Saltwater intrusion may shift plant communities from freshwater-adapted to salt-tolerant species, degrading freshwater wetland habitats that serve as critical nurseries for many species and ultimately transforming productive coastal ecosystems into less diverse salt marshes or open water areas 5. If the amount of sediment input cannot offset the sea level rise, marshes can eventually drown **B2: Protect and restore water quality by minimizing or eliminating targeted sources of water pollution** 6. Warmer water temperatures may increase frequency and extent of harmful algal bloom 7. Runoff can reduce water clarity, thus reducing light availability for SAV **B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions** 8. As subsurface soil becomes more saturated, its capacity to absorb additional waters from rainfall or flooding declines, raising the risk for surface inundation by interrupting flow directions

		Consequence of Impact		
		Low	**Medium**	**High**
Likelihood of Occurrence	**Medium**	**B1: Protect and restore areas containing significant natural communities and habitats** 1. Canopy gaps created by wind damage provide places for invasive exotic and/or shade-intolerant plant species to become established **C1: Foster watershed stewardship** 2. Peak seasons for fall foliage, spring blooms, and wildlife watching may shift, creating confusion and lower visitor satisfaction 3. Closure of sites due to flooding or damage from extreme weather 4. Trail washouts due to flooding 5. Damage to boardwalks, downed trees blocking trails, increased marine debris and vessel groundings, and erosion create hazards for staff and visitors **C2: Conduct targeted environmental education efforts regarding estuarine habitats, water quality, and ecosystem services** 6. Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas 7. Training and education programs may be affected by delays or cancellations **D1: Develop and maintain an integrated monitoring network to collect and disseminate information for assessment of ecosystem outcomes and management actions associated with CCMP implementation** 8. Uncertainty of net ecosystem services forecast estimates may be greater	**B1. Protect and restore areas containing significant natural communities and habitats** 1. Mild winters are expected to promote the expansion of invasive exotic species including cogon grass, Chinese tallowtree, and fire ants 2. Desired fish species may shift their migration route to occur further offshore or deeper in the water column, affecting catchability, as has been observed in spot fish 3. Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries 4. Storm surge flooding may overtop, breach, or even drown barrier islands 5. Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring **B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions** 6. During drought, saltwater may reach upstream and impact freshwater intakes **B4: Restore spawning areas for diadromous fish** 7. Warm water can harm underwater grasses and reduce refuge, spawning, forage, and nursery areas for fish species **C1: Foster watershed stewardship** 8. Hotter summers and more frequent heatwaves make outdoor travel less appealing or even dangerous, especially for hiking or beachgoing **D1: Develop and maintain an integrated monitoring network to collect and disseminate information for assessment of ecosystem outcomes and management actions associated with CCMP implementation** 9. Monitoring program sampling schedules may be delayed	**B1. Protect and restore areas containing significant natural communities and habitats** 1. Plants and animals may be weakened by heat and become outcompeted by heat-tolerant species 2. Warmer waters may remove suitable habitat for species at the southern limit of their range (e.g., eelgrass) or at the edge of their thermal tolerance, causing declines 3. Native species may struggle with rising temperatures, and new species may thrive in the new environmental conditions 4. Flora and fauna population ranges may move northward, as has been observed in SAV, black sea bass, summer flounder, and white shrimp 5. Nonnative fishes which may prey on and compete with native fishes are likely to increase in numbers and distribution 6. Water shortages due to drought increase the risk of catastrophic wildfires, temporarily reduce availability of suitable habitat for wetland and aquatic animal populations, and can cause outright mortality for individual animals and plants that are unable to migrate to a suitable habitat 7. Coastal erosion may reduce habitat for freshwater tidal wetlands, maritime uplands, and maritime wetlands **B2: Protect and restore water quality by minimizing or eliminating targeted sources of water pollution** 8. For municipal and industrial water supplies that use surface waters as their primary source, low stream flows resulting from drought can result in poor water quality, high turbidity, and even an inability for water intakes to function properly 9. Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life 10. Flooding can directly contaminate source waters, resulting in drinking water service interruptions and the potential for adverse public health outcomes 11. Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season

		Consequence of Impact		
		Low	**Medium**	**High**
Likelihood of Occurrence	**Low**	**B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions** 1. Increased temperatures can reduce availability of water during times of drought **B4: Restore spawning areas for diadromous fish** 2. Heavy precipitation events and associated flooding can cause significant damage to infrastructure such as utility services, dams, and fish ladders **C1: Foster watershed stewardship** 3. Inland wetlands that provide essential habitats for birding and hunting may shrink or dry out due to heat and drought 4. Disruption of tourist amenities due to access issues 5. Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity **C2: Conduct targeted environmental education efforts regarding estuarine habitats, water quality, and ecosystem services** 6. Storm impacts increase workload for staff during the immediate response and long-term recovery process **C3: Provide tools and training to support ecosystem-based management** 7. Localized events can threaten government functions, for example by shutting down arterial roadways and temporarily closing government buildings **D1: Develop and maintain an integrated monitoring network to collect and disseminate information for assessment of ecosystem outcomes and management actions associated with CCMP implementation** 8. Uncertainty of system-wide model forecasts may be greater	**B1: Protect and restore areas containing significant natural communities and habitats** 1. More intense hurricanes may damage wetlands and natural barriers which help to protect infrastructure and communities from storm surge, increasing the vulnerability to subsequent storms	**B1: Protect and restore areas containing significant natural communities and habitats** 1. Ocean acidification may cause oysters and other shelled organisms to be unable to grow their shells, affecting the fishery and the marine organisms that rely on them for habitat and food **B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions** 2. Groundwater may become more saline, contaminating freshwater aquifers and altering soil chemistry 3. Saltwater intrusion may make drinking water from both groundwater and surface waters more vulnerable to contamination and/or expensive to treat and secure 4. Areas relying on sole-source aquifers may increasingly face challenges with saltwater intrusion of drinking water supplies 5. The combined forces of higher baseline water levels and more frequent storm surge events may remove protective barriers and expose previously stable inland areas to direct marine influence

5 Action Plan

An action plan documents the plan for managing the risks identified during the vulnerability assessment (Section 4), including actions that might help to decrease the risks and increase the sustainability of APNEP's program and goals.

The process of developing an action plan involves five steps, which build off the five steps completed for the vulnerability assessment:

- Step 6. Establish the context for the action plan
- Step 7: Decide on a risk management course
- Step 8: Develop adaptation actions
- Step 9: Prepare and implement an action plan
- Step 10: Monitor and review

The following sections describe Steps 6–10 in greater detail.

5.1 Step 6—Establishing the Context for the Action Plan

Step 6 is intended to support individual NEPs in re-examining the context of their organization to help create and implement an action plan that responds to the risks identified in their vulnerability assessment.

For this step, APNEP explored opportunities and constraints that influence their organization's choices and developed a list of potential partners that could help address the risks they identified in their vulnerability assessment. To do this, APNEP identified organizational barriers and opportunities across seven different categories: (1) social, (2) technical, (3) administrative, (4) political, (5) legal, (6) economic, and (7) environmental. Next, APNEP identified potential partnerships/organizations for each CCMP objective. Table 5-1 below shows APNEP's identified barriers, opportunities, and partnerships for each CCMP objective. CCMP objectives under the "A - Understand" theme were excluded by design due to the nature of the objectives/actions.

Table 5-1: Organizational Context and Potential Partners

CCMP Objective	Organizational Barriers	Organizational Opportunities	Partner / Organization*
B1: Protect and restore areas containing significant natural communities and habitats	**Social:** Public may not support new management strategies and adaption actions to respond to climate change. Extensive estuarine coastline limits the ability to effectively address erosion. **Technical:** Limited data for many resources and very limited capacity to design and implement strategies for climate adaptation actions. Limited ability to address invasive species. Limited ability to address species migration. **Administrative:** Funding constraints for implementation of strategies for climate adaptation actions. Limited staff capacity. **Political:** Inconsistent support for climate adaptation strategies. APNEP cannot advocate. **Legal:** Limited statutory and regulatory authority for federal, state, and local governments to implement climate adaptation actions. Wetland regulations are changing and protections are being lost. Limited regulatory structure for wetland restoration (i.e., thin layer placement) **Economic:** Lack of funding for addressing climate adaptation strategies. Limited funding to address habitat restoration and resilience measures. Limited understanding of potential economic impacts from climate change on resources. **Environmental:** Effectively addressing that portion of environmental conditions is improbable due to global is improbable. APNEP does not have the capacity to manage water or air temperature. Limited ability to address invasive species. Very limited ability to address ocean acidification.	**Social:** Increase public awareness about changes documented in estuary system. Many of the communities in the APNEP study area are experiencing impacts from climate change so there are numerous partners focused on resilience. **Technical:** APNEP has connections to several climate-related science resources and expertise in the watershed (government and university) for information. **Administrative:** APNEP's host, NC DEQ, has a State Resilience Office available for collaboration. **Political:** Interest groups could garner support to protect natural resources from existing and emerging climate change impacts. **Legal:** A regulatory authority could potentially protect certain species. **Economic:** Could apply for various grants for activities to raise awareness. APNEP will continue to study economic impacts of loss of significant natural resources due to climate change. **Environmental:** Opportunities may be present for implementing habitat adaptation measures for some habitats. May be able to enact limited actions to slow replacement by non-native species in some habitats. May be able to target some habitats for resilience measures (e.g., tide gates, habitat restoration)	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments, NC WRC, NC DACS
B2: Protect and restore water quality by minimizing or eliminating	**Social:** Public may not support new management strategies and adaption actions to respond to climate change. **Technical:** Limited data for many resources and very limited capacity to design and implement strategies for	**Social:** Increase public awareness about changes documented in estuary system. Many of the communities in the APNEP study area are experiencing impacts from climate change so there are numerous groups focused on resilience. Lost resources may	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities,

CCMP Objective	Organizational Barriers	Organizational Opportunities	Partner / Organization*
targeted sources of water pollution	climate adaptation actions. **Administrative:** Funding constraints for implementation of strategies for climate adaptation actions. Limited staff capacity. **Political:** Inconsistent support for climate adaptation strategies. APNEP cannot advocate. **Legal:** Limited statutory and regulatory authority for federal, state, and local governments to implement climate adaptation actions. Limited ability to influence floodplain development. **Economic:** Lack of funding for addressing climate adaptation strategies. Limited understanding of potential economic impacts from climate change on resources. **Environmental:** Effectively addressing that portion of environmental conditions is improbable due to global is improbable. APNEP does not have the capacity to manage water or air temperature.	increase public support for adaptations actions. Many partners support adaptation/resilience action implementation for habitats. **Technical:** APNEP has connections to several climate related science resources and expertise in the watershed (government and university) for information. Numerous adaptation strategies exist for implementation. **Administrative:** APNEP's host, NC DEQ, has a State Resilience Office available for collaboration. **Political:** Interest groups could garner support to protect natural resources from existing and emerging climate change impacts. **Legal:** A regulatory authority could potentially protect certain species. NC Flood blueprint program may be able to support changes in floodplain development. **Economic:** Could apply for various grants for activities to raise awareness. APNEP will continue to study economic impacts of loss of significant natural resources due to climate change. Increase impacts may lead to increased economic support for floodplain management, wastewater infrastructure improvements, and other resilience efforts. **Environmental:** Many partners support adaptation/resilience action implementation for habitats. Limited opportunities of mitigating climate. Opportunities may be present for implementing habitat adaptation measures for some habitats.	NGOs, COGs, Tribal, Local Governments, NC WRC, NC DACS
B3: Ensure hydrological processes in rivers and estuaries support significant natural communities and ecosystem functions	**Social:** Public may not support new management strategies and adaption actions to respond to climate change. **Technical:** Limited data for many of resources and very limited capacity to design and implement strategies for climate adaptation actions. **Administrative:** Funding constraints for implementation of strategies for climate adaptation actions. Limited staff capacity.	**Social:** Increase public awareness about changes documented in estuary system. Many of the communities in the APNEP study area are experiencing impacts from climate change so there are numerous groups focused on resilience. **Technical:** APNEP has connections to several climate-related science resources and expertise in the watershed (government and university) for information.	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments,

CCMP Objective	Organizational Barriers	Organizational Opportunities	Partner / Organization*
	Political: Inconsistent support for climate adaptation strategies. APNEP cannot advocate. **Legal:** Limited statutory and regulatory authority for federal, state, and local governments to implement climate adaptation actions. **Economic:** Lack of funding for addressing climate adaptation strategies. Limited understanding of potential economic impacts from climate change on resources. **Environmental:** Effectively addressing environmental conditions is improbable due to global environmental conditions. APNEP does not have the capacity to manage water or air temperature.	**Administrative:** APNEP's host, NC DEQ, has a State Resilience Office available for collaboration. **Political:** Interest groups could garner support to protect natural resources from existing and emerging climate change impacts. **Legal:** A regulatory authority could potentially protect certain species. **Economic:** Could apply for various grants for activities to raise awareness. APNEP will continue to study economic impacts of loss of significant natural resources due to climate change. **Environmental:** Opportunities may be present for implementing habitat adaptation measures for some habitats. Could result in connection of new habitats as water rises.	NC WRC, NC DACS
B4: Restore spawning areas for diadromous fish	**Social:** Loss of fishing access may result in blame on management agencies. **Technical:** Limited data may hinder diagnosis or links to causation. **Administrative:** Repair and rebuilding will require time and funds **Political:** Cross-jurisdictional cooperation issues due to spawning areas crossing multiple political boundaries. **Legal:** Permits may be needed for repair or replacement. **Economic:** Unknown economic impacts for loss or damage to spawning activities. Potential loss in fishing opportunities. **Environmental:** Potential widespread environmental impacts from loss of habitat and declines in diadromous species populations.	**Social:** Learning and communication opportunities. **Technical:** May be able to replace damaged infrastructure with more effective approaches/ facilities **Administrative:** APNEP's host, NC DEQ, has Division of Marine Fisheries available for collaboration. Additional collaboration opportunities with NC WRC. **Political:** Cross-jurisdictional cooperation opportunities. **Legal:** Potential for fast-tracking permits for infrastructure repairs. **Economic:** Unknown **Environmental:** Increased spawning areas if increased rains result in fuller wetlands.	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments, NC WRC, NC DACS
C1: Foster watershed stewardship	**Social:** Potential for disconnecting with natural world due to uncomfortable and potentially dangerous conditions. **Technical:** Limited data on whether climate changes (i.e., heatwaves) affect natural resource interactions.	**Social:** Longer/hotter summers with less rain could increase outdoor stewardship opportunities. More residents willing to be stewards given increase in environmental issues. **Technical:** Increase in number of engaged persons	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities,

CCMP Objective	Organizational Barriers	Organizational Opportunities	Partner / Organization*
	(i.e., less birders) **Administrative:** Loss of staff and partner time preparing for events that do not occur. Loss of expended funds. Potential cost due to damaged facilities. **Political:** Partisan debate over the impacts of climate change. **Legal:** N/A **Economic:** Loss of recreation and tourist income. **Environmental:** Damage to natural resources and infrastructure.	could increase citizen science monitoring opportunities. **Administrative:** Result in need to establish environmental education program specific to recurring extreme weather events and other stressors. **Political:** More constituents affected could result in more political attention to issues. **Legal:** N/A **Economic:** Could apply for various grants for activities to raise awareness. **Environmental:** Changes to natural resources and species present could provide new stewardship opportunities to certain areas.	NGOs, COGs, Tribal, Local Governments, NC WRC, NC DACS
C2: Conduct targeted environmental education efforts regarding estuarine habitats, water quality, and ecosystem services	**Social:** May lead to public dissatisfaction with event or program if cancelled. **Technical:** May need to plan alternative sites or events. **Administrative:** Loss of staff time preparing for events that do not occur. Loss of expended funds. Potential cost due to damage to natural areas. **Political:** Potential loss of political support if an event is impacted. **Legal:** Potential for contract litigation. **Economic:** Reduction in participation and loss of funding cancelled events. **Environmental:** Impacted natural areas may need significant time to recover.	**Social:** Rescheduled events may provide public learning opportunities about climate events. **Technical:** Design new event formats. **Administrative:** Fewer events reduce capacity constraints on staff. **Political:** Politicians responding to storms or other dramatic climate events could draw attention towards needs **Legal:** Opportunity for more climate legislation that includes environmental education **Economic:** Climate recovery funds (i.e., FEMA) could contribute to environmental education efforts **Environmental:** Impacts could highlight areas of greatest need (i.e., new maps in smaller, less mapped areas)	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments, NC WRC, NC DACS
C3: Provide tools and training to support ecosystem-based management	**Social:** May lead to public dissatisfaction with event or program if cancelled. **Technical:** May need to plan alternative sites or events. **Administrative:** Loss of staff and partner time preparing for events that do not occur. Loss of expended funds. Potential cost due to damaged facilities. **Political:** Potential loss of political support if an event	**Social:** More tools and training opportunities available based on emergent risks **Technical:** Create new tools and training for ecosystem-based management for emergent risks **Administrative:** New staff opportunities to address emergent risks **Political:** Political support for increased used of ecosystem-based management **Legal:** Required trainings for ecosystem-based	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments,

CCMP Objective	Organizational Barriers	Organizational Opportunities	Partner / Organization*
	is impacted. **Legal:** N/A **Economic:** Reduction in participation and loss of funding cancelled events. **Environmental:** Impacted natural areas may need significant time to recover.	management **Economic:** Could apply for various grants for activities to administer trainings **Environmental:** N/A	NC WRC, NC DACS
D1: Develop and maintain an integrated monitoring network to collect and disseminate information for assessment of ecosystem outcomes and management actions associated with CCMP implementation	**Social:** Public may request data that is delayed or unavailable. **Technical:** Limited data for many resources. **Administrative:** Funding constraints for implementation of monitoring strategies. Limited staff capacity. **Political:** Inconsistent support for environmental monitoring and assessments. **Legal:** Very limited statutory and regulatory support. **Economic:** Lack of funding. **Environmental:** Need for focused monitoring activities to support NEP mission and CCMP implementation.	**Social:** Increase public awareness about the need for monitoring and assessment. **Technical:** New approaches to collection of data constantly emerging. **Administrative:** Limited funds and partner support for consistent long-term monitoring **Political:** Interest groups could garner support to improve data collection and interpretation to better manage environmental resources **Legal:** Potential regulations to support monitoring / funding. Consideration of legal penalties to support **Economic:** Economic studies could support the case for monitoring. **Environmental:** Will adapt field work as necessary to address impact from weather events	APNEP, NC DEQ (DMF, DCM, DWR, SEO), VA DEQ, Universities, NGOs, COGs, Tribal, Local Governments, NC WRC, NC DAC

*See acronym list for full name of organizations

5.2 Step 7—Risk Evaluation: Deciding on a Course

APNEP completed a high-level evaluation of the risks identified during the vulnerability assessment to determine how organizational resources should be prioritized within the adaptation planning process. Recognizing that not all identified risks could be addressed through direct mitigation, APNEP balanced the need to understand potential adaptation actions with the practical limitations of available resources. To support decision-making, APNEP reviewed common adaptation and mitigation strategies, assessed whether risks appeared realistically addressable, and screened out risks that might be more appropriately managed through alternative approaches.

During this step, APNEP examined how risks interacted with one another, including shared impacts on habitats, resources, and organizational objectives. This analysis helped identify opportunities where a single adaptation action could reduce multiple related risks, improving the efficiency and effectiveness of future adaptation efforts.

APNEP also evaluated whether mitigation was a realistic option for each risk by developing a general understanding of the types of actions that could potentially reduce risk likelihood or consequences. While specific adaptation actions were not selected at this stage, APNEP reviewed available adaptation approaches and considered whether practical solutions existed that could reasonably lower identified risks.

Using this information, APNEP assigned a preliminary risk management approach to each risk. Four approaches were considered:

- **Mitigate**: Reduce the likelihood and/or consequences of the risk through adaptation actions.
- **Transfer**: Rely on partner organizations or external entities to implement actions that reduce risk exposure or impacts.
- **Accept**: Continue operating under existing conditions and address consequences if the risk occurs.
- **Avoid**: Reduce exposure to a risk by modifying or narrowing organizational activities or objectives associated with that risk.

APNEP considered organizational priorities, stakeholder interests, available resources, partnerships, and the geographic scale of impacts when selecting an approach for each risk. As a result of this step, APNEP established a prioritized set of risks that were candidates for mitigation and documented a high-level management approach for all identified risks. This provided the foundation for subsequent steps focused on identifying, evaluating, and selecting specific adaptation actions (Step 8; Section 5.3).

Table 5-2 shows APNEP's chosen risk management approach for each risk. The table retains risks designated for avoidance to preserve future flexibility should new information, technologies, partnerships, or funding opportunities emerge.

Table 5-2: Risk Identification – Choosing an Approach

CCMP Objective	Risk	Risk Management Approach
Warmer summers		
B1	Plants and animals may be weakened by heat and become outcompeted by heat-tolerant species	Accept
	Warmer waters may remove suitable habitat for species at the southern limit of their range (e.g., eelgrass) or at the edge of their thermal tolerance, causing declines	Accept
	Native species may struggle with rising temperatures, and new species may thrive in the new environmental conditions	Accept
C1	Hotter summers and more frequent heatwaves make outdoor travel less appealing or even dangerous, especially for hiking or beachgoing	Accept
	Peak seasons for fall foliage, spring blooms, and wildlife watching may shift, creating confusion and lower visitor satisfaction	Accept
Warmer winters		
B1	Mild winters are expected to promote the expansion of invasive exotic species including cogon grass, Chinese tallowtree, and fire ants	Accept
Warmer waters		
B1	Desired fish species may shift their migration route to occur further offshore or deeper in the water column, affecting catchability, as has been observed in spot fish	Accept
	Flora and fauna population ranges may move northward, as has been observed in SAV, black sea bass, summer flounder, and white shrimp	Accept
	As water temperatures increase, fish species may experience more frequent and extended periods of low dissolved oxygen, causing physiological stress that can interfere with feeding and reproduction	Accept
	Nonnative fishes which may prey on and compete with native fishes are likely to increase in numbers and distribution	Accept
B2	Warmer water temperatures may increase frequency and extent of harmful algal bloom	Mitigate
B4	Warm water can harm underwater grasses and reduce refuge, spawning, forage, and nursery areas for fish species	Accept
Increasing droughts		
B1	Water shortages due to drought increase the risk of catastrophic wildfires, temporarily reduce availability of suitable habitat for wetland and aquatic animal populations, and can cause outright mortality for individual animals and plants that are unable to migrate to a suitable habitat	Accept

CCMP Objective	Risk	Risk Management Approach
B2	For municipal and industrial water supplies that use surface waters as their primary source, low stream flows resulting from drought can result in poor water quality, high turbidity, and even an inability for water intakes to function properly	Transfer
B3	During drought, saltwater may reach upstream and impact freshwater intakes	Transfer
	Increased temperatures can reduce availability of water during times of drought	Accept
C1	Inland wetlands that provide essential habitats for birding and hunting may shrink or dry out due to heat and drought	Accept
Increasing storminess		
B1	Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality of aquatic fauna	Mitigate
	Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries	Mitigate
	Storm surge flooding may overtop, breach, or even drown barrier islands	Accept
	Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring	Mitigate
	Canopy gaps created by wind damage provide places for invasive exotic and/or shade-intolerant plant species to become established	Accept
	More intense hurricanes may damage wetlands and natural barriers which help to protect infrastructure and communities from storm surge, increasing the vulnerability to subsequent storms	Accept
B2	Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life	Mitigate
	Flooding can directly contaminate source waters, resulting in drinking water service interruptions and the potential for adverse public health outcomes	Accept
	Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season	Mitigate
	Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding	Mitigate

CCMP Objective	Risk	Risk Management Approach
	Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines	Mitigate
	Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a SSO at manholes or treatment plants	Mitigate
	Runoff can reduce water clarity, thus reducing light availability for SAV	Mitigate
B4	Heavy precipitation events and associated flooding can cause significant damage to infrastructure such as utility services, dams, and fish ladders	Accept
C1	Disruption of tourist amenities due to access issues	Transfer
	Closure of sites due to flooding or damage from extreme weather	Transfer
	Trail washouts due to flooding	Transfer
	Damage to boardwalks, downed trees blocking trails, increased marine debris and vessel groundings, and erosion create hazards for staff and visitors	Accept
C2	Training and education programs may be affected by delays or cancellations	Mitigate
	Storm impacts increase workload for staff during the immediate response and long-term recovery process	Accept
	Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas	Mitigate
C3	Localized events can threaten government functions, for example by shutting down arterial roadways and temporarily closing government buildings	Accept
Sea Level Rise		
B1	Coastal erosion may reduce habitat for freshwater tidal wetlands, maritime uplands, and maritime wetlands	Accept
	Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities	Mitigate
	Increased saltwater intrusion due to sea level rise is expected to change the salinity of estuarine communities and to convert lower coastal floodplains from swamp forest to wetlands	Accept

CCMP Objective	Risk	Risk Management Approach
	Saltwater intrusion may shift plant communities from freshwater-adapted to salt-tolerant species, degrading freshwater wetland habitats that serve as critical nurseries for many species and ultimately transforming productive coastal ecosystems into less diverse salt marshes or open water areas	Accept
	If the amount of sediment input cannot offset the sea level rise, marshes can eventually drown	Transfer
B3	Groundwater may become more saline, contaminating freshwater aquifers and altering soil chemistry	Accept
	Saltwater intrusion may make drinking water from both groundwater and surface waters more vulnerable to contamination and/or expensive to treat and secure	Accept
	Areas relying on sole-source aquifers may increasingly face challenges with saltwater intrusion of drinking water supplies	Accept
	The combined forces of higher baseline water levels and more frequent storm surge events may remove protective barriers and expose previously stable inland areas to direct marine influence	Accept
	As subsurface soil becomes more saturated, its capacity to absorb additional waters from rainfall or flooding declines, raising the risk for surface inundation by interrupting flow directions	Accept
C1	Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity	Mitigate
Ocean acidification		
B1	Ocean acidification may cause oysters and other shelled organisms to be unable to grow their shells, affecting the fishery and the marine organisms that rely on them for habitat and food	Accept
All		
D1	Monitoring program sampling schedules may be delayed	Accept
	Uncertainty of system-wide model forecasts may be greater	Accept
	Uncertainty of net ecosystem services forecast estimates may be greater	Accept

5.3 Step 8—Adaptation Actions

In this step, APNEP reviewed the risks selected for mitigation in Step 7 and chose a set of adaptation actions that could be effective. The objective of this step was to develop a list of adaptation actions for APNEP to further assess before developing and implementing an action plan.

5.3.1 Step 8a—Finding Adaptation Actions

APNEP identified potential adaptation actions for the risks selected for mitigation in Step 7 and developed a list of adaptation actions that addressed those risks. Risks designated for transfer, acceptance, or avoidance are retained in Table 5-2 for future consideration during monitoring and review but were not advanced for action development at this stage.

Building on the previous steps of the process, APNEP used the risk pathways developed in Step 3, where each risk was defined by how recurring extreme weather events and other stressors could affect organizational goals. The consequence and likelihood ratings established in Steps 4 and 5—and represented within the consequence/probability (C/P) matrix (Figure 4-1)—provided the foundation for evaluating how adaptation actions could reduce risk. APNEP also drew on the review of adaptation options completed in Step 7 to support the identification of potential risk mitigation strategies.

APNEP recognized that the purpose of adaptation actions is to reduce the likelihood and/or consequence of a risk, thereby moving risks toward the lower-left (green) corner of the C/P matrix. The objective of this step was to identify actions that could substantially reduce risk by altering the underlying cause-and-effect pathways that connect recurring extreme weather events and other stressors to adverse consequences.

To identify adaptation opportunities, APNEP examined the causal pathways through which recurring extreme weather events and other stressors could prevent achievement of organizational goals. This process helped identify intervention points where actions could disrupt those pathways and reduce risk. Where knowledge gaps limited understanding of system processes, APNEP considered research and information gathering as potential initial adaptation actions, while recognizing that uncertainty should not delay action. However, depending on the circumstances; delaying action to allow research to reduce uncertainty can be a reasonable path. Using professional judgment, technical expertise, and available adaptation-planning resources, APNEP then identified a broad range of plausible adaptation actions, including actions that could provide co-benefits, address multiple risks simultaneously, or represent novel approaches. The same adaptation action was allowed to address more than one risk where appropriate.

At this stage, APNEP generated a list of candidate actions for further evaluation rather than a detailed assessment of adaptation actions. APNEP screened each action at a high level to determine whether it was reasonable to expect that implementation of the action alone or in combination with other actions, could reduce a risk by at least one category of consequence or likelihood within the C/P matrix. Actions that were unlikely to produce a meaningful reduction in risk were not prioritized.

APNEP also evaluated whether each risk identified for mitigation could realistically be paired with at least one potential adaptation action.

As a result of this step, APNEP developed a preliminary portfolio of adaptation actions linked to priority risks. These actions served as the basis for the subsequent evaluation and selection process conducted in Step 8b. Table 5-3 below shows the list of potential adaptation actions developed by APNEP.

Table 5-3: Selection of Adaptation Actions

CCMP Objective	Risk Description	C/P matrix	Step 8a		
			Potential Adaptation Action (1 or more for each risk)	Could the action reduce likelihood?	Could the action reduce consequences?
B1	Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality aquatic fauna	Top center	Support implementation of BMPs to address stormwater runoff to reduce site nutrient loads	Yes	Yes
	Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries	Middle center	Support the installation of living shoreline and other nature-based strategies	Yes	Yes
	Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring	Middle center	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	Yes	Yes
	Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities	Top right	Support wetland protection and restoration efforts	Yes	Yes
B2	Warmer water temperatures may increase frequency and extent of harmful algal bloom	Top right	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	Yes	Yes
	Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life	Middle right	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	Yes	Yes

CCMP Objective	Risk Description	C/P matrix	Step 8a		
			Potential Adaptation Action (1 or more for each risk)	Could the action reduce likelihood?	Could the action reduce consequences?
	Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season	Middle right	Support implementation of BMPs and other Nature-based strategies to address stormwater runoff	Yes	Yes
	Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding	Top center	Support Wastewater treatment plant / system upgrades	Yes	Yes
	Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines	Top center	Support Wastewater treatment plant / system upgrades	Yes	Yes
	Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a SSO at manholes or treatment plants	Top center	Support Wastewater treatment plant / system upgrades	Yes	Yes
	Runoff can reduce water clarity, thus reducing light availability for SAV	Top right	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff (potential for new WQ standard)	Yes	Yes
C1	Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity	Bottom left	Support the implementation of living shoreline and other nature-based strategies to address stormwater runoff (potential for new WQ standard)	Yes	Yes
C2	Training and education programs may be affected by delays or cancellations	Middle left	Reschedule/ adjust training activities	Yes	Yes
	Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas	Middle left	Repair/ restore as possible or realignment research/ education efforts	No	Yes

5.3.2 Step 8b—Selecting Adaptation Actions

APNEP evaluated the preliminary list of adaptation actions identified in Step 8a to determine which actions were both appropriate and effective for reducing identified risks. While Step 8a focused on identifying potential adaptation actions that could disrupt risk pathways and reduce risk likelihood or consequence, Step 8b focused on screening, ranking, and selecting actions for implementation.

In this step, APNEP screened the adaptation actions identified in Step 8a to determine whether they are candidates for implementation. Actions that passed their screening tests were ranked according to risk-reduction potential, with the top actions likely to be selected for implementation.

APNEP assessed each adaptation action using six evaluation criteria, using a 5-point scale for each category (1=low, 5=high): (1) risk reduction potential, (2) feasibility and effectiveness, (3) cost and cost-effectiveness, (4) ancillary costs and benefits, (5) equity and fairness, and (6) robustness. The purpose of this review was to identify actions that were not only capable of reducing risk but were also practical, affordable, sustainable, and suitable for implementation within the organizational context.

APNEP confirmed the **risk reduction potential** initially identified in Step 8a by evaluating whether each adaptation action, individually or in combination with other actions, could reasonably be expected to move a risk at least one category on the consequence/probability (C/P) matrix. APNEP reviewed actions to determine whether they remained capable of reducing the likelihood and/or consequence of the targeted risk.

APNEP assessed the **feasibility and effectiveness** of each action by considering whether the action represented a proven strategy, whether sufficient time existed to implement the action before risks occurred, whether implementation was politically feasible, whether the necessary authority or permissions could be obtained, and whether the action would be acceptable to stakeholders and affected communities.

Cost and cost-effectiveness were also evaluated. APNEP considered the affordability of each action, the relationship between implementation costs and expected risk reduction, potential long-term maintenance requirements, opportunities to avoid future damages or costs, and the potential for positive economic benefits. APNEP assessed actions in the context of available organizational resources and implementation capacity.

APNEP reviewed **ancillary costs and benefits** to identify potential tradeoffs and co-benefits associated with each adaptation action. APNEP considered whether actions could be maladaptive by creating problems in other locations or sectors, encouraging unintended risk-taking behavior, or limiting future adaptation options. At the same time, APNEP evaluated whether actions could provide co-benefits by addressing multiple risks, supporting other organizational objectives, or producing social, environmental, or economic benefits. Lastly, APNEP also considered sustainability, including the balance between social, environmental, and economic costs and benefits, impacts on ecosystem functions and services, and the balance of present and future needs.

For **equity and fairness**, APNEP examined whether actions aligned with organizational values and principles, whether any groups could experience disproportionately high and adverse impacts, whether costs and benefits were distributed fairly, and whether implementation could limit adaptation opportunities for other communities or sectors.

APNEP also evaluated the **robustness** of each action under future uncertainty by determining whether they (1) could perform under a range of future conditions, (2) were flexible and could be modified as conditions changed, (3) contributed to a coordinated adaptation strategy, and (4) represented no-regrets or win-win actions that would provide benefits regardless of how future conditions evolved.

APNEP used the screening process to determine whether individual actions were suitable for implementation rather than as a simple pass/fail exercise. Where actions did not perform well against certain criteria, APNEP considered whether obstacles could be overcome through partnerships, additional resources, changes in implementation strategy, or mitigation of unintended consequences. APNEP retained any actions that did not advance at this time for future consideration because changing conditions, resources, or opportunities could improve their viability.

Following the screening process, APNEP returned to the vulnerability assessment and consequence/probability matrix to rank adaptation actions according to the amount of risk they would reduce. Actions targeting high-impact (red) risks received the highest priority because those risks were determined to have both high likelihood and high consequence. Additional priority was given to actions that reduced multiple risks, generated co-benefits, or moved risks substantially toward the lower-left corner of the C/P matrix. Actions focused solely on medium-impact (yellow) risks were evaluated in the context of overall risk reduction, while actions addressing only low-impact (green) risks received lower priority unless they could be implemented with minimal effort or as components of higher-priority actions.

Finally, APNEP reviewed all risks originally selected for mitigation in Step 7 and reassessed any risks without an associated adaptation action because they would not be actively mitigated at this time. Where mitigation actions could not be identified, did not pass screening criteria, or could not be implemented because of resource limitations, APNEP recognized that alternative approaches such as risk acceptance or avoidance might be necessary. This review also highlighted situations where significant risks remained unmitigated, requiring continued consideration of organizational priorities and the balance between managing for resilience and managing for change.

As a result of this step, APNEP identified, screened, and ranked adaptation actions that provided the greatest achievable reduction in risk and established the actions that would move forward for implementation.

Table 5-4 below highlights these rankings and adaptation priorities, including the score for each evaluation category (1=low, 5=high) and the total score across categories. The total scores provide APNEP with an additional metric for prioritizing potential adaptation options.

Table 5-4: Evaluation of Adaption Actions Using Ranking Criteria (1=low, 5=high)

CCMP Objective	Risk Description	Potential Adaptation Action	Step 8b						
			Risk Reduction Potential	Feasibility and Effectiveness	Cost and Cost-Effectiveness	Ancillary Costs and Benefits	Equity and Fairness	Robustness	Total
B1	Increased runoff containing excess nutrients may lead to more frequent or severe hypoxic conditions, resulting in mass mortality of aquatic fauna	Support implementation of BMPs to address stormwater runoff to reduce site nutrient loads	3	3	2	3	4	4	19
	Increased storm surges may erode shorelines and kill vegetation in maritime grasslands, tidal marshes, estuaries, lower reaches of coastal plain rivers, and low-lying wetlands near estuaries	Support the installation of living shoreline and other nature-based strategies	3	3	2	3	3	4	18
	Heavy precipitation events are expected to damage waterways and riparian zones by causing excessive flooding and scouring	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	2	3	2	3	3	3	16
	Loss of wetlands due to sea level rise may result in habitat losses that would impact both commercial and recreational fisheries, decreasing buffering capacity, adversely impacting water quality, and reducing the resilience of coastal communities	Support wetland protection and restoration efforts	3	3	2	3	4	4	19
B2	Warmer water temperatures may increase frequency and extent of harmful algal bloom	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	1	2	1	3	4	1	12

CCMP Objective	Risk Description	Potential Adaptation Action	Step 8b						
			Risk Reduction Potential	Feasibility and Effectiveness	Cost and Cost-Effectiveness	Ancillary Costs and Benefits	Equity and Fairness	Robustness	Total
	Floodwaters may carry nonpoint-source pollutants (i.e., nutrients, sediments, pathogens, heavy metals, and chemical constituents) as well as harmful substances from waste facilities such as onsite septic systems and waste lagoons into surface waters during extreme rain events, potentially resulting in exceedances of state water quality standards for human health and aquatic life	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff	1	2	1	3	2	1	10
	Increased pathogen and nutrient loading to the watershed due to extreme precipitation events may increase beach closures and result in a shortened shellfish harvest season	Support implementation of BMPs and other Nature-based strategies to address stormwater runoff	1	1	1	3	4	1	11
	Sewer lines often occur in low-lying areas and may be susceptible to inflow and infiltration during flooding	Support Wastewater treatment plant / system upgrades	4	2	2	3	3	4	18
	Treatment plants may become overwhelmed with additional load due to water entering sewer systems through manholes and cracks in lines	Support Wastewater treatment plant / system upgrades	4	4	2	3	3	4	20
	Sewage may leak from sewer lines in parts of the system away from flooded areas or cause a SSO at manholes or treatment plants	Support Wastewater treatment plant / system upgrades	4	4	2	3	3	4	20

CCMP Objective	Risk Description	Potential Adaptation Action	Step 8b						
			Risk Reduction Potential	Feasibility and Effectiveness	Cost and Cost-Effectiveness	Ancillary Costs and Benefits	Equity and Fairness	Robustness	Total
	Runoff can reduce water clarity, thus reducing light availability for SAV	Support the implementation of BMPs and other nature-based strategies to mitigate stormwater runoff (potential for new WQ standard)	2	2	2	3	4	3	16
C1	Coastal land loss from sea level rise may create follow-on water quality concerns such as potential increases in sedimentation and turbidity	Support the implementation of living shoreline and other nature-based strategies to address stormwater runoff (potential for new WQ standard)	2	3	2	3	4	3	17
C2	Training and education programs may be affected by delays or cancellations	Reschedule/ adjust training activities	2	4	5	4	4	4	23
	Reduced access to natural resource demonstration areas, biological and environmental research and education due to damages to natural areas	Repair/ restore as possible or realignment research/ education efforts	2	4	3	4	5	4	22

5.4 Step 9—Preparing and Implementing an Action Plan

With the completion of Steps 1 through 8, APNEP identified adaptation actions to address priority risks. APNEP's next steps to prepare and implement an action plan include (1) establishing a framework to support implementation, accountability, and progress tracking and (2) designate responsible parties to oversee implementation.

As part of this process, APNEP may review the proposed risk management approach with leadership, staff, partners, and other key decision makers to confirm concurrence with the selected adaptation strategies. This includes confirming approaches for risks that will be mitigated, transferred, accepted, or avoided.

To support implementation, APNEP may also establish two complementary tracking systems:

- **Action Tracking System**: Documents each adaptation action, the risks it addresses, responsible parties, implementation status, and key milestones. Individual actions may contribute to reducing multiple risks.
- **Risk Tracking System**: Tracks each identified risk and records the adaptation actions being used to manage that risk, including implementation progress and completion status. Risks may be addressed through multiple actions, and transferred risks are tracked to ensure appropriate follow-through with partner organizations.

APNEP may revisit opportunities identified during the risk assessment process and incorporate strategies to capture potential benefits where appropriate. Depending on the opportunity, APNEP may choose to exploit, enhance, share, or accept positive outcomes associated with changing conditions.

After assigning responsible parties and identifying potential funding sources, APNEP may transition from planning to implementation. Designated project managers would be responsible for advancing adaptation actions through project development and execution. This may include refining project scope, conducting site assessments, coordinating partnerships, securing funding, obtaining permits, engaging technical experts, and managing implementation activities. APNEP may regularly update both tracking systems to monitor progress, maintain accountability, and ensure adaptation actions continue to reduce risks over time.

5.5 Step 10—Monitoring and Review

After preparing and implementing the action plan, APNEP may then establish a process for monitoring progress, evaluating outcomes, and updating both the vulnerability assessment, adaptation strategy, and ultimately its future CCMPs. The purpose of this phase is to ensure that adaptation actions remain effective, relevant, and aligned with changing environmental, organizational, and stakeholder conditions.

APNEP may conduct reviews of adaptation projects as they are implemented and completed to assess whether actions are achieving the intended reduction in climate-related risks. During these reviews, APNEP may also revisit risks that were previously accepted, transferred, or avoided to determine whether new information or changing circumstances warrant a different management approach.

To maintain an up-to-date understanding of risks, APNEP may monitor emerging science, regional environmental conditions, and new information regarding projected effects of recurring extreme weather events and other stressors. As updated research, datasets, and assessments become available, APNEP may evaluate whether assumptions made during the vulnerability assessment remain valid and whether existing risks should be reassessed.

APNEP may also review changes in organizational context that could affect implementation priorities. This may include changes in strategic goals, staffing, budgets, partnerships, regulatory requirements, political conditions, or programmatic responsibilities. Any significant changes would be incorporated into future updates of the adaptation plan to ensure it remains aligned with organizational needs and available resources.

As part of the monitoring and review process, APNEP may:

- Review implementation progress for all adaptation actions and track completion status.
- Evaluate whether adaptation actions are reducing risks as intended.
- Identify any unintended outcomes, both positive and negative.
- Reassess risk rankings as conditions, scientific understanding, and program priorities evolve.
- Identify new stressors, vulnerabilities, or opportunities that may emerge over time.
- Update adaptation actions if effective approaches become available.
- Revisit opportunities identified during the risk assessment process and evaluate whether additional actions are warranted to capture associated benefits.

Recognizing that risk adaptation is an iterative process, APNEP intends for the adaptation plan to serve as a living document that will be updated periodically rather than treated as a one-time planning effort (updates typically occur on a 5–10-year basis). Results from monitoring and review activities will be documented and communicated to internal leadership, staff, partners, stakeholders, and funding organizations, as appropriate.

To support long-term plan effectiveness, APNEP may establish a regular review schedule for both adaptation projects and the broader vulnerability assessment. Whenever significant changes in science, organizational priorities, environmental conditions, or risk profiles occur, APNEP may revisit earlier planning steps and revise the adaptation plan as needed to ensure continued progress toward targeted ecosystem outcomes, as well as organizational and watershed resilience goals.

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