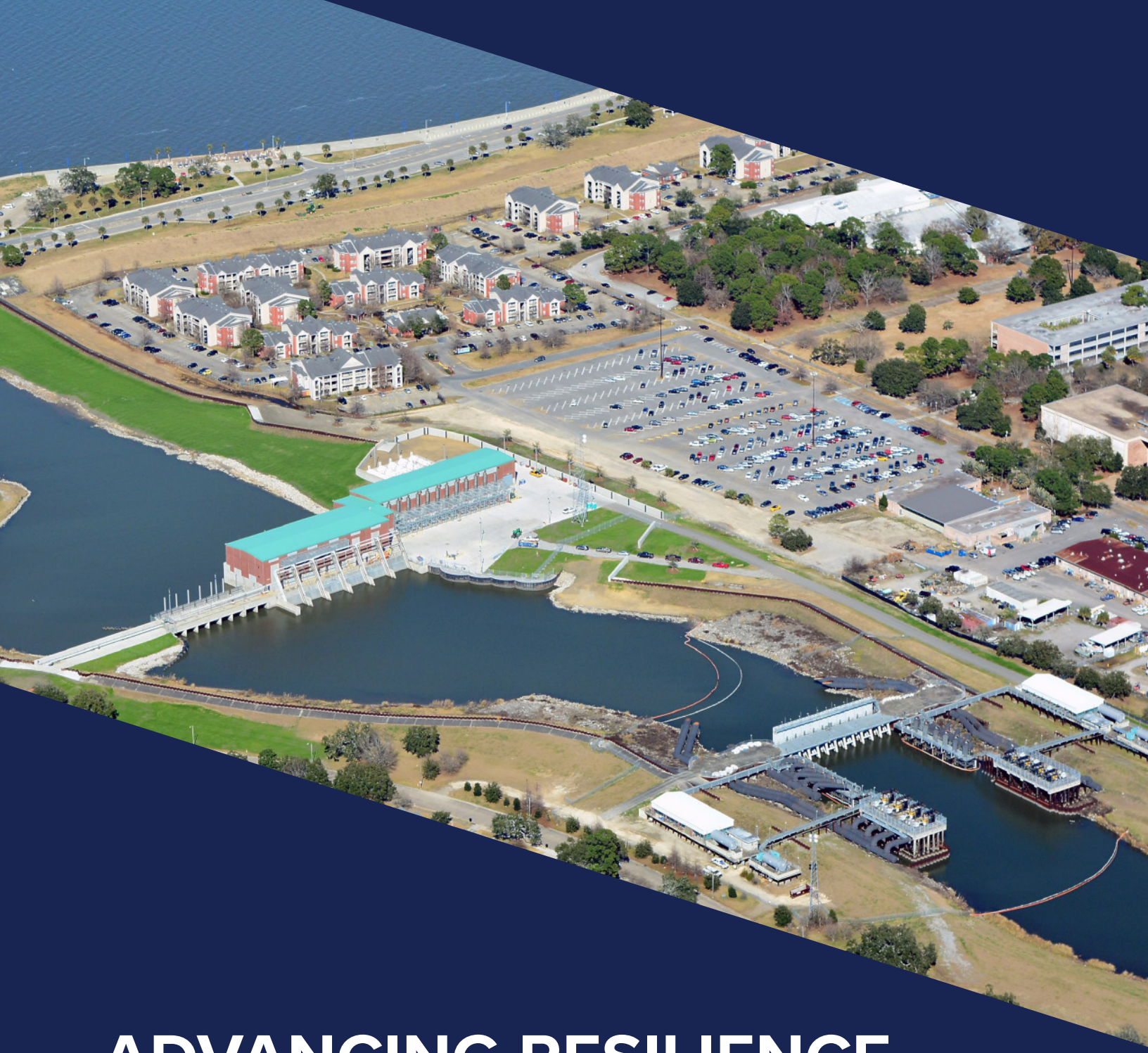

ADVANCING RESILIENCE FOR DEFENSE COMMUNITIES

A PLANNING FRAMEWORK

ASSOCIATION OF DEFENSE COMMUNITIES | Stantec

ADVANCING RESILIENCE FOR DEFENSE COMMUNITIES
A PLANNING FRAMEWORK

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ASSOCIATION OF DEFENSE COMMUNITIES

Stantec

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On the cover: **Permanent Canal Closures and Pumps Project***
New Orleans, Louisiana | *London Avenue Pump Station protects against storm surge and drains New Orleans stormwater*

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1.0 INTRODUCTION

Increases in extreme weather events, human-induced hazards, and a global pandemic have shed ample light on risks and vulnerabilities within our communities. Across the United States, we are facing devastating effects from natural and non-natural disasters and the tough realities of resiliency shortfalls that communities must respond to in real time. We are seeing a rise in billion-dollar disasters impacting communities across the U.S., including severe storm, tornado, drought/heatwave, hurricane, and wildfire events.[1] 2020 marked the sixth consecutive year in which the U.S. experienced 10 or more billion-dollar disaster events.[2] We are also seeing significant human-induced incidents such as civil unrest, cybersecurity threats, and aging infrastructure. It is apparent that communities need to better understand their collective risks and vulnerabilities to these types of events and their effect on the people, services, facilities, and systems on which we rely for daily life.

Military installations are far from immune to the devastation of these threats, particularly natural hazards. From Hurricane Michael slamming into Tyndall Air Force Base in Florida in October 2018[3] to the July 2019 earthquake that hit Naval Air Weapons Station China Lake, California, to the growing threat of flooding at Norfolk Naval Shipyard in Virginia.[4] The effects of these disasters will continue to threaten military operations and readiness and do not stop at the gate.

Community decision-makers also will continue to face the daunting task of figuring out how to approach the complex problems of climate and other human-induced hazards that pose real threats to their livelihoods, public health, safety, and general welfare. However, communities do not have to go it alone. There is a growing wealth of information, guidance, and funding sources available to support their mission to become more resilient and reduce the impacts of natural disasters and human-induced hazards. Community resilience is widely accepted in the planning industry as the sustained ability of a community to respond to, withstand, and recover from adverse situations. Resilient communities can respond to and adapt quickly to system shocks while maintaining their economic, environmental, and social functionality.

Defense communities are deserving of specific attention because they are essential to supporting military installations that maintain our national security. Defense communities, whether large or small, are part of a larger network of essential operations, services, and infrastructure necessary for military installations to sustain continued military operations and readiness. Congress and the Department of Defense's (DoD) recent emphasis on supporting military installation resilience presents significant opportunities for defense communities to improve their own resilience while effectively supporting the broader spectrum of military operations and national security.

Wildfire Response (Urban Land Institute Center for Sustainability and Economic Performance)

Fire fighters respond to wildfire spread in California

1 *Billion-Dollar Weather and Climate Disasters: Overview* (2020). NOAA. Retrieved from https://www.ncdc.noaa.gov/billions/.

2 Smith, Adam (2020). 2010-2019: *A landmark decade of U.S. billion-dollar weather and climate disasters*. NOAA. Retrieved from https://www.climate.gov/news-features/blogs/beyond-data/2010-2019-landmark-decade-us-billion-dollar-weather-and-climate.

3 *Tyndall one year after Hurricane Michael* (2019). Retrieved from https://www.tyndall.af.mil/News/Article-Display/Article/1985607/tyndall-one-year-after-hurricane-michael/.

4 *Rising seas threaten Norfolk Naval Shipyard, raising fears of 'catastrophic damage'* (2018). InsideClimate News. Retrieved from https://www.nbcnews.com/news/us-news/rising-seas-threaten-norfolk-naval-shipyard-raising-fears-catastrophic-damage-n937396.

Military installations are often the major economic engine of a community, region and even a state. Therefore, state and local governments have a vested interest in supporting development and maintenance of infrastructure beyond installation boundaries to support military mission assurance and continued operations. These significant endeavors are best done through partnerships between the military installation and broader region. Infrastructure forms the framework of a military installation and is necessary to support military operations. This infrastructure must not only protect and preserve military readiness and defense capabilities but also provide safe places for service members and their families to live, work, and play. Defense communities and the military installations they host must understand these shared risks and vulnerabilities and work together to address the considerable challenges.

Defense communities and military installations are expected to have separate approaches and opinions on sharing information, considering vulnerability and risk, defining success, and implementing solutions. However, to make the most of resilience planning and funding sources, achieve stronger outcomes, and enhance resilience more broadly for both entities, the two should work together to understand where there are shared interests and, more importantly, shared needs. In finding shared weaknesses in the broader system, the two can work more effectively to address these weaknesses and identify more impactful resilience solutions. While internal methods and implementation strategies may not change, both parties may pursue the outcomes with a common understanding of the interconnectedness of their systems. The results of this are more informed resilience strategies that even if pursued by the individual entity, have a broader perspective of the factors that might impact their decision-making. However, the ultimate goal is to identify significant solutions that are well informed, address multiple vulnerabilities, and support resilience for both the community and installation. The best projects check many boxes, and working together is an essential piece to figuring out which boxes to check.

While there are many planning resources that support the execution and implementation of resilience strategies, few, if any, address the uniqueness of defense community resilience efforts and their role in maintaining military mission assurance and mission-essential functions. The focus of this Special Report is to present a framework that identifies the nexus between defense community and installation assessment of risks and vulnerabilities. Furthermore, specific collaborations between these two entities to further resilience on a broader scale is identified. The successes of defense communities and military installations are interdependent; together they must plan, design, and finance to successfully shape a resilient future. These significant endeavors are best done through strong partnerships formed from shared, cohesive visions and understandings of vulnerabilities and risks, prioritization of resilience projects, and innovative financing tools.

1.1 DEFENSE COMMUNITY RESILIENCE PLANNING FRAMEWORK

The defense community resilience planning framework presented in this report is meant to support defense communities in their efforts to assess, plan, prioritize, and implement resilience strategies and infrastructure projects. Resilience should be pursued for both the military installation and the broader region to provide critical services and infrastructure in support of maintaining military mission assurance and mission-essential functions. The overall goal of this framework is to arm defense communities with knowledge of resilience planning and tools for implementing resilience projects, including potential funding mechanisms. This framework and the referenced material are focused more on natural hazards, but the same approach and principles can be applied to human-induced hazards.

The resilience planning framework provides methods to assess risks and vulnerabilities not only independently but also in coordination with threats to installation resiliency. Thus, it provides a risk-informed, phased approach to identify and prioritize investments for resiliency projects. This resilience planning framework includes elements designed to foster partnership opportunities through a series of actions that are broken into four stages as follows and as shown in **Figure 1:**

1. Designing a robust and multi-functional resilience network
2. Conducting a shared vulnerability and risk assessment
3. Conceptualizing and prioritizing impactful projects
4. Identifying funding sources and implementing resilience projects

This approach is not meant to represent a comprehensive list of steps but rather a breakdown of the key actions that will support defense communities in their pursuit for a more resilient future. A webinar series over the course of 2021, with corresponding white papers, provides additional context for each of these four stages of the resilience planning framework.

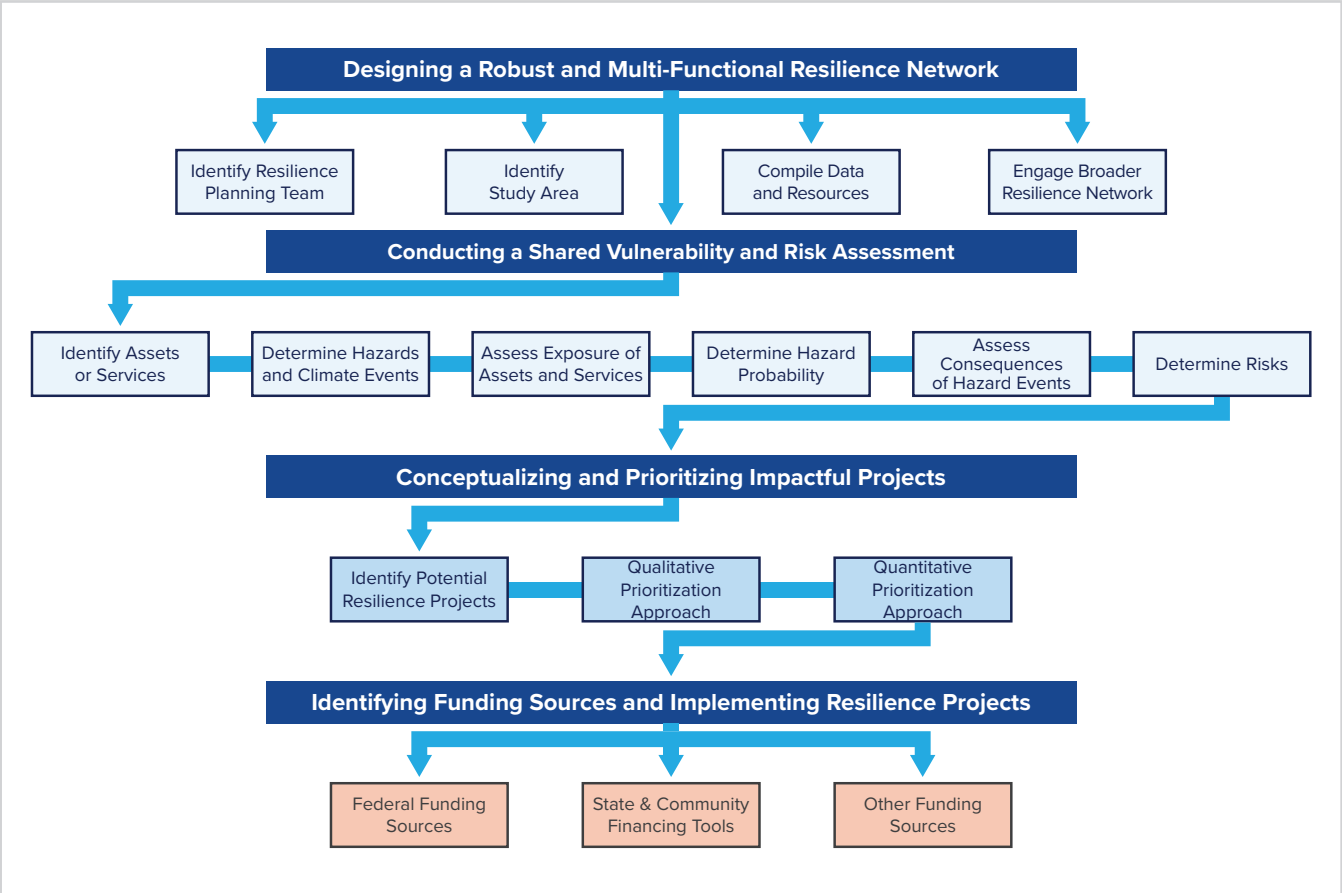


Figure 1: Defense Community Resilience Planning Framework Overview

Manitoba Flood Inspections*

Manitoba, Canada | *Roadway and culvert failure due to flooding*

2.0 BACKGROUND

Stantec Consulting Services Inc. (Stantec) and the Association of Defense Communities (ADC) established a research partnership to support the development of the defense community resilience planning framework. Designed as a resource for defense communities, the framework gives special attention to one key community stakeholder – the military installation – and its unique perspective on resilience as captured in the following definition:

> *Military installation resilience is defined as the capability of an installation to avoid, prepare for, minimize the effect of, adapt to, and recover from extreme weather events, or from anticipated or unanticipated changes in environmental conditions, that do, or have the potential to, adversely affect the military installation or essential transportation, logistical, or other necessary resources outside of the military installation that are necessary in order to maintain, improve, or rapidly reestablish installation mission assurance and mission-essential functions.*[5]

This definition of military installation resilience, particularly as it relates to resources beyond installation boundaries, provides the basis to identify shared opportunities for defense communities and installations to work together to enhance resilience. As defense communities play a key role in supporting military installations, there is a need to empower defense communities with the resources they need to implement meaningful resilience measures. Therefore, in addition to traditional funding sources, unique funding opportunities exist specifically for defense communities to engage in resiliency planning and to implement resilience projects. Given these opportunities, capital resilience projects will often pull from a variety of different funding sources, prompting the need for insight into cost sharing, leveraging partnerships, and improving bond and rate structures. The defense community resilience planning framework can be used to plan resilience projects and strategies at virtually any size or scale.

Further, there are many existing concepts and planning approaches that are relevant and helpful in providing context to resilience efforts. This framework includes references to concepts and materials that can help frame a more comprehensive understanding of resiliency enhancement in a variety of different settings. This framework builds off industry-recognized planning methodologies and resilience concepts, as discussed in the next section.

2.1 A STANDARDIZED PROCESS

The concept of resilience is closely linked to a wide variety of planning approaches, methodologies, and design concepts aimed at reducing risk to or lessening the impacts of shocks and stressors. Communities can enhance resiliency through hazard mitigation planning, climate change adaptation, smart technology, redundancy, sustainability efforts, or some combination of these approaches. While each of these may view risk reduction through a different lens, all seek to protect communities from loss of life and damages to infrastructure and property while simultaneously seeking to expedite the recovery process in a manner that improves the quality of life for community members. To foster a comprehensive approach to resilience planning, it is important to understand the merits and drivers behind these key planning concepts when executing a resilience strategy.

- **Hazard Mitigation –** Broadly, hazard mitigation is any action taken to reduce risk before, during, or after a hazard event. It is a planning concept that looks to reduce harmful impacts from natural hazards, such as flooding, wildfires, earthquakes, severe weather, and hurricanes, or from human-induced threats, such as chemical releases, cyberattacks, and terrorism. Hazard mitigation planning can incorporate climate adaptation by assessing and seeking to reduce future risks.

5 FY2019 National Defense Authorization Act.

Through the Disaster Mitigation Act of 2000, the Federal Emergency Management Agency (FEMA) put forth guidance and incentives for states, localities, and tribal communities to develop hazard mitigation plans and implement hazard mitigation projects.[6] This process involves analyzing risk from natural hazards, assessing a community's capability to mitigate hazards, and developing strategies to implement hazard mitigation actions. While not required, more communities are choosing to integrate social vulnerability considerations into their hazard mitigation planning processes.

Also integral to hazard mitigation is the practice of performing benefit-cost analyses to assess the cost-effectiveness of mitigation strategies. Project benefits typically come in the form of damages avoided if a certain mitigation measure were implemented. This approach is often essential in securing federal dollars for infrastructure projects and other mitigation activities.[7] Hazard mitigation should not be confused with climate change mitigation, which focuses on reducing emissions of heat-trapping greenhouse gases into the atmosphere.

- **Climate Adaptation –** Climate adaptation is the international practice of assessing and implementing strategies to respond to local variability in climate-related elements such as temperature, precipitation, wind, storm events, and sea level rise. With observed trends in cases of extreme heat and cold, heavy precipitation, drought, and stronger storm events, it is important for communities to assess how increased variability might affect the daily lives of the people, processes, and systems within them. Adaptation can take many forms and should be tailored to the specific needs of a community or region. Adaptation solutions should seek to abate potential damages or benefits from opportunities that climate change presents, with consideration to climate uncertainties regarding magnitude and timing.[8] The concept of climate adaptation considers current trends and future conditions to inform decision-making that seeks to maintain or improve standard of living despite the effects of climate change.[9]

- **Smart Community –** The smart community movement encompasses the broad concept of creating interconnected communities that leverage technologies and data to improve day-to-day problems people experience and to benefit community activities.[10] Some common examples include using traffic data to alleviate traffic and parking problems, analyzing energy data to improve efficiencies, or developing modern community engagement strategies to improve communications and disseminate information. While utilizing technology and data does raise additional concerns about cybersecurity, these risks can be managed so communities can still benefit from these tools. Many communities look to smart technology to improve resilience to natural disasters. For example, real-time sensors can quickly alert officials to elevated flood stages, seismic waves, or impending tsunamis, while advances in communication technology can save lives by reducing warning times and issuing automatic alerts. Therefore, smart technology and informed approaches to problems can be integrated into resilience projects, often amplifying the effects of larger capital improvements.

- **Redundancy –** The concept of redundancy within resilience focuses on achieving safeguards against the failure of a system. Redundancy aims to increase reliability and predictability by providing alternatives when a primary system or process fails. Redundancy is valuable in disaster response by accounting for unknown contingencies.[11] For

6 *Disaster Mitigation Act of 2000* (Public Law 106-390). October 30, 2020. Retrieved from https://www.congress.gov/106/plaws/publ390/PLAW-106publ390.pdf.

7 *Benefit-Cost Analysis*. FEMA. Retrieved from https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis.

8 *What do adaptation to climate change and climate resilience mean?* United Nations Climate Change. Retrieved from https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean.

9 *Responding to Climate Change*. NASA. Retrieved from https://climate.nasa.gov/solutions/adaptation-mitigation/.

10 Nam, Taewoo and Theresa Pardo (2011). *Conceptualizing Smart City with Dimensions of Technology, People, and Institutions.* Center for Technology in Government, University at Albany, SUNY. Retrieved from https://inta-aivn.org/images/cc/Urbanism/background%20documents/dgo_2011_smartcity.pdf.

11 Streeter, Calvin L. (1991). Redundancy in social systems: Implications for warning and evacuation planning. International Journal of Mass emergencies and Disasters (1991), 9:167-182.

example, emergency planners may identify multiple evacuation routes from a single egress point in the event of a road failure during a flood or earthquake. Similarly, a water utility may construct multiple water mains capable of serving a critical facility, such as a military installation, in the event of a main break.

- **Sustainability –** While resilience captures the ability to respond to shocks to a system, sustainability speaks to the long-term ability to maintain or improve functions. Sustainability emphasizes the importance of economic efficacy, environmental stewardship, and equity or social vitality through what is often referred to as the "triple bottom line" concept.[12] Sustainability recognizes that these three pillars are essential in maintaining and improving long-term functionality and quality of life within communities. However, this concept recognizes that these three goals often have diverging priorities that present challenges in planning, such as issues regarding environmental justice and access to community lifelines. With consideration to potential conflicts, a triple bottom line approach seeks to balance these goals in decision-making processes to achieve sustainability. Defense communities face the added complexity of considering their relationship with the local military installation when striving to balance these goals during decision-making processes.

  Overall, sustainability is an important complement to resilience, as a healthy, just, and prosperous community is far better equipped to respond to shocks and adapt quickly than a community burdened by chronic stressors, such as economic distress, poverty, social unrest, and/or environmental degradation. A resilient solution is not always the most sustainable, and vice versa, but sustainability is still an important concept to keep in mind when planning for resilience.

A myriad of guidance and process frameworks have been developed to support the implementation of these broad concepts. For instance, FEMA provides guidance for developing hazard mitigation plans[13], the National Institute of Standards and Technology (NIST) has put forth a Community Resilience Planning Guide[14], and the International Organization for Standardization (ISO) provides guidelines for risk management, vulnerability assessments, and climate change adaptation. Other guidance documents also exist, including several the military services have developed to guide resiliency planning on installations, which are described in **Section 2.2**.

With guidance documents available from a wide range of agencies and organizations, this framework seeks to present a standardized approach to assessing risk and vulnerability. In developing a standardized resilience approach, it was important to consider the universality of the message and to present a methodology that a diverse range of communities and organizations can use. Therefore, this report follows the ISO process for developing risk and vulnerability assessments. The ISO is a worldwide federation of national standards body that has developed an internationally standardized process for conducting climate adaptation risk and vulnerability assessments. The ISO process is scalable to any organization, regardless of type, size, and nature.

The resilience planning framework presented herein aligns with ISO Standards 31000:2018 - Risk Management Guideline, 14090:2019 - Adaptation to Climate Change, and 14091:2020 - Guidelines on Vulnerability Impacts and Risk Assessment, while incorporating best practices from the key planning concepts described previously. An overview of the risk and vulnerability assessment process described in Section 4.0 of this report is provided in **Figure 2**, as adapted from the ISO process described in **Section 4.0** of this report, as adapted from the ISO Vulnerability Assessment process. Again, this process does skew towards natural hazards but can be applied to non-natural hazards as discussed in **Section 4.2**.

12 Goodland, Robert. *The Concept of Environmental Sustainability*. Annual Review of Ecology and Systematics (1995), 26: 1-24. Retrieved from https://www.jstor.org/stable/2097196.

13 *Create a Hazard Mitigation Plan*. FEMA. Retrieved from https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/create-hazard-plan.

14 *Community Resilience Planning Guide* (2019). NIST. Retrieved from https://www.nist.gov/topics/community-resilience/planning-guide.

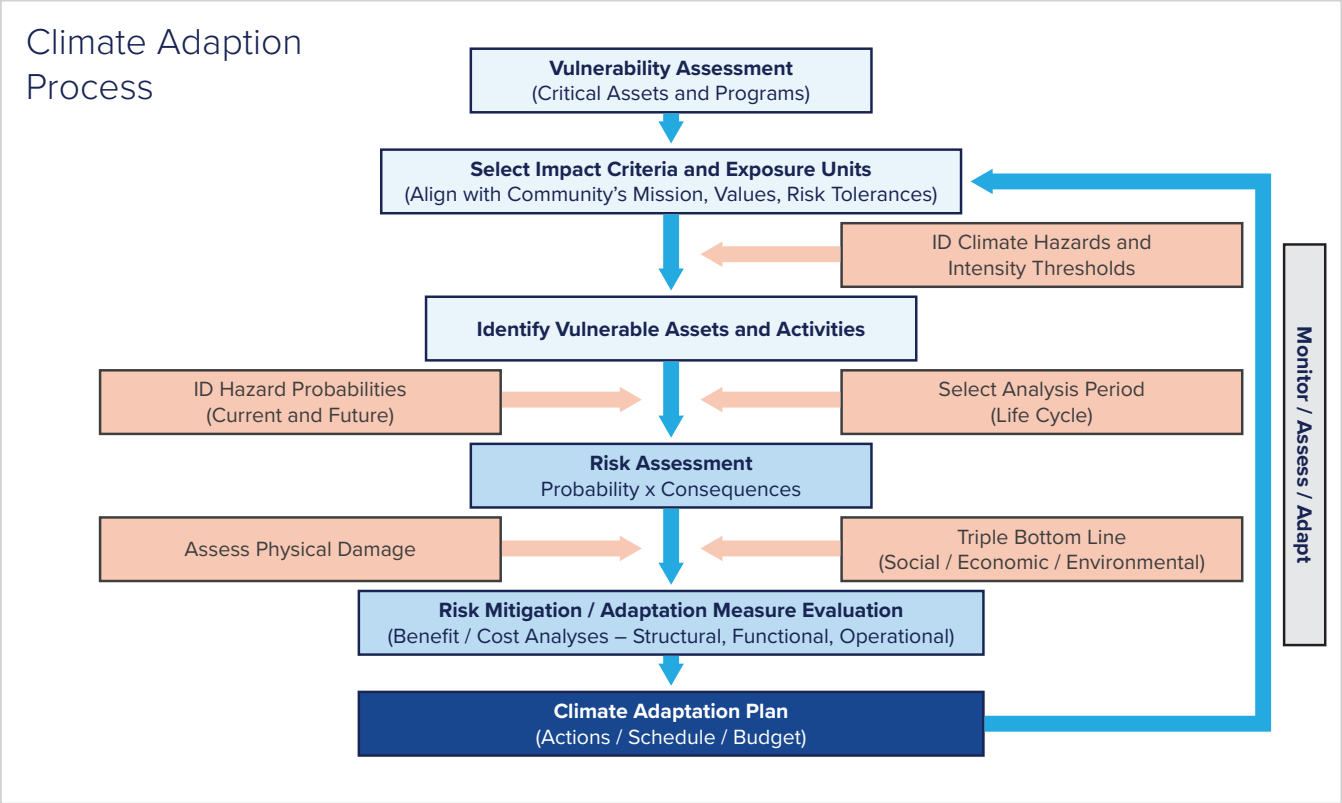


Figure 2: General Process Flow of Resilience Risk and Vulnerability Assessment Adopted from ISO Climate Adaptation Process

Resilience planning is not meant to be a one-off, linear process but rather a cyclical one. Some defense communities may only use this framework once to help implement a much-needed resilience project to address a priority vulnerability within the community. Or a defense community may use the framework, as intended, to support the community's development of an overall resilience program with the goal of continuous improvement in resilience, quality of life, and public safety. In most cases, and especially with national security in play, it is encouraged that defense communities adopt the programmatic approach to address the critical services and lifelines[15] of defense communities and the military installations they host. In the long term, defense communities can continue to evaluate and build upon their resilience strategy and implementation. As communities and installations become more resilient in a local sense, they can further their resilience on a broader scale, strengthening regional and national networks in pursuit of national defense resilience strategies overall.

2.2 RESILIENCE PLANNING "INSIDE THE FENCE"

In recent years, DoD has placed a growing emphasis on resilience to natural hazards as it relates to impacts on military installations and mission-essential functions. DoD recognizes the threat that climate hazards pose to our national security and the need for enhanced resilience considerations for military installations.[16] This has led to significant studies and efforts across the military services to better understand the risks they face and what can be done to address them. Many efforts to date have focused on enhancing water and energy resilience, as well as addressing cybersecurity threats.

Several DoD and military service resources can support and inform a defense community's resilience planning efforts and specifically advance military installation resilience. These resources provide significant context about how resiliency is viewed through the lens of the

15 Lifelines, as defined by FEMA, are systems, like roads, electricity, and water networks, that allow government and critical business operations to continue. Lifelines are essential to human health and safety and economic security. Retrieved from https://www.fema.gov/emergency-managers/practitioners/lifelines.

16 National Security Implications of Climate-Related Risks and a Changing Climate (23 July 2015). *Response to Senate Report 113-211.* Retrieved from https://archive.defense.gov/pubs/150724-congressional-report-on-national-implications-of-climate-change.pdf.

military installation, predominantly military resilience from "inside the fence" of military installations themselves. However, additional perspective is needed to expand these considerations and approaches beyond installation boundaries and across the broader community and region to ensure facilities, infrastructure, and services critical to continued military operations and readiness are identified, understood, and preserved.

The military services have some noteworthy resources available to help understand the hazards and impacts climate factors pose to installation operations, infrastructure, and facilities. In accordance with Unified Facilities Criteria (UFC) 2-100-01, Installation Master Planning, and other DoD guidance, Master Development Planners for the Military Services are directed "to consider" climate change in the development of Master Plans and projects. The Navy's *Climate Change Installation and Adaptation Resilience Planning Handbook*[17] also provides guidance to Navy installation staff, particularly for the element of climate change adaptation involving sea level rise as it stands to impact many Navy bases around the world. The handbook provides the analytical framework, as well as tools and other guidance, to help Navy planners understand how to consider climate change in their plans and projects for installation infrastructure. More specifically, the handbook leads planners through the process of identifying and assessing possible adaptation action alternatives, or methods for adapting to the impacts of climate change. These adaptation measures are intended to improve their installation's resiliency, or capability to anticipate, prepare for, respond to, and recover from significant hazards.

With guidance from the *Air Force Severe Weather/ Climate Hazard Screening and Risk Assessment Playbook*, Air Force installation planners gather information through severe weather/climate risk assessments to help identify and quantify the level of risk installations may face from impacts associated with severe weather/climate hazards. This initial assessment serves as a first step toward developing mitigation strategies to offset the identified risks on a larger scale. The screening and risk assessment outputs are incorporated into existing plans and processes, such as planning products, programming for projects, emergency management plans, mission sustainment risk reports, etc. Ultimately these risk assessments also help ensure compliance with UFC 2-100-01, Installation Master Planning, and other DoD and Air Force policies and guidance, which mandate that Air Force installation personnel consider severe weather and climate risk in Installation Development Plans and facility projects.

The Army Climate Resilience Handbook[18] includes guidance for Army installation planners to assess climate risk as they write or revise a diversity of plans, including Real Property Master Plans, Integrated Natural Resource Management Plans, Installation Energy and Water Plans, and emergency management plans. The handbook is organized around a four-step, risk-informed planning process with the goal of increasing climate resilience. An integral part of the process is the on-line Army Climate Assessment Tool (ACRH) that contains information on individual Army installations that planners can use to determine current extreme weather and climate change effects, infrastructure, and assets that are vulnerable to these effects, and adaptation measures that can be used to increase an installation's climate resilience. The ACRH builds on existing Army efforts to identify and address water and energy vulnerabilities at its installations.

DoD also recently announced its initiative to conduct climate assessments on all U.S. installations and major installations outside the continental U.S. using the Defense Climate Assessment Tool (DCAT). The DCAT helps identify the climate hazards to which DoD installations are most exposed, which is the first step in addressing the potential physical harm, security impacts, and degradation in readiness resulting from global climate change. The DCAT is a CAC-enabled, web-based collection of scientific climate data to support research, analysis, and decision-making about exposure to historical extreme weather and reasonably foreseeable climate effects.

17 Climate Change Installation Adaptation and Resilience Planning Handbook (January 2017). *Naval Facilities Engineering Command*. Prepared by Louis Berger, Inc. Retrieved from https://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=31041&destination=ShowItem.

18 Army Climate Resilience Handbook (August 2020). *US Army Corps of Engineers*. Retrieved from https://www.asaie.army.mil/Public/ES/doc/Army_Climate_Resilience_Handbook_Change_1.pdf

DCAT will enable the military services and their installation personnel deliver consistent exposure assessments and identify regions or installations for additional climate-related studies. The tool uses data from past extreme weather events (e.g., hurricanes, tornado tracks) and the effects of future changes in sea levels, riverine flooding, drought, heat, land degradation, energy demand, and wildfires to produce hazard indicators, providing an important component toward understanding an installation's vulnerability to climate-related hazards; determining potential mission impacts; and conducting detailed engineering studies to assess which adaptation strategies may be effective to reduce risk. Using DCAT as part of a comprehensive analysis will help DoD and the installations determine where best to apply resources to improve climate adaptation and resiliency. The DCAT tool supports screening level vulnerability assessments like what is required under this defense community resilience planning framework. Additional resources related to military installation resilience and climate planning is provided in **Appendix 1**.

While working with military installations presents an obvious need for sensitivity to classified national security information, their insights are essential in identifying vulnerabilities and needs shared between the community and installation. Working together opens the door for broader, more impactful resilience initiatives and is worth the added layer of consideration that comes with sensitivity to military installation activities that rely on community systems. From the perspective of military installations, expanding resilience considerations outside the fence allows for a more holistic and robust assessment of essential community infrastructure and services needed for maintaining mission-essential functions. From the perspective of the community, working with military installations strengthens the influence and reach associated with their resilience planning and funding needs. An overview of resilience planning with a shared perspective is outlined in **Figure 3**.

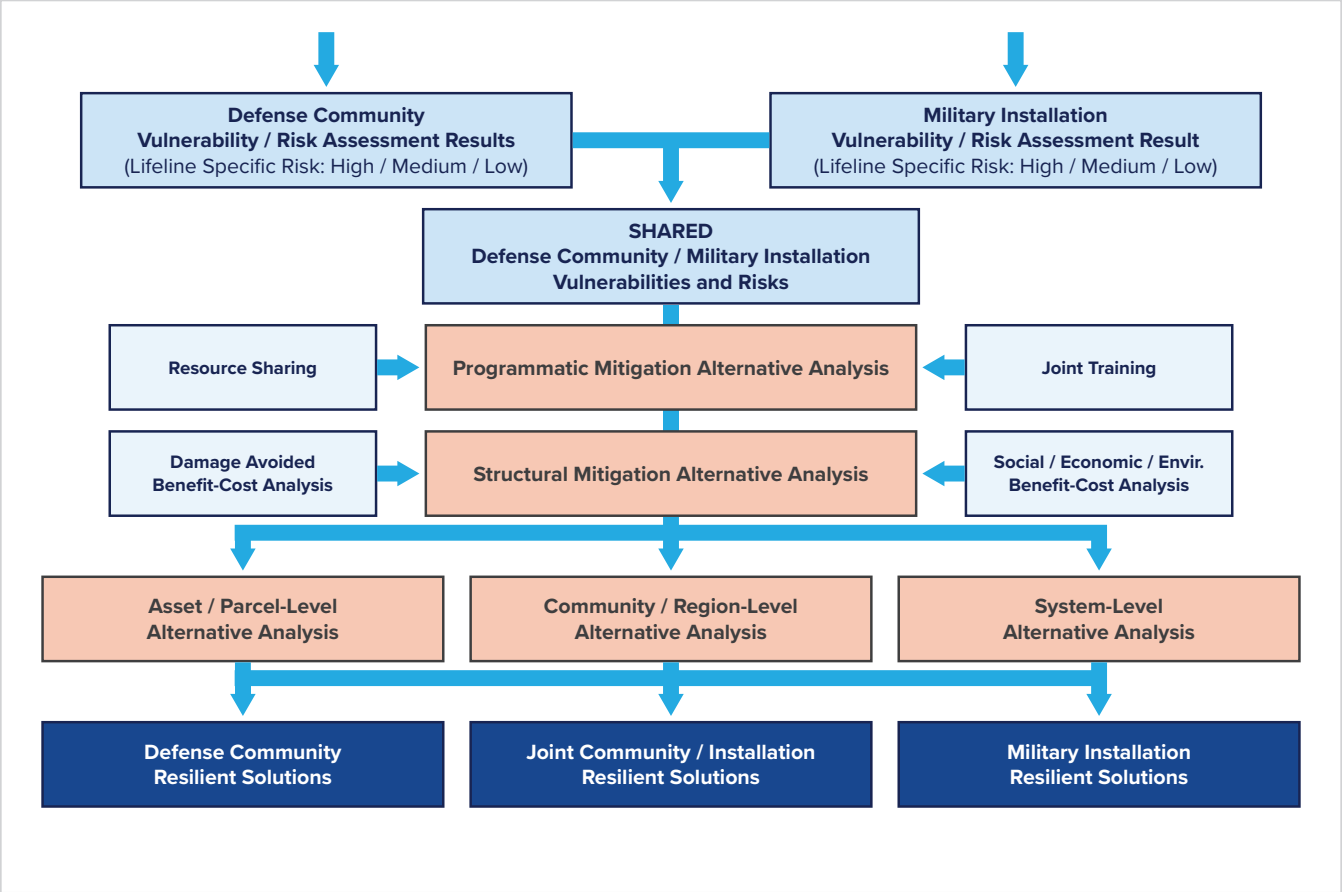


Figure 3: Shared Vulnerability Assessment Approach to Capture Joint Vulnerabilities and Risks

Offutt Air Force Base Flooding

Sharpy County, Nebraska | *Photo by Tech. Sgt. Rachelle Blake*

Coastal damage from Hurricanes Irma and Maria*

Puerto Rico

Damage from Hurricane Michael

Mexico Beach, FL | *FEMA Photo by Kenneth Wilsey*

3.0 DESIGNING A ROBUST AND MULTIFUNCTIONAL RESILIENCE NETWORK

Developing impactful resilience strategies first requires a defense community to carefully consider and initiate the planning process to set themselves up for success. This is accomplished through development of a resilience network to support resilience planning efforts. Convening the right people, organizations, and resources is essential to producing strategies that are effective in enhancing community and military installation resilience, quality of life, and public safety. Typically, the broader the resilience goals, the more extensive the resilience network required to accommodate the needs of the community.

Resilience networks can take many different forms. The terms used in this report are meant to generally capture the essential elements of a resilience program with room for customization and adaptation to fit a community's specific needs and dynamics. This structure builds upon organizational guidance from FEMA Hazard Mitigation Planning as well as DoD Compatible Use Planning. Following is an overview of elements comprising an overall resilience network, also displayed in **Figure 4:**

- **Resilience Planning Team –** The team of individuals and organizations who support the resilience planning process. These individuals and organizations work together to gather resources and data, contribute expertise, and help develop the path forward for the community with representing a broad range of interests.

  The resilience planning team is typically comprised of an executive steering committee and a broader stakeholder pool to form relevant committees and working groups. The executive steering committee is tasked with executing the planning process and coordinating efforts between the defense community and the installation, while the stakeholder pool contributes to the planning process through knowledge sharing and collaboration. For more information on forming a resilience planning team, refer to **Section 3.1**.

- **Resilience Study Area –** The geographic boundary which defines the region being considered in the resilience planning effort. Special attention should be given to the military mission footprint (land area affected by military operations beyond the installation boundaries) and the broader network of systems and people needed for maintaining military mission assurance. For more information on defining a resilience study area, refer to **Section 3.2**.

- **Resilience Network –** The broader coalition of leaders, stakeholders, entities, resources, data, regulators, and government officials with a role or vested interest in advancing defense community and military installation resilience. The broader network can include federal agencies who administer grant funding, regulatory bodies for project approvals, academic institutions who have studied similar issues, and more. For more information on defining a resilience network, refer to **Section 3.3**.

There is no single way for a team to begin its path to a more resilient future. These efforts can involve a variety of different catalysts and start at different places within the overall process and structure. The descriptions in this section provide a basic framework that communities may tailor to address their specific needs and capabilities; communities should not feel the need to tether themselves to a specific approach. However, no matter the initial advocate for resilience planning, communities should follow a general approach and keep key entities in mind to increase chances for success.

Resilience Planning Team	Executive Steering Committee				
	City / County Manager	Military Installation Commander	Key Elected Officials	Key Community Department Staff	Planning, Engineering, Environmental Consultant (optional)
	Stakeholder Pool				
	GIS Technician	Emergency Manager	Dam Safety Engineer	Working Group	Military Planner City Planner
	County Commissioner	Working Group	Hazard Mitigation Planner	Electric Utility	Floodplain Manager
	Transit Planner	Water System Manager	University Researcher	Fire Chief	EMS
Study Area	Military Mission Footprint	Watershed	Building Stock	City Township, County, or Region	
	Telecommunications Infrastructure	Transportation Network	Power Grid Network	Water/Wastewater District	
Resilience Network	Academia	FEMA	USACE	EPA	Consultants
	DOT	Universities	DoD	State Agencies	Key Landowners & Private Citizens
	Congress	Community Development Finance Institutions	DOE	HUD	Non-Profits/NGOs

Figure 4: Example of a Layered Resilience Network Structure

3.1 RESILIENCE PLANNING TEAM

A resilience planning team will move the planning process forward and contribute to the plan's overall success. Including the appropriate people on the planning team, while maximizing the team's engagement within the planning process, will foster outcomes that maximize benefits for defense communities and military installations. As described in the next sections, a resilience planning team consists of a limited steering committee supported by a broader team of stakeholders.

3.1.1 Executive Steering Committee

An executive steering committee is a limited, core team of individuals representing key public and private sector organizations or entities integral to the execution of the resilience plan. This committee should comprise, at a minimum, a planning sponsor and military installation commander, along with other key stakeholders responsible for the direct management and implementation of the resilience planning process. The planning sponsor may be a local government, a regional planning organization, or a state. The planning sponsor, with guidance and support from the steering committee, is charged with organizing meetings, tracking progress, gathering resources, conducting analyses, communicating with the team, and writing reports and grant applications. The broader steering committee is needed to provide general oversight, strategic guidance, and political support. As this group drives the process, it is important for the steering committee to be dynamic and agile, with the ability to make timely decisions and act as champions for the resilience planning effort.

To initiate the resilience planning process, a senior staff member with the planning sponsor (e.g. City Manager on behalf of a city) will usually establish the steering committee and may serve, or designate a representative, as the point of contact for the entire effort, leading the development of the resilience network and advancing the program towards tangible results. The planning sponsor, under the leadership of the designated representative, with support from the steering committee, will engage military installation leadership, local, federal, and state agency representatives, private sector leaders, and elected officials. The sponsor should know the community, have a broad understanding of resiliency challenges, have authority to guide development and infrastructure investment, and ideally have financing authorities and tools.

Aside from the planning sponsor, the military installation commander is a key stakeholder on the executive steering committee unique to defense community resilience. Installation commanders have an essential seat at the table for communicating and advancing issues important to the installation to protect and preserve military readiness and defense capabilities, including deficiencies beyond the fence line within the purview of the defense community.

A strong partnership among the sponsor, military installation, and greater community is essential to success. The military installation should engage early in the process since their support is key in furthering military installation resilience and, in some cases, securing funds through DoD. The installation's commander serves on the steering committee as an ex-officio member, with support from other installation personnel. Installation commander involvement is important for necessary but cautioned sharing of information, such as available data and ongoing resilience efforts inside the fence.

Other potential members of the executive steering committee may include the planning sponsor senior staff (e.g., representatives from departments of planning, resiliency, emergency management, transportation, or public works), planning and

Sample Executive Steering Committee Structure
Mayor and/or City Council Member
City Manager
Installation Commander (Ex-Officio Member)
Chief Resilience Officer (State and/or Local Gov)
Public Works Director
Economic Development Director
Congressional Staff Member (Ex-Officio Member)

engineering consultants (if applicable/appropriate), essential private sector representatives, or local elected officials, as appropriate.

3.1.2 Stakeholder Identification

The executive steering committee should identify the stakeholders to participate on the broader resilience planning team. To identify the appropriate stakeholders, it may be beneficial for the executive committee to first define the study area, as described in **Section 3.2**. It is also helpful to consider how stakeholders might participate in the process and what types of roles are expected, as addressed in the next section.

Identifying stakeholders requires the steering committee to have a broad understanding of local, state, and federal entities and officials who can contribute effectively to the resilience planning effort. Stakeholders are identified with consideration to program needs and structure, technical or institutional expertise, and the study area. Effort should be taken to include interested, engaged stakeholders that will actively participate in the process. As needed, specific stakeholder involvement can be limited to targeted opportunities for input (e.g., an interview or data sharing) or span the entire planning process. For example, state and federal agency representatives may be available for an interview but may not be available to participate in regular meetings. **Table 1** provides a list of common stakeholders, which will vary significantly depending on the community.

Table 1: Overview of Example Stakeholder Pool Members to Populate Resilience Planning Team

Entity Type	Potential Stakeholders	
Key Military Installation Staff (Ex-Officio Members)	• Public Works • Asset/Facility Management • Installation Planner • Aviation Operations • Range Operations • Emergency Operations	• Environmental Resource Manager • Public Affairs Officer • Community Plan Liaison Officer
Local Departments or Agencies	• City / County Manager • Emergency Management • Floodplain Management • Stormwater Management • Geographic Information Systems (GIS) • Public Works / Transportation • Elected Officials	• Planning • Public Information / Communications • Code Enforcement • Water and Wastewater Services • Economic Development
Local Community Organizations or Entities	• Local Emergency Responders (e.g., Fire & Rescue, EMS) • Utility Company Representatives (e.g., electric, water/wastewater, gas, telecommunications) • Private Business Representatives (e.g., developers, major employers, insurance, and banking industry) • Private Essential Service Providers (e.g., solid waste, snow removal)	• Hospital Representatives • Local School District Representatives • Community Non-Profit Leaders • Special Interest Groups (e.g., environmental / historical preservation) • Neighborhood Leaders • University Representatives • Key Landowners, Private Citizens

Entity Type	Potential Stakeholders	
Regional Organizations	• Regional Planning Agencies (e.g., Council of Governments) • Watershed Associations	• Soil and Water Conservation Districts • Regional Transit Authority (e.g., Metropolitan Planning Organizations)
State Agency Representatives	• Natural Resources / Water Resources • Environmental Quality • Dam Safety • Emergency Management • Homeland Security / State Police • State Elected Official	• State Hazard Mitigation Officer • State Floodplain Manager • Transportation • Land Use • State Resilience Officer • Utility Councils or Boards
Federal Agency Representatives	• Federal Emergency Management Agency Region Office • Army Corps of Engineers • Housing and Urban Development Region Office • Environmental Protection Agency Region Office	• U.S. Department of Agriculture • U.S. Department of Energy • DoD Office of Local Defense Community Cooperation • Local Congressional Representative

3.1.3 **Resilience Team Structure**

The resilience planning team can take on many different structures to fit the needs of the defense community. Factors that may influence the planning team structure include geography, hazards of concern, affected installations and communities, state roles and responsibilities, and stakeholder dynamics. While the executive steering committee serves as the planning team's leadership, it may be beneficial for the broader resilience planning team to form committees and working groups focused on achieving specific planning tasks.

For example, DoD's Military Installation Sustainability planning process, for both compatible use plans and military installation resilience, may utilize a technical committee and focused working groups or subcommittees to achieve planning tasks. Under this structure, a technical committee, working groups, or groups of stakeholders on the planning team, are tasked with taking deeper dives into specific plan elements. These groups can form to gather data related to specific issues or hazards, conduct analyses, compile reports, and assess projects. Similarly, subcommittees within a planning team may focus on execution of specific implementation requirements. These committees are likely to form around different stages of the planning process. Additionally, crucial planning needs such as administration and coordination, resource review, regulatory approval, and grant development may warrant committees to capitalize on stakeholder skillsets.

Generally, a resilience planning team should employ smaller working groups or committees to facilitate an inclusive and engaging planning process. Groups may form around specific hazards, special interests, or system themes such as transit planning, flood mitigation, resilient water systems, housing, or energy supply. These groups may also form around specific planning tasks such as data collection, risk assessment, resilience project conceptualization, or benefit-cost analysis. However, these tasks are intertwined, necessitating cohesion and information-sharing across groups formed around them. Further, it is recommended that military representation be built into each layer of the overall resilience team to ensure shared military installation and defense community data and interests are prioritized.

If a resilience planning team opts to utilize working groups or committees, frequency of group meetings may vary based on need. Some groups may only need to meet a few times to contribute (such as brainstorming solutions to address specific hazards), while others may meet throughout the entire planning process for more involved efforts. It is possible that certain stakeholders may participate in multiple groups or committees depending on availability, expertise, and capability. For instance, an installation planner may participate in several groups to help determine which defense community vulnerabilities are shared with the installation, whereas a local transportation planner might participate solely in a working group geared towards transportation system resiliency.

Developing too many working groups or committees may be difficult to manage or may result in a siloed planning process or disparate outcomes. Therefore, it is important for the resilience planning team to have opportunities to share information and ideas. For example, a working group focused on the plan's risk and vulnerability assessment should share results and ideas with a group focused on project conceptualization, as resilience projects should be informed by risk. Ultimately, defense communities should structure their planning team in a manner that is scaled with their needs and expectations. Care should also be taken to foster engaged planning team members to get the most out of the planning process.

Sample Resilience Subcommittee: Data Collection
Resiliency Planner
Floodplain Manager
Installation Planner
Regional Council of Governments (COG) Planner
GIS Technician
University Researcher
Emergency Manager

Sample Technical Working Group: Transportation Resilience
Transit Planner
Transportation / Public Works Engineer
Installation Planner
MPO / Transit Authority Representative
Emergency Management

3.1.4 Stakeholder Roles and Planning Schedule

The planning sponsor may kick off the resilience planning process with a full resilience team meeting. At this meeting, the sponsor should lay out the vision and program goals, generate a shared mission statement, review expectations and stakeholder responsibilities, review program milestones and schedule, and determine how to execute the program. Specific stakeholder assignments do not have to be assigned at the kick-off meeting but should occur early in the process. The planning sponsor can guide the roles based on team inputs and strengths. Identifying broader roles and populating committees and working groups will be important for holding stakeholders accountable and keeping the process moving.

Once momentum is built and committees are established, the team should lay out a program schedule. Often, a driving factor for schedules is funding request deadlines. The team should keep these deadlines in mind and back out from the deadline to identify key deliverable dates and milestones, with a cushion built in to allow for contingencies and delays. A typical plan development process is 8 to 12 months but may be expedited to meet funding deadlines. The team should continue to meet as a group at key points in the schedule to provide updates and share results. Typical meeting milestones may include a kickoff meeting, risk and vulnerability workshop, resilience actions workshop, and implementation workshop. The team may also choose to have regular check-ins (e.g., weekly, bi-weekly, or monthly) or meet more frequently within committees and working groups. After the planning process has concluded, the resilience planning team should meet periodically (e.g., quarterly,

bi-annually) to discuss monitoring and progress on mitigation strategy implementation as well as additional measures to take in the future.

3.2 STUDY AREA IDENTIFICATION

Before selecting stakeholders to participate on the resilience planning team, the steering committee should identify the resilience study area, which is the geographic area to consider in the planning process. When selecting a study area, the steering committee should consider the intended scale of the resilience effort. The study area can encompass a regional area with multiple installations or interdependent systems (e.g., transportation networks, utility systems, economic centers). Alternatively, a more focused study area can reflect a single jurisdictional boundary, individual service district, or an area well-known for hazard impacts.

For defense communities, the military mission footprint is also important to inform the study area. The military mission footprint represents the land area beyond the installation boundaries that is affected by military operations. Strong consideration should be given to geographies and systems that have a direct impact on operations that may include where military members live, commute modes and routes, sources of utilities, infrastructure networks, and other key assets.

Additional considerations should include the profile of hazards considered. For example, efforts focused on riverine flooding might include a sub-watershed; efforts involving energy resilience should consider the energy grid, electric utility service area, and location of power-generation facilities.

3.3 COMMUNITY AND INSTALLATION PLANNING RESOURCES

Compiling available resources is an essential part of developing a resilience network as it provides necessary context and background data. Specifically, existing military installation and/or community studies and reports that include identified risks, vulnerabilities, or mitigation recommendations are helpful resources. Examples of relevant resources are presented in **Table 2**.

Table 2: Overview of Recommended Resources for Resilience Planning Team to Consider

Military Installation Studies and Reports Note any sensitivity related to clearances and national security concerns.
Installation Risk and Vulnerability Assessments
Installation Development and Area Development Plans (with specific references to resilience)
Integrated Natural Resource Management Plans (INRMPs)
Installation Encroachment Management Plans (EAP, ECP, ICEMAP)
Installation Energy and Water Plans (IEWP)
Energy Resilience and Conservation Investment Program (ERCIP)
Resilience planning resources specific to military installation
Community Plans and Reports
Hazard Mitigation Plans
Climate Adaptation Plans
Capital Improvement Plans
Compatible Use Plans / Joint Land Use Studies
Land Use and Comprehensive Plans
Water Conservation Plans / Water Supply Plans
Watershed Management Plans
Stormwater Management Plans
Community Development Codes or Ordinances (e.g., Floodplain Management Ordinance)
Other Technical Documentation and Peer-Reviewed Resources
Published Federal Agency Guidance
Peer-Review Journal Articles
University Research and Data Tools
Previous Damage Reports (e.g., structural and content damages, repair, and recovery costs)
Data Layers, GIS Data, and Datasets Necessary for Risk and Vulnerability Assessment
Tools Developed by Federal and State Agencies for Assessing Risk
State Hazard Mitigation Plans
Master Coastal Resilience Plans

3.4 UTILIZING YOUR BROADER RESILIENCE NETWORK

While not involved in the week-to-week functions of a resilience planning program, entities that are part of a broad resilience network are vital in supporting resiliency efforts. Resilience planning teams should keep this broader network in mind to strengthen the coordination and reach of resilience strategies by leveraging the full breadth of knowledge and influence that might be available to them.

Entities included in the broader resilience network may include federal or state agencies that administer programs supporting resilience, such as grant opportunities or revolving loan funds. For example, a state hazard mitigation officer (SHMO) can assist communities with funding allocations and sub-applications for FEMA grant programs. Counterparts within other state agencies can guide communities through the application process for other funding opportunities. In fact, communities are often required to apply for funding as sub-applicants under a state's broader funding application. Other state officials or entities may support funding applications by helping support compliance, such as a state historic preservation officer (SHPO), providing assistance with meeting environmental planning and historic preservation requirements.

State agencies may also administer low-interest loans for resiliency projects, such as a state department of natural resources administering Clean Water State Revolving Loan Funds that are funded through the EPA. More information on potential funding sources for resiliency projects can be found in **Section 6.0**. Aside from government agencies, congressional representatives can serve as advocates for funding and legislation that support resilience.

Non-governmental entities may also play roles in a resilience network. Communities may partner with universities to develop resiliency tools, research, and data used in the planning process. Non-profit organizations may offer funding opportunities, low-interest loans, or assistance with planning or design. Further, private sector entities with an interest in resiliency may serve as a provider towards reaching a grant's community cost share.

Tottenville Shoreline Protection Project*

Staten Island, New York | *Identification of project impact area for coastal hazard mitigation design*

4.0 CONDUCTING A SHARED VULNERABILITY AND RISK ASSESSMENT

With the resilience planning team established, the process of conducting a shared vulnerability and risk assessment can be undertaken. This process can be executed by the steering committee or delegated to a committee or working group, though it is recommended that the process solicit input and consensus from the majority of the full resilience planning team. Regardless, next steps to consider require agreement among the team members to identify key assets, services, and mission-critical components of the community with potential exposure to various hazards. The team sets the context for the focus of the assessment by following these steps:

1. Identifying Assets and Services for the Assessment
2. Determining Hazards or Climate Events
3. Assessing Exposure of Assets and Services
4. Determining Hazard Probability or Likelihood
5. Assessing Consequence of Hazard Occurrence on Assets and Services
6. Determining Risks of Asset and Service Exposure

4.1 STEP 1 - IDENTIFYING THE ASSETS OR SERVICES FOR ASSESSMENT

The first step in identifying the system or services at risk within the community is to identify the assets that provide lifelines and essential services to the community and/or installation, especially during and after a disaster. These facilities and services deserve initial attention since they contribute to essential services within a community that are especially important during disasters in which a community needs to exercise its resilience. Examples of such lifelines include[19]:

- Police and fire stations and first responders (e.g. EMS)
- Emergency operations centers (EOCs)
- Medical and health care facilities such as hospitals, nursing homes, and blood banks
- Schools and day care centers, especially if designated as a storm shelter
- Housing and community centers, especially those pivotal to response plans
- Government buildings, especially those involved in disaster response
- Power generating stations, including power plants, co-generation plants, hydropower, distribution systems, and wind/solar farms
- Water and wastewater facilities including source water, distribution mains, and treatment facilities
- Dams, levees, and other flood protection barriers
- Stormwater infrastructure such as sewer mains and lift stations

All assets, regardless of criticality to community and operations, should be considered as part of the assessment. The list can be further refined by the resilience planning team when evaluating project conditions (e.g. budget, timeline, local priorities). As part of the asset identification process, identified key services and/or third-party dependencies should be considered. Specific consideration should be given to services and dependencies which provide services to maintain the function and operations of facilities within the community. Examples of these might include:

19 FEMA Community Lifelines. Retrieved from https://www.fema.gov/media-library/assets/documents/177222.

- Electrical power
- Fuel and fuel storage
- Telecommunications and cellular connectivity
- Transportation and mobility (e.g., transit systems, strategic roadways, and railways)

Additionally, other community factors may help determine the selection of assets and services. These might include:

- Community safety, security, and shelter
- Economic drivers (potential for disruptions and loss of business income – direct and indirect)
- Socio-economic elements & quality of life for military communities
- Environmental assets and ecosystem services such as:
    - Wetlands protection
    - Critical habitat
    - Green infrastructure
    - Parks and open space
    - Carbon footprint
- Religious or cultural centers that hold community significance

Once the assets and services are determined, the resilience planning team shall give consideration for the level of detail needed when gathering data and the expected outcomes of the assessment. This may include decision-time horizons of the assessment, the available data from both asset and climate datasets, and the risk tolerance of the community. The urgency of resilience measures will likely impact the level of detail being sought for the first risk and vulnerability assessment. If the resilience planning team goes into the process to target a specific hazard already causing problems, the effort may focus on those already well understood hazards (e.g., nuisance flooding or power grid stability) and seek to get detailed data at the onset. In cases where a community is trying to get a broader handle on where their hazards and vulnerabilities lie, data gathering may be lighter at first and evolve as the vulnerabilities picture comes into focus.

4.2 STEP 2 - DETERMINING HAZARDS AND CLIMATE EVENTS

Next the resilience planning team needs to determine the potential hazards facing installation and defense community assets. The identification of the natural hazards posing a threat to maintaining military mission assurance and mission-essential functions calls for input from the full planning team. Hazards should be identified from the perspective of the community and installation then discussed to identify where these vulnerabilities overlap and what should be the focus of the resilience planning team.

Non-natural hazards can be considered under this framework, but the focus of this scope is primarily on natural hazards. In many cases, hazards can be selected by considering historical impacts experienced by the community from extreme weather events and considering the likely change in patterns due to evolving climate factors. However, it is important to realize that not all hazards that pose risk to a community will have historic precedent. Additional sources of information that can help inform initial hazard screening include local hazard mitigation plans, compatible use plans, local climate information, and other academic or planning resources. Once selected, the team will determine the probability of hazard occurrence (e.g., frequency of occurrence) and potential consequences of each hazard. Examples of potential hazards to consider include:

Riverbay Cogeneration Facility*

Bronx, New York | *Many critical infrastructure assets located near hazard sources in densely populated areas*

Table 3: Overview of Natural and Non-natural Hazard Events

Natural Hazards		Non-Natural Hazards
Tidal Flooding and Sea Level Rise	Tornados	Terrorism and Malevolent Attacks
Storm Surge, Coastal Erosion, and Wave Hazards	Drought	External Acts of Aggression
Riverine Flooding	Wildfire	Dam and Levee Failure
Persistent/Nuisance Flooding	Landslide, Debris Flows, and Erosion	Power Grid Failure
Increased Precipitation	Extreme Heat and Heat Waves	Supply Chain Failure
Lightning	Extreme Cold and Freeze Events	Hazardous Material or Chemical Releases
Wind Storm	Earthquakes and Seismic Activities	Traffic and Transportation Hazards
Hurricanes and Tropical Storms	Tsunamis and Volcanic Activities	Labor Strikes
Hail Storms	Infectious Disease Outbreak	Cybersecurity Threats

Information on climate and hazard events can be obtained from various sources, including (but not limited to):

- Government agencies such as the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), FEMA, and local and state climatological records
- Local records of extreme events impacting the community, insurance claims
- Historical records of severe weather events: newspapers articles, online reports, severe event databases
- Academic studies and databases (e.g. state universities, research efforts)

Community and military stakeholders should work together to develop a consensus on the selection of relevant hazards, data sources and information, and other key inputs to the process, as priorities and standards with respect to impacts and consequences of hazard occurrence may be different among the range of stakeholders. The vulnerability and risk assessment focuses on climate events that have or will cause malfunctions or failures in the critical lifelines or endanger the community. By focusing on these types of events, thresholds or “breaking points” can be established based upon design of assets, known issues with specific events, or existing planning documents that specify response to events. Thresholds specify the intensity or magnitude of a climate event above which the asset, service, or community is impacted structurally and/or does not function or operate as needed. These intensity thresholds are often specific to asset or service-climate event interactions. For example, wind gust speeds exceeding a particular threshold have a large impact on insurance claim frequency and can directly indicate where damages start to occur. One of these established thresholds is for gusts of 55 mph or greater, as this speed is where impacts to housing (shingles fly off, debris impacts) and trees (branches break) can lead to cascading impacts through the community (e.g. power failures, road blockage, flying debris, falling tree branches).

4.3 STEP 3 - ASSESSING EXPOSURE OF ASSETS AND SERVICES

Using the selected groups of assets and services from Step 1, the next step is to assess the exposure of the asset or service to the hazards selected from Step 2. This process starts with simply identifying whether the exposure exists. For example, if assessing a stretch of paved road in the community, one would evaluate the exposure of the road to a series of hazards for whether there is a potential interaction. This type of assessment would be common to all community/base interface points including sewer, water, energy, and telecommunications. This process is described in **Figure 5**.

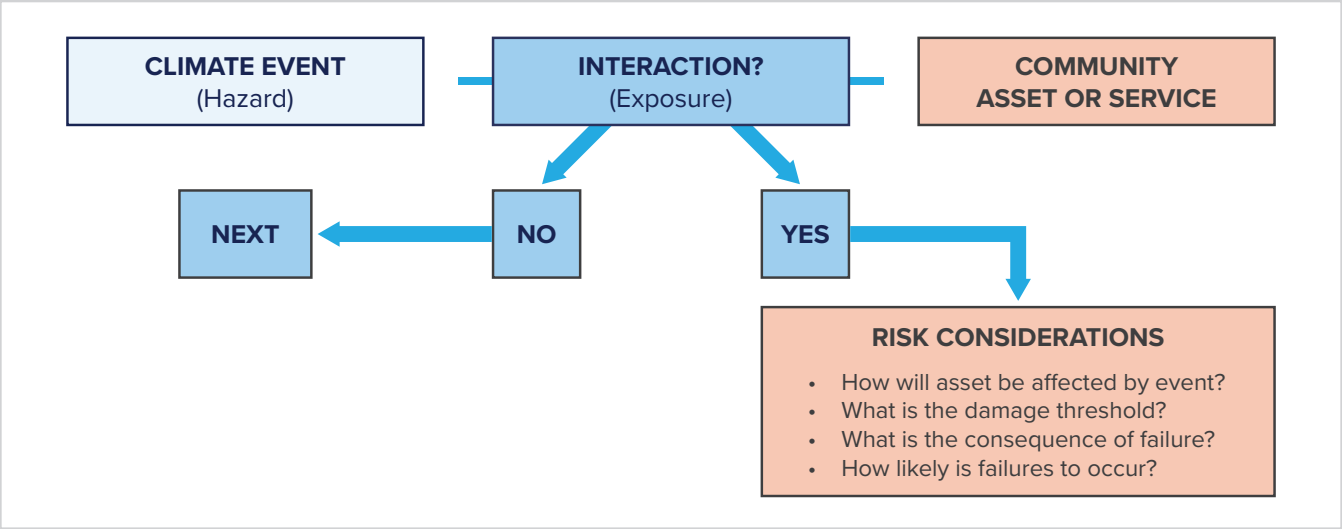


Figure 5: Decision Workflow for Assessing Exposure of Assets to Natural and Non-Natural Hazards

4.4 STEP 4 – DETERMINING NATURAL HAZARD PROBABILITY

Probability is a statistical measurement of the likelihood of occurrence. It is typically attributed to different magnitudes of hazard events based on statistical exercises on historic data and reoccurrence observations. Determining likelihood of occurrence is very important in understanding risk and how much emphasis should be placed on certain occurrences. However, probability is not a constant. With changes in climate factors and other activities, observed trends in occurrence probabilities change as well. It is important for communities to appreciate the dynamic nature of climate conditions and to consider this as they approach resilience planning.

Current hazard probabilities often leverage empirical datasets such as those kept by NOAA and NWS. Empirical data can be analyzed to indicate probability of occurrence of given hazards. However, these observation-based datasets only capture existing hazard probability and don't necessarily account for future conditions.

Future climate projections use internationally recognized greenhouse gas (GHG) emissions scenarios published by the Intergovernmental Panel on Climate Change[20]. The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. The IPCC was established in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Program (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation. IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive. They may present projections of future climate change, the risks posed, and the implications

20 IPCC – accessible from http://www.ipcc.ch/.

of response options, but they do not tell policymakers what actions to take.

Climate projections are descriptions of the future climate and are most often generated by Global Climate Models (GCMs). There are nearly 40 GCMs that have contributed to the Fifth Coupled Model Intercomparison Project (CMIP5[21]); which forms the basis of Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report[22] (IPCC, 2013). The IPCC recommended best practices advice using the mean of several GCMs instead of relying only on one or two GCMs to give a more reliable estimate of future climate.

A large source of uncertainty in all future climate projections is based in the ultimately unknown future trajectory of GHG emissions as well as the international progress towards meeting GHG emissions targets. There are four Representative Concentration Pathways (RCP)[23] scenarios adopted by the IPCC for its Firth Assessment Report (IPCC, 2013) that are based on various future greenhouse gas concentration scenarios. Typically, a maximum of two GHG emissions scenarios are used to represent future climate changes. Current global greenhouse gas emissions correspond with the RCP 8.5 trajectory[24]. These are as follows and shown in **Figure 6:**

- RCP4.5 scenario – a stabilization scenario in which global GHG emissions effects are stabilized shortly after 2100.
- RCP8.5 scenario – increasing global GHG emissions over time with no stabilization.

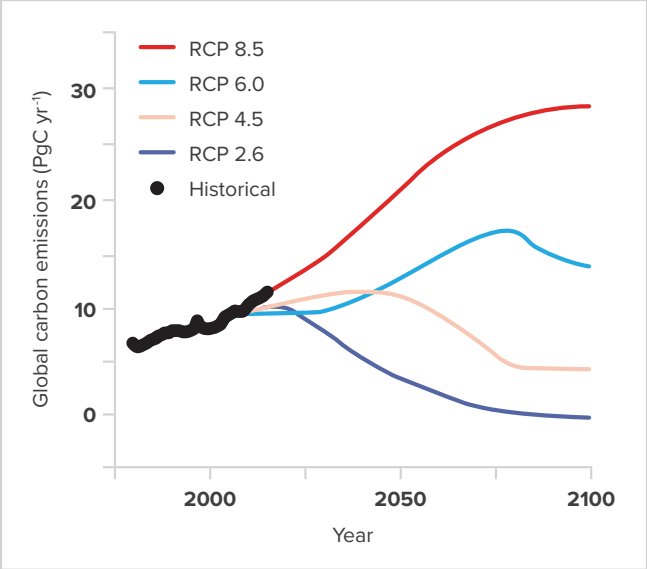


Figure 6: Historical CO_2 Emissions for 1980-2017 and Projected Emissions Trajectories Until 2100 for the Four RCP Scenarios

It is standard practice to use RCP8.5 only when conducting risk assessment, as the scenario tracks along current GHG emissions and represents a risk-averse assessment. This means that assessing future climate under the RCP8.5 scenario will not underestimate future risk from climate change, protecting the community against maladaptation or under-estimation of future climate change. In the event that multiple future climate scenarios are of interest to the resilience planning team, the recommendation is to then use RCP4.5, allowing for a scenario that assumes mid-century peak of GHG emissions followed by global mitigation and carbon removal strategies to minimize temperature increases at the end of the century. It should be noted that while carbon emissions shown in **Figure 7** vary greatly between RCPs, the overall temperature change produced by each scenario tracks similarly for RCP4.5 and RCP8.5 and does not greatly diverge until post 2050. This is relevant if the time horizon chosen for future analysis only includes the 2050s, as adding an additional RCP increases both the time to complete hazard analysis and the complexity of

21 Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An Overview of CMIP5 and the Experiment Design. *Bull. Amer. Meteor*. Soc., **93**, 485–498. Retrieved from https://doi.org/10.1175/BAMS-D-11-00094.1.

22 IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.] Retrieved from https://www.ipcc.ch/report/ar5/wg1/.

23 RCP: Representative Concentration Pathways – greenhouse gas concentration trajectories (van Vuuren et al., 2011). Retrieved from https://link.springer.com/article/10.1007/s10584-011-0148-z.

24 Smith, M.R., Myers, S.S. Impact of anthropogenic CO2 emissions on global human nutrition. Nature Climate Change 8, 834–839 (2018). Retrieved from https://doi.org/10.1038/s41558-018-0253-3.

analysis of risks. Selection of climate scenario should be completed by the project team, with advice from a consulting team as needed, to align with the risk tolerance level of the community and relevant critical lifelines.

Using historical hazard occurrence information and a future climate scenario, probabilities for each hazard selected in Step 2 – Determining Hazards and Climate Events should be calculated. In some cases, where direct calculations are not possible, probability can be assigned using the judgment of the project team, using supporting documentation from academic studies, historical trends, and input of stakeholders to determine the likelihood of occurrence of an event. In this case, decisions need to be documented to provide proper context to the decision-making process. Where possible, the team should include local climate and hazard experts to assist with this process. Once probabilities are determined, a score of 0 to 5 should be assigned in the fashion described in **Table 4**.

Table 4: Assigning Qualitative Probability of Occurrences to Hazard Events

Score	Probability of occurrence (P)	
	Description	Example of return period
0	Negligible – Not applicable	< 1 in 1,000
1	Highly unlikely – Improbable	1 in 100
2	Remotely possible – Somewhat probable	1 in 20
3	Possible – Occasional	1 in 10
4	Somewhat likely – Normal	1 in 5
5	Likely – Frequent	> 1 in 2.5

Probabilities should be assessed across multiple timeframes, including a historical baseline, to understand current risk levels and the change in overall risk induced by a changing climate. For instance, coastal flooding may be moderate under existing conditions, but overtime risk may increase due to sea level rise and other factors. Typically, time horizons for this are 30-year periods. Sample 30-year periods for assessment are:

- Past 30 years (i.e. Historical Baseline: 1981 – 2010)[25]
- Current to 30 years in future (i.e. 2020s: 2011 – 2040)
- 30 to 60 years in the future (i.e. 2050s: 2041 – 2070)
- 60 to 90 years in the future (i.e. 2080s: 2071 – 2100)

These periods are customizable and should align with the lifespan of service and critical assets within the community being assessed. This decision is typically made at earlier meetings with the planning team.

4.5 STEP 5 - ASSESSING CONSEQUENCE OF HAZARD OCCURRENCE ON ASSETS AND SERVICES

Following the exposure analysis from Step 3, each community asset or service where the planning team identified a potential interaction with the hazard must be assessed for severity of impact (or consequence). This process can be repeated across the community in asset groupings of similar lifeline (e.g. police, fire, and emergency services; clinics and hospitals; etc.). This activity is typically conducted by the project team together with relevant stakeholders and service providers to best understand the impact of interactions with various hazards on the community's resilience.

Consequence scoring relies on the development of criteria that describe the risk tolerance of the community to various hazards. This is typically customized to match the needs of the community and not prescribed due to differences in many key considerations from location to location. An example is shown in **Table 5**.

However, it is important to think beyond an individual asset or service and consider how it fits into the

25 Calculated based on World Meteorological Organization standard 30-year, non-rolling periods.

broader picture of community resilience. The resilience planning team should take care in assigning consequence scores and consider not only the direct impact, but how lessened services could impact other resilience elements of the community. The table below describes a sample consequence rating table that should be customized by the resilience planning team to match the needs, risk tolerance, and impacts that the community might experience. This customization is important at the individual risk tolerance, and adaptive capacity for each community is likely to differ based on a number of factors, including types of hazards, previous exposures to extreme events, interdependent assets and services, and local ability to recover from events. The resilience planning team should also consider how priorities will vary among stakeholders and seek to find shared priorities or aggregate scores across the different stakeholder groups to capture the range of different priorities of those involved. An example workflow of the Risk and Vulnerability process is seen in **Figure 7**.

Table 5: Sample Consequence Rating Method from a Community. Customization Should Be Performed by Individual Communities.

Consequence Rating	Qualitative Descriptor	Description of Impact
0	No Effect	• No effects
1	Insignificant	• Measurable but cosmetic effects • Very low consequence • Costs handled within normal budgeting for entity • Correctible using O&M practices
2	Minor	• Some extra costs to repair but can be covered within current O&M and capital budgets • Routine operations for minor incidents; community and assets have capacity to meet demand • Asset or service is still operable and accessible, although minor service disruption may be possible • Slightly reduced ability to perform scheduled maintenance
3	Moderate	• Manageable asset or service damage but repair costs may be beyond current O&M and capital budgets • Asset or service still operable but some access limited • Brief service disruption may be possible; asset design capacity being reached
4	Major	• Heavy burden on internal resources of the entity to repair or service assets • Significant threat to installation mission critical readiness • Asset or service still operable but accessibility limited • Lengthy service disruption; assets or services operating at capacity for lengthy periods of time
5	Catastrophic	• Loss of life, property, mobility, access to emergency services, or power • Loss of installation mission critical readiness • Complete asset or service replacement due to hazard severity • Need for outside emergency funding (FEMA disaster declaration) • Significant service disruptions may be possible, requiring alternate service delivery • No access to assets

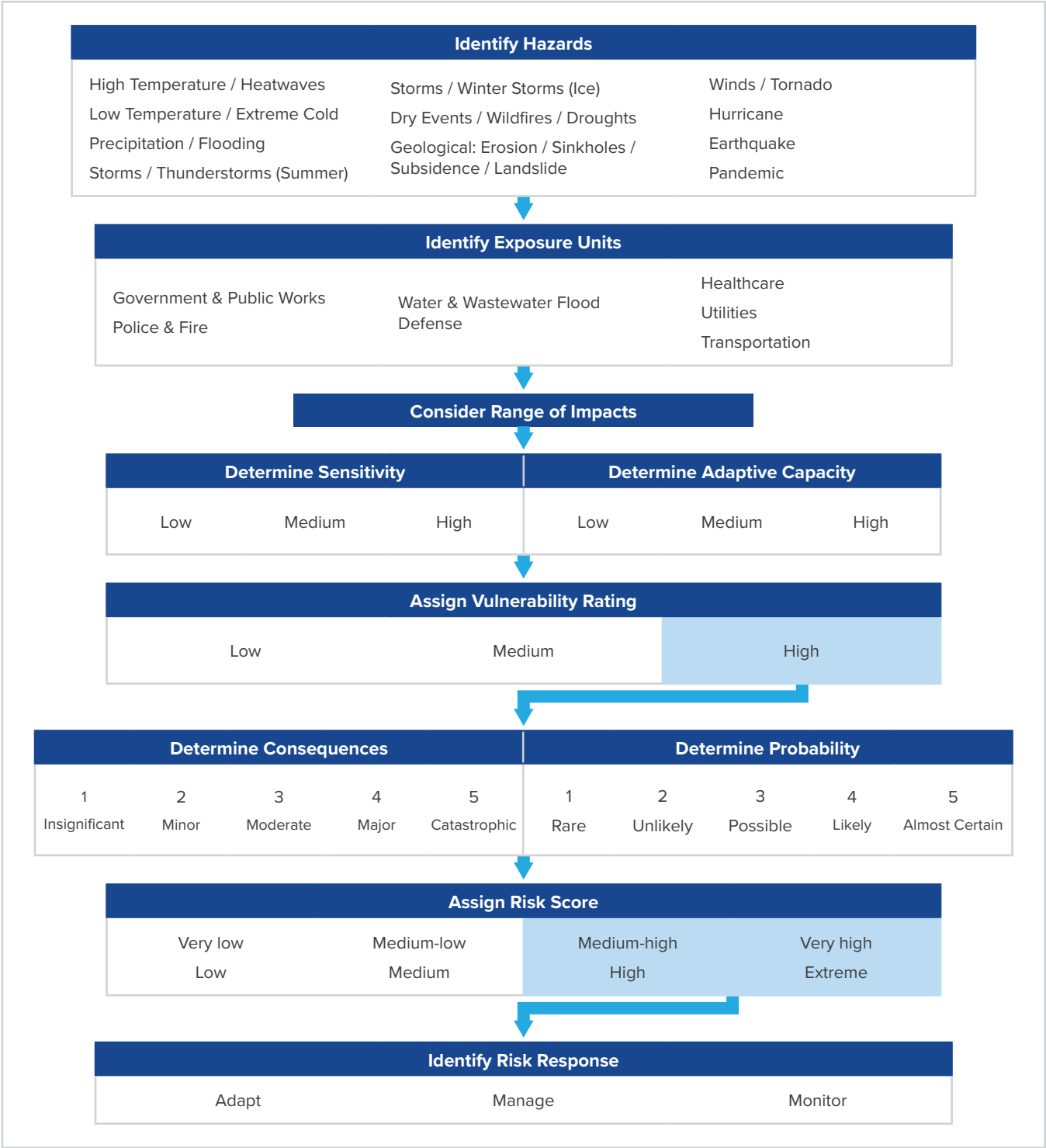


Figure 7: Sample Illustration of Vulnerability and Risk Assessment Process Flow

4.6 STEP 6 - DETERMINING RISKS (SIMPLIFIED SCORING SYSTEM)

The final step in the process is to calculate a risk rating for each asset or service evaluated in the process. This step involves combining the probability (P) and the consequence (C) scoring through multiplication to calculate the risk rating. The simple equation for this is **R = (P x C)**. If using a 5x5 scoring system (five probability bins and five consequence categories), the maximum risk calculatable would be 25. The risk scoring system is shown in **Figure 8**. Red (or high risk) coloration indicates the need for immediate resilience and adaptation measures to handle risks. Orange (or moderate risk) indicates the need for possible planning, while green (or low risk) indicates that the risks posed by the specific hazard are of lower priority to address with respect to orange or red categories.

The blue categories represent two separate types of events – "shock" and "stress" hazards. An example of a shock-based risk would be a very infrequent event that has a major consequence, such as a major hurricane hitting the community or an extremely intense earthquake. Typically, these events are difficult to adapt to or prepare for outside of emergency planning activities and would require measures for adaptation or resilience that are cost-prohibitive to implement to reduce overall risk.

A stress event represents something that is very frequent and little consequence if manifested as an individual event. This might be represented by cycles of freezing and thawing, gradual warming of temperatures, or small rainfall events. Typically, these events are still of importance for planning, but require less adaptation or resiliency measures to properly address. In general, stress events can act to magnify the outcomes of other hazard occurrences and risks within the community, in particular if they occur in tandem with a "shock" event.

Using the risk tolerance of the community as a guiding principle, any risk above a certain threshold is carried forward for determining controls. In practice, risks that fall into the orange (high) to red (very high to extreme) are typically carried forward to determine adaptation and resiliency measures that can help to reduce the consequence of the event. Using the established understanding of community risk and vulnerability will help the resilience planning team to determine the best steps forward to conceptualize and prioritize impactful projects to increase the community's resilience.

Consequence	Catastrophic	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Highly Unlikely	Remotely Possible	Occasional	Normal	Frequent
			Probability of Occurrence				

Figure 8: Risk Matrix Based on Simplified Scoring System

5.0 CONCEPTUALIZING AND PRIORITIZING IMPACTFUL PROJECTS

Once a shared understanding of community risk and vulnerability is established, the resilience planning team can begin conceptualizing mitigation strategies to address community and installation vulnerabilities. Once resilience projects have been identified, potential projects can then be prioritized using a qualitative and/or quantitative approach. A qualitative approach (Phase I) can be used as a lower-effort, initial step to determine projects that are most beneficial and/or feasible to implement. A quantitative approach (Phase II) can be used to assess detailed, comprehensive costs and benefits of potential resilience projects, and is often a requirement to receive grant funds for project implementation. As the quantitative approach requires more time, resources, and expertise, it is recommended that only the highest-priority projects identified in Phase I be considered under Phase II. This report describes the Phase II approach at a high level but does not provide detailed guidance for communities.

5.1 IDENTIFYING POTENTIAL RESILIENCE PROJECTS

Before resilience projects are prioritized, the planning team must identify potential projects. The team should use the results of the risk and vulnerability assessment to translate shared deficiencies in community and installation resilience into actions. Conceptual projects should mitigate impacts from the highest scoring risks on the risk matrix developed during the risk assessment (**Figure 9**). Further, identified actions should enhance the resiliency of both the defense community and the military installation. Such actions include, but are not limited to, enhancements to energy, water and sanitation, and transportation systems, as well as off-base housing and critical services (e.g., firefighting, emergency response, hospitals) that support military families.

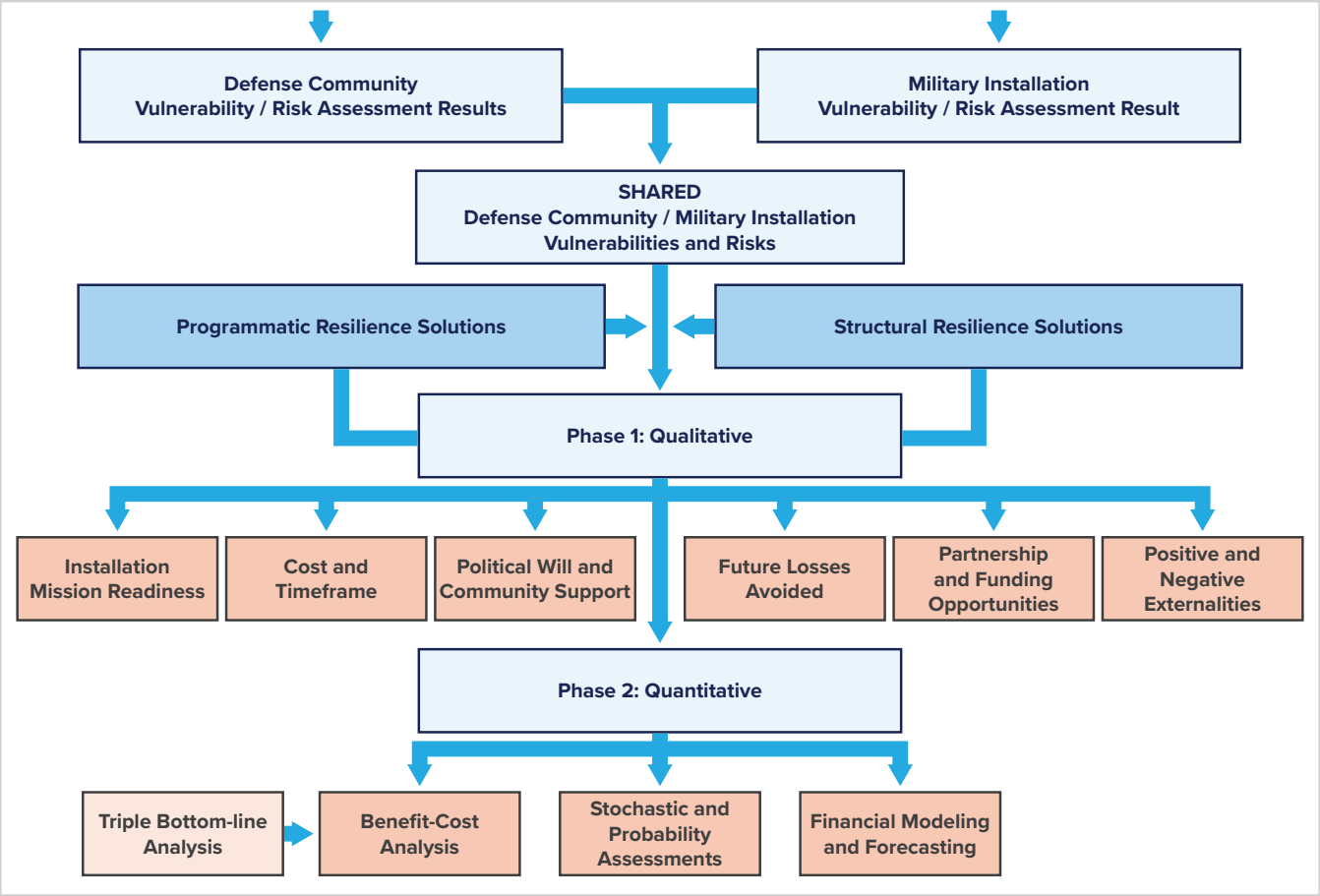


Figure 9: Process for Identifying and Prioritizing Resilience Projects

The planning team should be utilized to generate a list of potential projects, as they will have a working knowledge of the community and the systems within, as well as the readiness needs of the military installation. Teams should think broadly in identifying types of potential projects. While some projects may be structural in nature, others may be programmatic. Generally, programmatic, or management, resilience actions bolster resiliency through policies, regulations, and coordination efforts. Programmatic measures include those addressing planning, public education, emergency management, and long-term maintenance. Alternatively, structural projects are physical in nature and may include large structural modifications, infrastructure upgrades or property protection opportunities. Structural projects can be site-specific, community-based, or even regional.[26,27] **Figure 9** presents a process for identifying and prioritizing resilience solutions based on shared community and installation risks.

5.1.1 **Programmatic Actions**

Programmatic activities focus largely on:

- Preventing hazard impacts from occurring through policies, plans, and regulations intended to minimize hazard risk in areas of potential future development
- Educating the public regarding potential hazard impacts and providing information on measures individuals can take to reduce their risk
- Emergency management planning and policies that better position Defense communities to respond during hazard events
- Types of programmatic activities presented in **Table 6**, along with examples.

Table 6: Examples of Programmatic Resilience Activities

Activity Type	Examples
Land-Use Planning, Zoning, and Development Regulations	• Floodplain ordinances • Firebreak requirements • Cluster development • Transfer of development rights • Coastal development setbacks • Adequate public facilities ordinances • Riparian buffer requirements • Natural resource overlays • Long-range planning (parks and open space preservation) • Conservation easements
Building Codes and Standards	• Seismic requirements • Design wind speeds • Floodplain design codes • Adoption of uniform/model building codes • Special requirements for critical facilities

26 Introduction to Hazard Mitigation (2013). FEMA. Retrieved from https://training.fema.gov/emiweb/is/is393a/is393.a-lesson4.pdf.

27 *Community Resiliency Planning Guide for Buildings and Infrastructure* (2016). NIST. Retrieved from https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1190v1.pdf.

Activity Type	Examples
Stormwater Management Planning	• Adoption of state / DOT requirements • Design requirements for culverts and SWM BMPs[28] to accommodate future flows • SWM requirements (e.g., peak flows, on-site detention/retention) • Requirements for drainage system debris removal • Creation of stormwater utilities
Capital Improvement Planning	• Not extending infrastructure into hazard areas • Joint training for infrastructure maintenance
Public Education and Awareness	• Real estate disclosures and/or notices • Television and radio announcements • Websites and interactive mapping platforms • Outreach and engagement programs • Social media campaigns • Mass mailings • School handouts • Evacuation route signage
Emergency Management	• Public alert systems (e.g. flood warning) • Mutual aid agreements (MAAs) or memoranda of understanding (MOUs) • Use of the National Incident Management System (NIMS) and Incident Command System (ICS) • Emergency Response and Continuity of Operations plans • Joint training exercises

5.1.2 **Structural (Physical) Actions**

Structural projects include alterations to the physical environment that protect people and property from natural hazard impacts. Structural projects can vary in scale by reducing risk at the site, community, or regional level. Site-specific projects are those focused on reducing risk to structures and infrastructure on a small geographic scale, often applied to a single property or group of properties. Types of property protection measures include property acquisitions, building or infrastructure relocations, and retrofitting. Retrofitting aims to upgrade or alter structures and infrastructure to be more resilient to hazards without moving them to a new location. Retrofits to infrastructure systems should enhance system interconnectedness and redundancy, especially for interdependent systems. In considering site-specific projects, special consideration should be given to critical facilities, such as those defined in Section 4.1. Critical facilities are considered essential for communities to respond to and recover from a hazard event. Community- and region-based projects typically occur at a larger geographic scale and require significant capital investment. These types of projects are used when there is potential for a high return in terms of losses avoided.

Aside from being defined by geographic scale, structural projects may be nature-based, structure-based, or infrastructure-based. Nature-based projects have the potential to reduce hazard impacts, and often provide the co-benefits of recreation, environmental protection, and/or wildlife habitat. Nature-based solutions are frequently proposed in clusters and/or designed to imitate nature while protecting critical infrastructure. Structure-based projects are those aimed at enhancing the resilience of buildings, such as residential structures, public buildings, and critical facilities. These types of measures often include

28 Stormwater management (SWM) and best management practices (BMP).

retrofits, relocation, or construction of new facilities and are often site-specific. Lastly, infrastructure-based projects are those that enhance resiliency of infrastructure systems, such as water and stormwater, energy, and transportation systems. While infrastructure projects can be site-specific, most are associated with large-scale infrastructure improvements carried out at the community or regional scale, such as dams, levees, smart grids, roadway/bridge improvements and water recharge facilities.

While structural projects aimed at protecting buildings and infrastructure may be necessary to protect existing development, there is encouragement within the planning community to use programmatic measures (such as building outside of floodplains) and nature-based solutions to reduce the need for large-scale infrastructure projects where possible. These types of structural projects tend to be more costly to construct and maintain, have the potential to fail, and could have adverse impacts on natural systems.

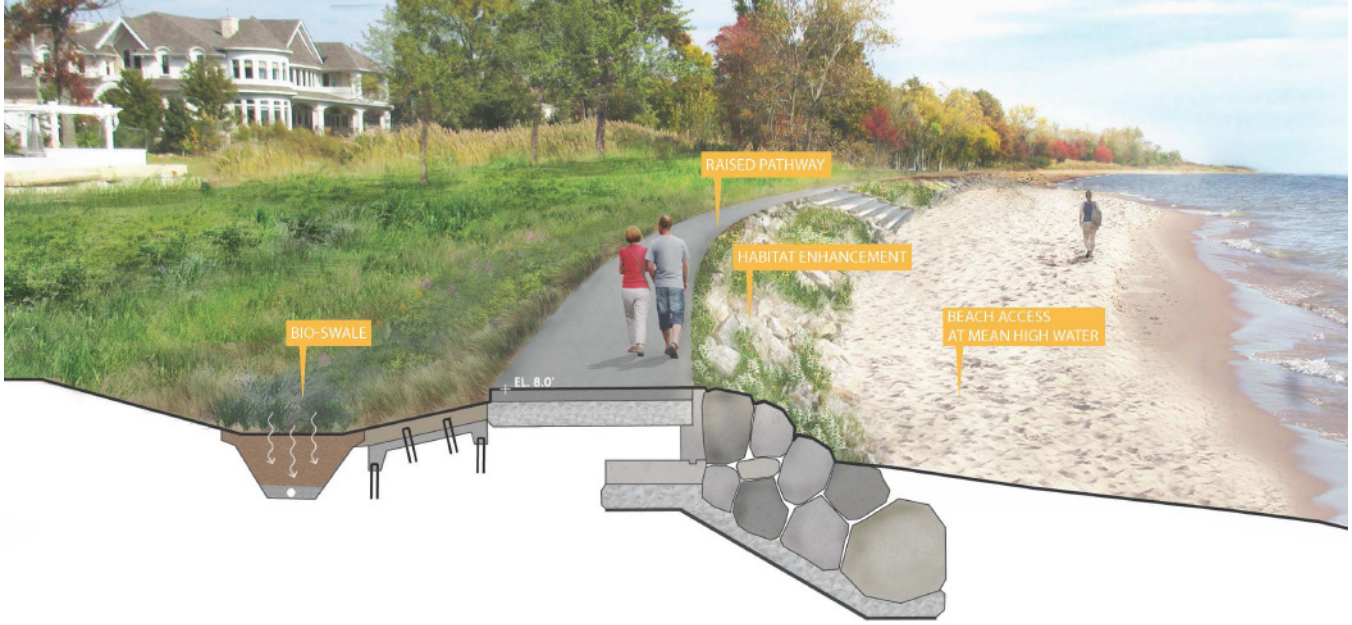
Table 7: Sample List of Structural Projects

Site-Specific	Nature-based	• On-site SMW (e.g., bioretention, infiltration, cisterns, low-impact development) • Ecosystem service restoration (e.g. wetland, riverine, coastal/shoreline, living shorelines) • Renewable energy projects (e.g. micro grids, geo-thermal energy)
	Structure-based	• Relocate homes or critical facilities out of hazard areas • Dry floodproofing • Elevation of structures or equipment • Anchoring manufactured homes • Storm shutters • Tornado safe rooms • Seismic retrofits • Fire breaks • Sump pumps • Emergency generators
	Infrastructure-based	• Floodwalls and levees • Culvert upgrades • SWM basins • Burying overhead power lines • Off-shore wave breaks • Grey water system • Renewable energy/storage
Community-based	Nature-based	• Floodplain conservation / protection • Regional flood management (dry- and wet-detention basins, constructed wetlands • Coastal (beach/dune) management • Green stormwater infrastructure • Blue-green infrastructure • Stream restoration, daylighting, or floodplain benching • Community buffers and land use management projects
	Structure-based	• Community centers (e.g., cooling centers, safe rooms, triage centers) • Emergency operation centers

Community-based	Infrastructure-based	• Earthen levees and berms • Dams and/or reservoirs • Floodwalls, gates and pump stations • Off-shore wave breaks • Storm sewer upgrades • Detention basins • Relocate / elevate roads subject to flooding or coastal risk • Relocate water mains to be outside of sea level rise zones • Burying overhead power lines • Upgrading water mains or constructing redundant mains • Designed interconnections between service areas and providers • Looped water distribution networks • Dual energy feeds to critical infrastructure • Energy system retrofits – renewables (e.g., solar, wind, geothermal), smart grids, microgrids, energy storage • Evacuation route improvements • Multi-communication service providers • Upgrades to communications systems (e.g., cellular, internet/fiber, broadband) • Potable water reuse systems
Region-based	Nature-based	• Conservation buffers • Re-greening / re-planting / re-forestation • Invasive species management • Coastal environmental restoration (sea grass plantings / reefs / oyster beds)) • Natural reefs (e.g., coral and oyster)
	Structure-based	• N/A
	Infrastructure-based	• Levees, berms, and floodwalls (e.g., Gulf "Coastal Spine" project) • Watershed programs, dams and/or reservoirs • Water conveyance systems and recharge facilities • Transportation network upgrades (e.g., public transit projects) • Energy system retrofits, renewables (e.g., solar, wind, geothermal), smart grids, microgrids, energy storage • Upgrades to communications systems (e.g., cellular, internet/fiber, broadband)

Hamden Landfill and Solar Farm Site*

Hamden, Connecticut | *Converted landfill site for solar power generation*



5.2 **DATA NEEDS FOR PROJECT CONCEPTUALIZATION**

When developing resilience project design concepts and prioritizing for funding, there is often a significant need for relevant data. Retrofitting existing buildings requires as-built information and knowledge from building operators or public works departments. Designing infrastructure improvements will require engineers with expertise in resilience solutions. Further, climate change carries inherent uncertainties, and therefore additional data may be needed to design a solution that is resilient to future climate conditions. Communities may need downscaled climate data or models based on future climate conditions and development scenarios to conceptualize a project that is truly resilient. For instance, in designing a new culvert, engineers should consider future flows from both projected precipitation changes and increased impervious cover due to development, rather than current conditions, for the lifespan of the culvert.

As needs and ideas come into focus, it is often necessary to gather additional data and resources to support potential risk reduction measures. Expect to request existing plans or consult planning documents that discuss community shortfalls and risks to hazards. Further, data gaps should not deter communities from considering resiliency projects or from incorporating resilient design measures into proposed infrastructure projects. It may be necessary to build the cost of conducting future conditions studies or models into the project's engineering cost, or to consider conducting a study as a standalone resilience measure. For example, a project to model future flows across an entire watershed means that data can subsequently be used in identifying needed improvements and designing stormwater infrastructure throughout the community.

5.3 **PRIORITIZING POTENTIAL RESILIENCE PROJECTS**

For ease of implementation, two phases are defined for prioritizing resilience projects. Phase I describes a qualitative approach, in which projects are prioritized using generalized categories (low, medium, high), broadly defined ranges (e.g., cost or years to implement) or a weighted scorecard approach that considers a range of factors. This approach is often most effective during the planning process and can help planning teams quickly identify high-benefit, low-cost projects for implementation, filter out low-benefit/high-cost projects, or pinpoint high-cost/high-benefit projects for further analysis. Phase II describes a quantitative approach to project prioritization, and requires more time, resources, and expertise to conduct. Projects that are categorized as having a high benefit in Phase I but may require additional funding to implement are often candidate for a Phase II analysis. Similarly, many funding opportunities require detailed qualitative analyses as part of the application process.

5.3.1 **Phase I Qualitative Prioritization Approach**

The Phase I approach to prioritizing resilience projects or activities should weigh several factors at a high-level. For instance, instead of conducting detailed

Tottenville Shoreline Protection Project*

Staten Island, New York | *Resilient, nature based coastal armoring design to mitigate wave hazard for at-risk community*

engineering-level cost estimates for a specific project, an experienced member of the resilience team, such as a city engineer or public works official, may place projects into broad cost ranges. Resilience teams should include cost and benefit factors that are important to their community and weigh these factors accordingly, including elements such as feasibility, cost, and risk reduction.

1. **Benefit to key community stakeholders (i.e. installation resiliency) –** Consideration should be given to the benefit the project provides to installation resiliency, especially if applying for grant funding aimed at increasing mission readiness on installations. Projects that enhance military value, such as infrastructure systems, critical facilities, and housing that support the installation and/or its service members should be given priority.

2. **Damages avoided vs. risk reduction –** A broad estimation of the anticipated future losses avoided, including life safety, property damage, and infrastructure damages. These can be placed into broad monetary categories using estimates based on previous damages, or can simply be categorized as high, medium, or low based on expertise provided by those on the resilience team.

3. **Cost –** Generalized cost estimates or ranges can be used to weigh projects. For example, a new floodwall may be categorized as having a high cost, whereas adopting a floodplain ordinance may be categorized as having a low cost. Initial capital costs and lifecycle (e.g., maintenance) costs should be considered. Planning costs and demand for staff time can also be considered for non-structural projects.

4. **Time –** An estimate of the time needed to complete the project. Considerations may include regulatory review timeframes, design and construction, and political factors that may slow things down.

5. **Political will and community support –** An estimate of a project's ease of implementation. Projects that have political support and/or the support of the community and the installation will likely be implemented with minimal resistance or delays.

6. **Partnership opportunities –** Opportunities to develop new partnerships or utilize existing ones with the ability to leverage resources, such as funding, data, and expertise. Partnerships can increase project feasibility and efficiency and assist projects in garnering support. Partnerships may be developed with private industries, non-profit organizations, universities, or public agencies to achieve common goals.

7. **Identified funding sources –** Projects that have identified funding sources should be weighted higher than those without funding. Projects may already have funding allocated through awarded grants or capital improvement programs, may be eligible for funding through identified grants or budget allocations, or may not have any type of potential funding identified.

8. **Benefit to vulnerable populations –** Projects may be considered more effective if they provide a benefit to socially vulnerable populations. Social vulnerability provides insight into the underlying socioeconomic indicators that predispose a community to the negative impacts of disaster events. Communities with disproportionate populations considered socially vulnerable, such as the impoverished, elderly, and disabled, are often less equipped to prepare for, respond to, and recover from disasters. Therefore, projects that benefit socially vulnerable populations may be given priority over those that do not.

9. **Co-benefits –** The most effective resilience projects may solve multiple problems or achieve multiple goals through a single project. For instance, preserving floodplains as open space provides flood protection as well as a community recreation opportunities and ecosystem benefits.

10. **Negative externalities –** While some projects may have a resilience benefit or protect a certain facility, they have external, unintended consequences of other facilities, natural resources, or ecosystems. For instance, a seawall might protect a facility from high wave flooding or storm surges but could cause loss of the beach on the seaward side of the wall by disrupting sediment erosion and deposition patterns. Such impacts should be considered when weighing the costs and benefits of potential projects.

5.3.2 **Phase II Quantitative Prioritization Approach**

During later stages of prioritization and nearing funding requests, it may be prudent to conduct more detailed, quantitative assessments. This is where benefit-cost analyses come into play along with a growing body of sophisticated assessment tools to help communities assess and prioritize their resilience projects. Planning team members may consider handling some analyses in-house, depending on complexity and expertise, while other levels of analyses may prompt the need for outside expert consultation.

Either way, it is important to execute quantitative analyses carefully as this often occurs when projects are further along in consideration and can be expensive and complex to execute effectively. Thought should be given as to the goal of conducting quantitative analyses which will drive how elaborate the process should be. If the goal is to add a numerically (often in dollars) backed, additional layer of consideration to project prioritization, there are a variety of tools and approaches to support quantification of project attributes at a higher, but consistent level. If the goal is to conduct a more detailed comparison between several proposed projects and queue projects up for grant funding, specific methods and tools ought to be used to meet certain standards and requirements.

With so many resilience considerations, project metrics, and stakeholder interests, these planning processes can get rather complex depending on the scale of the resiliency program. This framework does encourage focused considerations and simplicity where able, but there may be times where complexity should be embraced. Some community issues may be so intricate that they require sophisticated methods to capture quantitively. And with growing variability in climate conditions, community demographics, and available financing, the assessment approaches need to match the complexity of the problems at hand. While there is no set way to manage all the uncertainty and intricacy that resilience issues pose, there are numerous tools, indices, and approaches in the industry to facilitate project evaluation. The general elements of these higher complexity approaches are outlined in the following section.

5.3.2.1 **Project Benefits and Costs Assessment**

The goal of this process should be to quantify the list factors described in Phase 1 – Qualitative Approach. Methodologies exist to calculate benefits for a wide variety of benefit types ranging from avoided loss of property to recreational value of greenspace to maintained utility services. This typically requires using standardized tools and methodologies from FEMA, the U.S. Army Corps of Engineers (USACE), the Department of Transportation (DOT), and other federal agencies.

Essentially, this approach is about using more robust methodologies to quantify project benefits and costs. Common practice is to calculate a project's lifecycle benefits as comprehensively as possible then divide by the project's lifecycle costs to determine a benefit-cost ratio. Benefit-cost ratios can be used to compare the project's cost-effectiveness against other projects that may or may not have a similar scope. Oftentimes, projects with large price tags are difficult to substantiate until a detailed accounting of the benefits provided is developed.

The qualitative approaches outlined in this framework are necessary for considering community priorities and honing focus to specific issues within the community that need to be addressed. These more detailed approaches are needed to take those project conceptualizations to the next level by justifying the community investment needed to implement projects and often are necessary to secure grant money.

5.3.2.2 **Stochastic Uncertainty and Probability Assessment**

As with climate projections, there is uncertainty in any model or estimation. A growing approach to manage uncertainty is to take a stochastic-based approach, where engineers and scientists will use computational methods to run hundreds or even thousands of model variations with differing inputs to determine sensitivity and statistical significance of different assumptions and possible outcomes. Essentially, the approaches to a standard benefit-cost assessment can be used to run a variety of estimations under different baseline conditions, assumptions about community inputs, and other factors.

These efforts will likely require expert consultation and necessary software. The benefit, however, is

generating a more comprehensive understanding of the range of possible outcomes and how changes to underlying assumptions would affect the resultant impact of projects being considered. The goal is certainly not to further complicate decision-making but to face uncertainty head-on and make more informed decisions based on how things can change over time. Project outcomes can be reported with a bell curve of uncertainty with the most likely outcomes in the middle. Communities can consider these results with confidence limits in mind and understand how likely a project is to succeed over time.

5.3.2.3 **Financial Modeling and Forecasting**

Finally, assessment tactics can be used to analyze the project financing side. Advancements in financial modeling can empower communities to understand how to finance and time project investments to achieve better outcomes. Coupled with climate horizon information, analytic approaches can seek to understand when investments are most beneficial or most necessary. For example, a large flood control project may not be cost-effective today, but with future precipitation or sea level trends, the project may make sense in 10 to 20 years. Project financing and timing considerations can also be analyzed to not only evaluate an individual project being considered but to develop recommendations for what and when a community should invest in resilience measures.

These three elements – benefit-cost considerations, uncertainty and probability, and financial forecasting – comprise an advanced, forward-thinking approach to risk management and community decision-making. While some communities may only need to leverage specific components of this approach to implement a resilience need, it is important to understand the tactics available to tackle the broad challenge of enhancing community resilience in an informed manner.

5.3.2.4 **Project Assessment Tools and Software**

Conducting these quantitative assessments usually requires use of a variety of tools and software. While this is not a comprehensive list, following is a sampling of commonly used tools and software packages for quantitative assessments and benefit-cost analyses:

1. **DoD's Climate Assessment Tool (DCAT) –** Planning tool which provides climate hazard exposure data for installations around the world. The data supports a screening-level assessment of installation vulnerability expressed as a combination of exposure and sensitivity based on past climate events and future projections.
2. **DoD's Energy Resilience Analysis (ERA) Tool –** Lets mission owners and energy managers balance the needs of critical missions on military installations with affordability when they design energy resilience solutions.
3. **FEMA's Benefit-Cost Analysis Toolkit –** Supports detailed benefit-cost considerations for variety of project types and hazards, particularly in support of FEMA's Hazard Mitigation Assistance grant programs.
4. **FEMA's HAZUS –** Standardized FEMA tool and methodology to support estimation of potential losses from natural hazards.
5. **AutoCASE –** Uses benefit-cost principles to consider triple bottom line metrics (economic, environmental, and social).
6. **XDI Cross-Dependency Initiative –** Platform for asset-based risk assessment of climate change and extreme weather risk.

FAMS Orange Water and Sewer Authority*

Carborro, North Carolina | *Data driven Financial Analysis and Management System (FAMS) application for water utility*

6.0 IDENTIFYING FUNDING SOURCES AND IMPLEMENTING RESILIENCE PROJECTS

Identifying and securing funding is often the biggest hurdle in implementing a resilience activity. Often, communities do not have reserves to invest in long-term resilience planning and infrastructure. However, there are a growing number of opportunities to leverage public and private investments to advance resilience. Resilience itself is an investment, and like any good investment, there are dividends. While not direct financial dividends, resilience investment produces a wide variety of benefits to defense communities and the installations they host in the form of avoided risk, enhanced mission readiness, improved quality of living, and ability to get through challenges together.

The following sections provide a variety of different funding sources that defense communities may consider pursuing to support their resilience planning efforts and subsequent design and construction of prioritized resilience projects. Some funding sources are more competitive than others, but with the right tools and requirements met, these funding sources can generate significant improvements in resiliency for defense communities and installations across the country. Although these funding sources are limited to defense communities rather than installations, the funding can address shared needs and promote military installation resilience.

6.1 FEDERAL FUNDING SOURCES

Many federal agencies operate grant programs that support resiliency projects. Most federal grant programs have specific eligibility and cost-share requirements. Further, most federal funding opportunities cannot be combined with other federal funds (i.e., a community cannot use a federal grant to meet their local cost share requirement for another federal grant). However, funds from state grant programs can typically be used to match federal grants, and vice versa. The following summarizes resilience-related grants available from federal agencies. Some of these grant programs are specific to Defense communities while others are available to both Defense and non-Defense communities.

6.1.1 DoD Office of Local Defense Community Cooperation

DoD Office of Local Defense Community Cooperation (OLDCC) administers the Military Installation Sustainability Program to provide technical and financial assistance to state and local governments to review existing capabilities supporting military installations and develop strategies to protect resources necessary to enhance resilience of military installations. This program provides communities planning support to perform a military installation resilience review to respond to threats to military installation resilience caused by lack of necessary resources outside the military installation which can adversely affect the military installation and its operations supporting the National Defense Strategy. State and/or local government partners with the military installation to plan and carry out strategies promoting protection of critical resources adjacent to installations, ranges, and military flight corridors which are vital to military installation resilience. The review includes a strategic plan with specific implementation actions to ensure military installation resilience is compatible with, and supportive of, vital training, testing, and other military missions. Grantees and participating governments are expected to adopt and implement the identified recommendations.

NOTE: The Office of Local Defense Community Cooperation was previously known as the Office of Economic Adjustment (OEA).

6.1.2 DoD Defense Community Infrastructure Program

The Defense Community Infrastrucutre Program (DCIP) is another OLDCC program, aimed at enhancing infrastructure in defense communities by

supporting projects that address deficiencies in off-base community infrastructure. The pilot program for this funding opportunity was approved in May 2020. Projects must improve infrastructure that supports quality of life for military families and improves the overall resilience of the installation. To be eligible, request funds must fall between $250,000 and $25 million and be ready for immediate construction (i.e., funding is only available for hard construction and renovation costs). State and local governments, including counties, non-profit organizations, and member-owned utilities are eligible to apply. The cost share for non-rural area projects (those with a population greater than 50,000) is 50%. Types of eligible projects include those that support off-base transportation, schools, hospitals, and emergency response facilities, as well as water and wastewater, telecommunications, electricity, and gas utilities. Projects must be endorsed by the local installation commander.[29]

6.1.3 **DoD Readiness and Environmental Protection Integration**

The Readiness and Environmental Protection Integration (REPI) program supports the use of encroachment management partnerships to combat encroachment that can limit or restrict military training and testing.[30] REPI program authority was recently expanded to include climate change as an encroachment concern that could affect military operations. With this broader and more flexible approach to defining encroachment, REPI funding may now address the use or development of real property in the vicinity of, or ecologically related to, a military installation for the purposes of preserving off-base habitat on the property to maintain or improve military installation resilience, such as impacts related to sea level rise and recurring flooding, inland flooding, increased precipitation, and increased drought conditions.

6.1.4 **Defense Access Roads Program**

DoD and the Federal Highway Administration cooperate to ensure the needs of the military are considered in the nation's Federal-aid Highway Program. The Defense Access Road (DAR) Program provides a means for the military to pay its share of the cost of public highway improvements necessary to mitigate an unusual impact of a defense activity. An unusual impact could be a significant increase in personnel at a military installation, relocation of an access gate, or the deployment of an oversized or overweight military vehicle or transporter unit. Congress has expanded the program authority to allow use of DAR funds to pay the cost of repairing damage to highways – or for any infrastructure to mitigate the risks posed to such roads – caused by recurrent flooding or sea level rise if DoD determines access to an installation is impacted by past flooding and mean sea level fluctuation.[31]

6.1.5 **Federal Emergency Management Agency Grant Programs**

The Federal Emergency Management Agency (FEMA) administers an array of grant programs that communities can use toward funding resilience projects, specifically for those geared toward hazard mitigation. Funding opportunities are often available to eligible states, communities, territories, and tribes, including defense communities. These grants fall under the FEMA Hazard Mitigation Assistance (HMA) program and have specific eligibility requirements. Many require the state (the applicant) and potentially the community (the sub-applicant) to have a current FEMA-approved hazard mitigation plan adopted to be eligible for funding.[32] FEMA funding sources also usually require a benefit-cost analysis, following FEMA guidelines, showing a benefit-cost ratio greater than 1.0 as described in **Section 5.3.2.1**.

The Flood Mitigation Assistance (FMA) and Building Resilient Infrastructure and Cities (BRIC) grant programs provide non-disaster funding, while the Hazard

29 *Announcement of Federal Funding Opportunity* (2020). DoD. Retrieved from https://oea.gov/sites/default/files/files/OEA_DCIP-FFO.pdf.

30 Readiness and Environmental Protection Integration. Retrieved from https://www.repi.mil/.

31 Defense Access Road Program. Retrieved from https://highways.dot.gov/federal-lands/programs/defense.

32 *Mitigation Planning and Grants* (2020). FEMA. Retrieved from https://www.fema.gov/emergency-managers/risk-management/hazard-mitigation-planning/requirements.

Table 8: Overview of FEMA HMA Grants and Requirements

Funding	Description
BRIC[33]	BRIC replaced the FEMA Pre-Disaster Mitigation (PDM) program to provide support to communities for implementation of hazard mitigation projects that reduce risk to all types of natural disasters. BRIC is administered through an annual national competition. BRIC aims to support innovative approaches to large-scale infrastructure projects, such as those that leverage partnerships and/or multiple funding sources. Therefore, defense communities may score more competitively on their application for partnering with local military installations. BRIC project applications consider factors such as mitigating risk to community lifelines , incorporating nature-based solutions, and prioritizing under-resourced communities. Communities applying for support under BRIC can apply for project scoping grants or apply to be reimbursed for pre-award costs including development of a required FEMA benefit-costs analysis. This award is driven by an annual notice of funding, and the total amount of funding available changes from year-to-year, as it is funded by a set-aside from post-disaster recovery funding. State and local applicants must have FEMA-approved hazard mitigation plans in place to be eligible for BRIC project grants.
FMA[36]	FMA is a nationally competitive grant program that provides support for flood-risk reduction projects and is aimed at buying down risk within FEMA special flood hazards areas (e.g., structures insured under the National Flood Insurance Program (NFIP)). Types of projects funded under FMA include buyouts of severe repetitive loss properties, nature-based solutions, and culverts, for example. Funding under FMA is awarded annually through a notice of funding, and total funding amounts are set by Congress (currently $200 million). State and local applicants must participate in the NFIP to be eligible for FMA project grants.
HMGP[37]	HMGP provides funding to communities to rebuild in a manner that mitigates future disaster losses. Grant funding is only available after a Presidentially declared disaster. While disasters are declared at the county level, funding is awarded to the state for disbursal to local governments and can be used anywhere in the state. Types of projects covered under HMGP include relocating structures out of hazard areas, retrofits, flood control projects, tornado-safe rooms, and development of hazard mitigation plans, for example. HMPG-funded projects typically have a 25% cost share for the state or community. The state applicant and local sub-applicant must have a current hazard mitigation plan to be eligible. (Local sub-applicants are not required to have plans in place when applying for planning grants under HMGP.)
PA[38]	PA provides reimbursement to help communities respond to and recover from declared disasters. Section 428 funding can be used to repair damaged public structures, and Section 406 can be used to mitigate damaged public structures against future losses while recovery is under way. Types of PA funded projects include dry floodproofing, elevating equipment, floodwalls, for example.[39] In most cases, PA has a 75% cost share for the community, though there are exceptions. State applicants must have FEMA-approved hazard mitigation plans in place to be eligible for funds to repair damaged buildings or infrastructure, but local sub-applicants do not.

33 *Building Resilient Infrastructure and Communities* (BRIC) (2020). FEMA. Retrieved from https://www.fema.gov/grants/mitigation/building-resilient-infrastructure-communities.

34 *Community Lifelines Implementation Toolkit* (2020). FEMA. Retrieved from Community Lifelines Implementation Toolkit | FEMA.gov.

35 *Building Resilient Infrastructure and Communities* (BRIC) grant program (2020). FEMA. Retrieved from https://www.fema.gov/sites/default/files/2020-09/fema_bric-infographic_september-2020.pdf.

36 *Flood Mitigation Assistance* (FMA) Grant (2020). FEMA. Retrieved from https://www.fema.gov/grants/mitigation/floods.

37 *Hazard Mitigation Grant Program* (HMGP) (2020). FEMA. Retrieved from https://www.fema.gov/grants/mitigation/hazard-mitigation.

38 *What is FEMA Public Assistance?* (2019). FEMA. Retrieved from https://www.fema.gov/news-release/20200220/what-fema-public-assistance.

39 *Mitigate Disaster Damage with FEMA Public Assistance* (2019). FEMA. Retrieved from https://www.fema.gov/sites/default/files/2020-06/fema-pa406-mitigation-brochure.pdf.

Mitigation Grant Program (HMGP) provides funding for hazard mitigation planning and projects following a Presidential major disaster declaration.

Additionally, the Public Assistance (PA) program provides reimbursement to communities for costs associated with responding to and recovering from declared disasters.

Another FEMA funding program, signed into law in early 2021, is the STORM Act. The STORM Act currently includes $200 million, half of which expected to be allocated in 2022, to help cities and towns establish revolving loan funds for infrastructure projects after disasters.[40] The program provides another tool in the funding toolbox to help get funds to communities in need.

6.1.6 **Department of Commerce Economic Development Administration Grants**

The Economic Development Administration (EDA) administers funds to support long-term community economic recovery planning, project implementation, redevelopment, and resiliency. EDA funding programs focus on economic recovery, or the ability for communities to restore economic and business activities and develop new economic opportunities, in communities impacted by Presidentially declared disasters. Such activities include those that mitigate risk and vulnerability to natural disasters, adopt new technologies to withstand disruptions from hazard events, diversify the economy, and develop resilient infrastructure. Projects can be construction or non-construction; project examples include recovery planning, infrastructure rebuilding and construction (including design and engineering), utility redundancy, and revolving loan fund programs. Opportunities are announced annually. In both 2018 and 2019, EDA received $600 million annually in disaster supplemental appropriations. EDA allocates funds to regional offices based on congressional intent (driven by Presidentially declared disasters), economic impact from specific disasters, and economic distress in affected areas. Projects must benefit declared disaster areas.[41]

6.1.7 **Department of Housing and Urban Development**

The Department of Housing and Urban Development (HUD) administers several grant programs that can be used toward hazard mitigation and/or disaster recovery projects. HUD administers the Community Development Block Grant (CDBG) program to provide annual funding opportunities to state, local, and county governments to develop viable urban communities, with an emphasis on creating suitable living environments and expanding economic opportunities for low- and moderate-income (LMI) persons. Through CDBG, HUD administers two programs, CBDG-Mitigation (CDBG-MIT) and CDBG-Disaster Recovery (CDBG-DR), that focus on enhancing community resilience. Defense communities can apply for and leverage these funds to reduce risk.

The HUD CDBG-MIT program originated in 2017 and provides assistance for areas recently impacted by disasters to mitigate future risk. Funds are provided through two programs – the Mitigation Resilient Infrastructure Program and the Resilience Planning and Public Service program. While CDBG-MIT is a separate program from CDBG, CDBG-MIT must meet CDBG application requirements. For instance, for the Overall Benefit Requirement, 50% of the total allocation must benefit LMI households. CDBG-MIT applicants are also required to develop a CDBG-MIT Action Plan, which must include a mitigation needs assessment. This assessment requires coordination with FEMA mitigation efforts in that applicants must use their most recent FEMA-approved state or local hazard mitigation plan risk assessment to outline risk within HUD-identified "most impacted and distressed" areas.[42] Program goals focus on high-impact projects that address repetitive loss properties and infrastructure, building capacity for understanding disaster risk, leverage funds through

40 STORM Law Creates Resilience Revolving Disaster Funds. Retrieved from https://www.enr.com/articles/50970-storm-law-creates-resilience-revolving-disaster-funds-but-money-wont-flow-until-2022.

41 *EDA Stakeholder Webinar FY2019 Disaster Supplemental NOFO* (2019). EDA. Retrieved from https://www.eda.gov/files/programs/disaster-recovery/supplemental/2019/NOFO_EDA-Disaster-Supplemental-Webinar_External.pdf.

42 *CDBG-MIT Action Plan Requirements*. HUD Exchange. Retrieved from https://www.hudexchange.info/programs/cdbg-mit/action-plan-requirements/.

partnerships and other federal programs, and reduce risk to community lifelines (e.g., communications, water, medical services, and energy).[43]

HUD also administers the CDBG-DR program to help communities recover from Presidentially declared disasters, with a focus on low-income areas. CDBG-DR assists communities that otherwise might not recover due to limited resources.[44] HUD CDBG-MIT and CDBG-DR funds are unique because they can be combined with other federal funding sources; once CDBG-MIT or -DR funds are disbursed, these funds lose their identity as federal funding.

NOTE: Some HUD grant programs are one-off programs, not annual allocations. However, these programs often provide significant funding for resilience initiatives across the nation and, when available, can substantially improve funding feasibility. Similarly, other one-off programs such as stimulus packages and other federal funding mechanisms could be considered as funding sources if eligibility requirements are met.

6.2 **STATE AND COMMUNITY FINANCING TOOLS**

In addition to federal funding, many states have their own resilience-related funding. These are often housed in state departments of natural resources, environmental quality, emergency management services (or similar naming conventions). These should be explored by defense communities in their respective states, as community financing tools can be used to meet local grant cost-share requirements or to fund projects that are not eligible or competitive for federal grants.

6.2.1 **Bonds**

Bonds are a common financing tool used by communities to finance infrastructure projects. When a city issues a bond, the bondholder is typically paid a set number of interest payments (called coupons) until the bond reaches its maturity date, on which the face value of the bond is repaid to the holder. In this way, municipal bonds can be used to finance resilient infrastructure projects in the same way they could be used to finance other community investments, such as schools or roads. Additionally, there is potential for community or utility credit rating downgrades due to climate risks and a community's ability to mitigate impacts. Moody's, a major credit rating agency, is increasingly utilizing climate risk to inform research and ratings.[45]

Two additional types of bonds that are linked specifically to resilience include catastrophe bonds and resilience bonds. Catastrophe bonds emerged in the 1990s, following the devastation caused by Hurricane Andrew in Florida. Catastrophe bonds provide a mechanism for entities with the potential to face large economic consequences from a natural disaster, such as cities, insurers, or reinsurance agencies, to transfer risk to the capital market.[46] Generally, the investor, or bondholder, only pays out the principal to the issuer if a disaster (e.g. a pre-defined loss threshold) occurs before the bond's maturity date. This way, principal can be used by the issuer to cover losses. Despite their higher risk, catastrophe bonds are popular with investors due to their relatively high interest rates, short duration, and opportunity to diversify. In addition, catastrophe bonds protect cities from missing payouts if insurers fail to pay out after a disaster event, as funds are held in a secure collateral account[47]. Additionally, parametric insurance is being used more commonly to address shortfalls in traditional insurance.[48]

43 *Mitigation – Resilient Infrastructure Program 101*. State of California Housing and Community Development. Retrieved from https://www.hcd.ca.gov/community-development/disaster-recovery-programs/cdbg-dr/cdbg-mit-2017/docs/mit-rip-101.pdf.

44 *Community Development Block Grant Disaster Recovery Program*. HUD Exchange. Retrieved from https://www.hudexchange.info/programs/cdbg-dr/.

45 Moody's: Climate change is forecast to heighten US exposure to economic loss placing short- and long-term credit pressure on US states and local governments (2017). Moody's Investors Service. Retrieved from https://www.moodys.com/research/Moodys-Climate-change-is-forecast-to-heighten-US-exposure-to--PR_376056.

46 Spector, Julian (2015). *How cities can avert financial ruin after a natural disaster*. Bloomberg CityLab. Retrieved from https://www.bloomberg.com/news/articles/2015-12-07/how-cities-can-avert-financial-ruin-after-a-natural-disaster.

47 Polacek, Andy (2018). *Catastrophe bonds: A primer and retrospective*. Federal Reserve Bank of Chicago, Chicago Fed Letter No. 405. Retrieved from https://www.chicagofed.org/publications/chicago-fed-letter/2018/405.

48 Parametric Insurance Fills Gaps Where Traditional Insurance Falls Short. Retrieved from https://www.insurancejournal.com/news/international/2020/01/09/553850.htm.

Resilience bonds aim to fund risk reduction projects by converting avoided losses (generated by resilient infrastructure) into a funding source. Resilience bonds are structured like catastrophe bonds, but they provide a mechanism to finance resiliency projects. Resilience bond investors accept lower interest (i.e., coupon) payments once a resilience project aimed at lowering losses from the bond's defined disaster is completed. The difference in the coupon payment with and without the completed project is referred to as a rebate, which is used to finance risk reduction projects. Essentially, resilient communities realize savings by having less risk, in the same way that being a good driver can lower car insurance premiums, and in turn, communities have the opportunity to reinvest those savings to further enhance resilience.[49]

6.2.2 **Capital Improvement Planning**

A Capital Improvement Plan (CIP) is a strategy for building and updating a community's publicly owned infrastructure. Capital improvements are often the costliest investments made by communities and are typically driven by new growth and repair/replacement of existing infrastructure. A CIP is used to coordinate the timing, location, and financing of capital improvements. CIPs can leverage hazard mitigation plans, resiliency plans, and risk assessments or studies for planning purposes.[50] For instance, water systems can use earthquake liquefaction geospatial data to prioritize upgrades to pipes made from brittle materials, or stormwater utilities can use future flow data to plan culvert upgrades.

6.2.3 **Revolving Loan Funds**

A revolving loan fund is a financing measure comprised of a self-replenishing pool of funds, in which the interest and principal payments on old loans are used to issue new loans. Revolving loan programs are typically used as a gap financing measure to target specific program areas, including resiliency and hazard mitigation. Revolving loan funds can be administered by the federal, state, or local government, or by private organizations such as community development finance institutions (CDFIs). For instance, the EPA administers the Clean Water State Revolving Loan Fund, which makes low-interest loans for water quality projects, including those that prevent floodwaters and other natural disasters from impacting water systems.[51] States can administer revolving loan funds to provide funding assistance (typically through low-interest loans) to local governments for projects that enhance resiliency. Local governments may use revolving loan funds to encourage individual property owners or businesses to undertake site-level resiliency projects.

6.2.4 **Stormwater Fees**

Stormwater utility fees provide a means for communities to fund stormwater management projects. Essentially, customers pay a fee to convey stormwater from their property. Stormwater fees are typically administered by a stormwater utility, similar to water and wastewater utilities in that they generate revenues through user fees. Flat rates can be applied, but rates are often tiered, meaning they are tied to the volume of stormwater runoff generated by a property, which is usually based on a property's impervious cover. Fees structured on proportions of impervious cover may incentivize users to reduce overall impervious cover, which may reduce the need for capital stormwater projects.

To determine equitable rate structures, stormwater utilities should consider factors such as poverty rate, median household income, and site characteristics. Further, exemptions for certain facilities such as schools, churches, and hospitals should be considered. Credit systems for stormwater best management practices, such as raingardens, green roofs, and cisterns, can also be implemented to reduce stormwater volumes. **Figure 10** shows the general process for developing a stormwater utility.[52]

49 *A guide for public-sector resilience bond sponsorship* (2017). Re:Focus Partners. Retrieved from http://www.refocuspartners.com/wp-content/uploads/pdf/RE.bound-Program-Report-September-2017.pdf.

50 DeAngelis, Joseph, Hailey Briel and Michael Laurer (2019). *Planning for Infrastructure Resilience*. American Planning Association, PAS Report 596. Retrieved from https://asfpm-library.s3-us-west-2.amazonaws.com/FSC/FPM-Reports/PAS_Report_596_Dec_2019.pdf.

51 *Funding Resilient Infrastructure with the Clean Water State Revolving Fund* (2016). EPA. Retrieved from https://www.epa.gov/sites/production/files/2016-11/documents/funding_resilient_infrastructure_with_the_clean_water_state_revolving_fund.pdf.

52 *Getting to Green: Paying for Green Infrastructure, Financing Options and Resources for Local Decision-Makers* (2014). EPA 842-R-14-005. Retrieved from https://www.epa.gov/sites/production/files/2015-02/documents/gi_financing_options_12-2014_4.pdf.

Figure 10: Developing and Implementing a Stormwater Utility

6.3 OTHER FUNDING SOURCES

While local, state, and federal funds are often significant drivers in community infrastructure and other projects, non-government funds can play a significant role in resilience strategies.

6.3.1 Foundation Funding Sources

As federal and state agencies' programs become increasingly oversubscribed, private foundations are playing larger roles in funding critical infrastructure projects. Many foundations typically prioritize resilience, climate, and environmental concerns, especially where there is a higher-than-average disadvantaged population. Foundational funding can be used as a local cost share requirement for federal or state grants. The following summarizes resilience-related grants available from national foundations. This is not an exhaustive list; additionally, there are regional, geographic specific foundations that could be explored on a case-by-case basis.

The Funders Network Partners for Places Program

Partners for Places is a matching grant program that improves U.S. and Canadian communities by building partnerships between local government leaders, community groups, and place-based foundations. National funders invest in local projects developed through these partnerships to advance efforts to create communities that are sustainable, prosperous, and just. This fund creates opportunities for cities and counties in the United States and Canada to improve communities by building partnerships between local government practitioners and place-based funders in partnership with the Urban Sustainability Directors Network (USDN).

Partners for Places aims to enhance local capacity to build equitable and sustainable communities in the United States and Canada. The fund does this by requiring local government and local foundation partnerships, and by pairing national and local philanthropic funding sources. These one-to-one matching awards support the planning and implementing of urban sustainability and green stormwater infrastructure projects. Proposed projects should advance goals listed out in a community-focused sustainability, climate action, or comprehensive plan that specifically addresses sustainability.

The Kresge Foundation Environment Program

Kresge's Environment Program helps cities combat and adapt to climate change while advancing racial and economic equity. It is encouraged that cities address climate change mitigation and adaptation concurrently. The pollution that causes heat waves, extreme storms and other climate disasters disproportionately harms low-income communities and communities of color. One of their top priorities is elevating the leadership, inclusion, and influence of people of color, people with low incomes, and equity-focused organizations in climate change decision-making at the local, state, and federal levels.

Its Environment Program supports efforts to reduce greenhouse gas emissions, prepare for the effects of climate change that cannot be avoided, and advance social cohesion and equity. Most often, it proactively invites or solicits applications from individual organizations and typically funds nonprofit organizations. As such, defense communities would be wise to form alliances with a local or regional nonprofit with similar goals towards resiliency. Their first step should be to reach out to Kresge to start relationship-building with the staff, given that they most often solicit direct applications.

National Fish and Wildlife Foundation (NFWF) Five Star and Urban Waters Restoration

NFWF is 501(c)(3) nonprofit organization that works to protect and restore imperiled species, promote healthy oceans and estuaries, improve working landscapes for wildlife, advance sustainable fisheries and conserve

water for wildlife and people. It administers some geographic specific programs, such as the Sustain Our Great Lakes Program and the Chesapeake Bay Stewardship Fund. Its Five Star and Urban Waters Restoration program focuses on the stewardship and restoration of coastal, wetland, and riparian ecosystems across the country.

The intent of Five Star is to address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. Funding priorities that match resiliency efforts include:

- On-the-ground wetland, riparian, in-stream, and/or coastal habitat restoration
- Meaningful education and training activities, either through community outreach, participation, and/or integration with K-12 environmental curriculum
- Measurable ecological, educational, and community benefits

NFWF and this program in particular have a mix of funding from various federal agencies and cannot be used to match other federal sources of funding.

6.3.2 **Mitigation Banking**

Mitigation banking is based upon a credit system derived from the preservation, creation, or restoration of Waters of the United States (WOUS) including streams and wetlands. Developers proposing to impact existing WOUS must compensate for unavoidable loses by purchasing credits from the mitigation bank. The bank site refers to the area preserved, established, or restored. Typically, the bank site and proposed impacts must be in the same service area, and an interagency review team provides regulatory review, approval, and oversight of the bank's activities.[53] By adopting or participating in credit systems, communities can incentivize the private sector to cover the cost of protecting, restoring, or establishing wetlands and waterways in lieu of utilizing public funds.

6.3.3 **Public-Private Partnerships**

Public-private partnerships (PPPs) can provide opportunities to fund resilient infrastructure when public funds or community financing tools alone fall short. PPPs typically utilize public and private financing to achieve project delivery. PPPs can range from design-build contracts, warranties, private financing, and private sector operations and maintenance contracts. For instance, a private firm that is not only designing and building a facility, but also responsible for long-term maintenance and operations, will likely consider life-cycle costs of that facility more closely and optimize opportunities to reduce potential future costs, such as those posed by climate risk.[54] Communities may also use PPPs to leverage climate data or innovative technologies.

53 Mitigation Banks under CWA Section 404. EPA. Retrieved from https://www.epa.gov/cwa-404/mitigation-banks-under-cwa-section-404.

54 *Public-Private Partnerships and Infrastructure Resilience*. U.S. Chamber of Commerce. Retrieved from https://www.uschamberfoundation.org/sites/default/files/article/foundation/PPPs%20and%20Infrastructure%20-%20NCF.pdf.

7.0 CONCLUDING REMARKS AND MOVING FORWARD

With this framework executed, Defense communities should be able to start seeing their resilience projects on the horizon. There are still regulatory and administrative requirements to get projects fully implemented, but this framework should help empower communities to take significant steps in planning for a resilient future.

The intent of this resilience planning framework is not to be a one-off process, but a cyclical one that the resilience planning team revisits and repeats over time. As the higher priorities are addressed, defense communities can work their way down the shared priorities list developed from **Section 4 and 5** to continue to enhance resilience in their communities.

This resilience planning guide serves to kick off a series of additional resources to help communities execute this framework. While the path forward may be daunting, there are significant improvements to be realized by appreciating and executing the concepts in this report. Together, we can help make our communities safer, happier, and ready to take on the challenges of tomorrow.

Blue and Green Corridors Project*

New Orleans, Louisiana | *Resilient design to mitigate flooding and subsidence while providing recreational community spaces*

APPENDIX 1 – **CLIMATE CHANGE AND NATIONAL SECURITY RESOURCES**

Following is list of DoD resources on the nexus of climate change and national security. Special thanks to John Conger, Director with the Center for Climate & Security for overseeing the compilation of this list of resources and allowing inclusion in this resilience planning guide.

The Center for Climate & Security, Washington DC

Climate and Security Resources: U.S. Government, Defense

2021

Tackling the Climate Crisis (website page), US DoD

DOD Installation Exposure to Climate Change at Home and Abroad, U.S. DoD, April 22, 2021

DOD Climate Assessment Tool, US DoD, April 22, 2021

Secretary Austin Remarks at Climate Change Summit, US DoD, April 22, 2021

2020

Air Force Civil Engineer Severe Weather/Climate Hazard Screening and Risk Assessment Playbook, April 24, 2020

Fiscal Year 2021: Top DoD Management Challenges, Inspector General, U.S. DoD, November 2020

Army Climate Resilience Handbook, US Army Corps of Engineers, August 2020

Climate Change and the National Defense Authorization Act (FY18-FY20), The Center for Climate and Security, June 2020

2019

National Defense Authorization Act for Fiscal Year 2020, U.S. Congress, December 2019

The Operational Environment and the Changing Character of Warfare, "United States Army Training and Doctrine Command," October 7, 2019

Research To Improve Installation Infrastructure Resiliency Processes, Systems, And Tools, "Strategic Environmental Research and Development Program (SERDP)," DoD

Climate Adaptation for DoD Natural Resource Managers, Office of the Assistant Secretary of Defense (Sustainment), June 3, 2019

- Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into INRMPs
- Memo: Adaptation for DoD Natural Resource Managers Guide
- Climate Adaptation for DoD Natural Resource Managers Fact Sheet

Implications of Climate Change for the U.S. Army, US Army War College, July 2019

Advance Policy Questions for Dr. Mark T. Esper, Nominee for Appointment to be Secretary of Defense, Senate Armed Services Committee, July 2019

Senate Armed Services Committee Advance Policy Questions for GEN Mark A. Milley, U.S. Army Nominee for Appointment to be Chairman of the Joint Chiefs of Staff, Senate Armed Services Committee, July 2019

U.S. Air Force's Top 10 Military Installations Most Vulnerable to Climate-Related Events as required by FY18 National Defense Authorization Act, U.S. Air Force to Senate Armed Services Committee, June 2019

U.S. Army's Top 10 Military Installations Most Vulnerable to Climate-Related Events as required by FY18 National Defense Authorization Act, U.S. Army to Senate Armed Services Committee, June 2019

U.S. Navy and Marine Corps' Top 10 Military Installations Most Vulnerable to Climate-Related Events as required by FY18 National Defense Authorization Act, U.S. Navy and Marine Corps to Senate Armed Services Committee, June 2019

Climate Resilience: DOD Needs to Assess Risk and Provide Guidance on Use of Climate Projections in Installation Master Plans and Facilities Designs. GAO-19-453, June 2019

Department of Defense Arctic Strategy, U.S. DoD, June 2019

The Department of Defense Indo-Pacific Strategy Report: Preparedness, Partnerships and Promoting a Networked Region, U.S. DoD, June 1, 2019

United States Coast Guard: Arctic Strategic Outlook, Commandant of the United States Coast Guard, April 2019.

United States Department of the Navy Fiscal Year (FY) 2020 Budget Estimates, Military Construction Active Force (MCON) and Family Housing, U.S. Department of the Navy, March 2019

United States Navy: Strategic Outlook for the Arctic, Chief of Naval Operations, January 2019.

Report on Effects of a Changing Climate to the Department of Defense. As required by Section 335 of the National Defense Authorization Act for Fiscal Year 2018 (Public Law 115-91), Office of the Under Secretary of Defense for Acquisition

2018

John S. McCain National Defense Authorization Act for Fiscal Year 2019, August 2018

The Impact of Sea-Level Rise and Climate Change on Department of Defense Installations on Atolls in the Pacific Ocean (RC-2334). Report to the U.S. DoD Strategic Environmental Research and Development Program, Published Feb 2018.

Climate-Related Risk to DoD Infrastructure Initial Vulnerability Assessment Survey (SLVAS) Report, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, U.S. DoD

2017

2018 National Defense Authorization Act

Climate Change Adaptation: DOD Needs to Better Incorporate Adaptation into Planning and Collaboration at Overseas Installations. GAO-18-206

Draft Integrated City of Norfolk Coastal Storm Risk Management Feasibility Study, U.S. Army Corps of Engineers and the City of Norfolk, VA

Directive 2017-017 Installation Energy and Water Security Policy, U.S. Army

Climate Change Planning Handbook: Final Report, Naval Facilities Engineering Command, January 2017

2016

Report to Congress on Strategy to Protect the United States National Security Interests in the Arctic Region, U.S. DoD

Report to the President and the Congress of the United States, National Commission on the Future of the Army,

2016 Special Issue: Climate Change and Policy, Marine Corps University Journal

DoD Directive 4715.21: Climate Change Adaptation and Resilience. U.S. DoD

Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms. U.S. DoD

Department of Defense Strategic Sustainability Performance Plan FY2016, U.S. DoD

Regional Sea Level Scenarios for Coastal Risk Management: Managing the Uncertainty of Future Sea Level Change and Extreme Water Levels for Department of Defense Coastal Sites Worldwide, U.S. DoD

OMB Scorecard on Sustainability/Energy, DoD

2015

El Nino: Potential Asia Pacific Impacts: U.S. Pacific Command

DoD Instruction 3200.21 “Sustaining Access to the Live Training Domain”: U.S. DoD

National Security Implications of Climate-Related Risks and a Changing Climate [Report to Congress on Geographic Combatant Command responses to climate risks], U.S. DoD

Department of Defense Strategic Sustainability Performance Plan FY2015, U.S. DoD

A Cooperative Strategy for 21st Century Seapower, U.S. Department of the Navy/ United States Marine Corps, U.S. Coast Guard

Department of Defense Annual Energy Management Report FY 2014, U.S. DoD

2014

"Environmental and Energy Issues for the Military: Environmental and Energy Security for the Americas," United States Southern Command

Department of Defense Strategic Sustainability Performance Plan FY2014, U.S. DoD

Fire Science Strategy: Resource Conservation and Climate Change, SERDP/ESTCP, U.S. DoD

Climate Change Adaptation Roadmap, U.S. DoD

"National Security and the Accelerating Risks of Climate Change," CNA Corporation

USCENTCOM, Climate Change Assessment, QDR, U.S. DoD

Quadrennial Defense Review, U.S. DoD

US Navy Arctic Roadmap, U.S. Department of the Navy

OMB Scorecard on Sustainability/ Energy: DoD

Shoreline Evolution and Coastal Resiliency at Two Military Installations: Investigating the Potential for the Loss of Protecting Barriers: SERDP: DoD, EPA, DOE

2013

DoDM 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual, DoD

US Coast Guard Arctic Strategy, U.S. Coast Guard

Assessing Impacts of Climate Change on Coastal Military Installations: Policy Implications, SERDP, DoD

2013 Addendum to the FY2012 Climate Change Adaptation Roadmap: DoD

Arctic Strategy: DoD

Department of Defense Strategic Sustainability Performance Plan FY2013, U.S. DoD

OMB Scorecard on Sustainability/ Energy: DoD

2012

Department of Defense FY 2012 Climate Change Adaptation Roadmap: DoD

Department of Defense Strategic Sustainability and Performance Plan FY2012: DoD

OMB Scorecard on Sustainability/ Energy: DoD

Key Strategic Issues List: U.S. Army War College

2011

DoDI 4715.03, Natural Resources Conservation Program: DoD

Department of Defense Strategic Sustainability Performance Plan FY2011: DoD

Incorporating Sea Level Change Considerations in Civil Works Programs: U.S. Army Corps of Engineers

Defense Science Board Task Force Report: Trends and Implications of Climate Change for National and International Security: DoD

The National Military Strategy of the United States of America: Redefining America's Military Leadership: Chairman of the Joint Chiefs of Staff

National Security Implications of Climate Change for U.S. Naval Forces: Naval Studies Board, Division on Engineering and Physical Sciences

OMB Scorecard on Energy/ Water: DoD

2010

Quadrennial Defense Review Report: DoD

The Joint Operating Environment (JOE), Ready for Today, Preparing for Tomorrow: United States Joint Forces Command

Climate Change Impacts and AFRICOM: A Briefing Note: Institute for Defense Analyses, Christine Youngblut

Strategic Sustainability and Performance Plan FY2010: DoD

U.S. Navy Climate Change Road Map: Task Force Climate Change, Department of the Navy

2009

US Navy Arctic Roadmap: DoD

us-navy-arctic-roadmap-nov-2009: U.S. Department of the Navy

Taking Up the Security Challenge of Climate Change: U.S. Army War College

Climate Change Effects: Issues for International and US National Security: Institute for Defense Analyses, Christine Youngblut

Two Degrees of Separation: Abrupt Climate Change and the Adverse Impact to US National Security: Air Command and Staff College

Creation of the US Navy Task Force Climate Change by the Chief of Naval Operations

2008

National Defense Strategy: DoD

The Joint Operating Environment, Trends and Challenges for the Future Joint Force Through 2030: United States Joint Forces Command

2007

The Joint Operating Environment (JOE), Trends and Challenges for the Future Joint Force Through 2030: United States Joint Forces Command

A Cooperative Strategy for 21st Century Sea Power: Department of the Navy, the Marine Corps and the Coast Guard

National Security and the Threat of Climate Change: CNA Military Advisory Board

2003

An Abrupt Climate Change Scenario and Its Implications for United States National Security: DoD Office of Net Assessment

Weather Operations in the Transformation Era. John M. Lanicci, Air War College Maxwell Paper No. 29 (Maxwell AFB: Air University Press 2003)

Global Warming Could Have a Chilling Effect on the Military. National Defense University

1990

Global Climate Change Implications for the United States: U.S. Navy War College

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