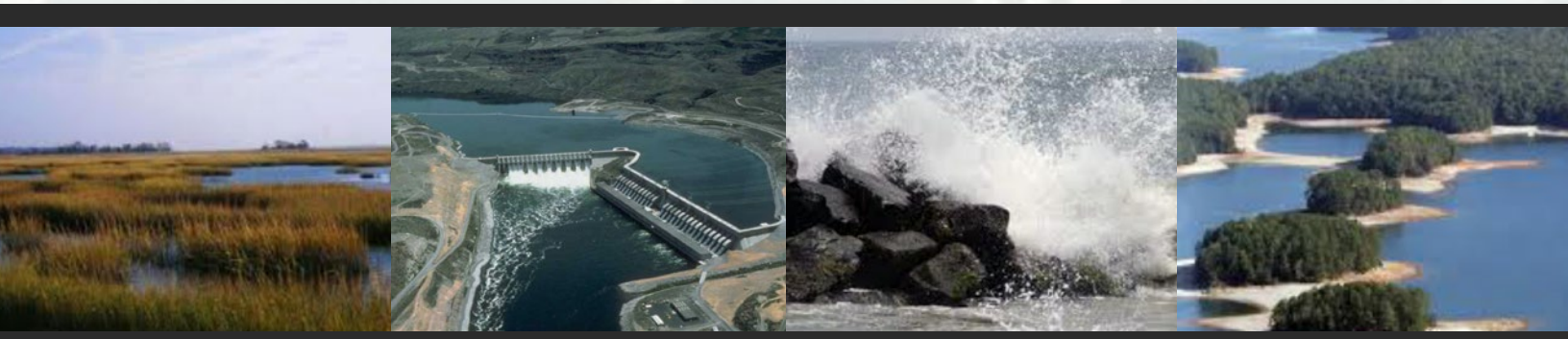
US Army Corps of Engineers

USACE CLIMATE PREPAREDNESS AND RESILIENCE STEERING COMMITTEE



USACE JUNE 2015

Climate Change Adaptation Plan

Update to 2014 Plan

EXECUTIVE SUMMARY

This US Army Corps of Engineers (USACE) June 2015 Adaptation Plan update, prepared at the direction of the USACE Committee on Climate Preparedness and Resilience (USACE CCPR), provides an update to the 2014 Adaptation Plan. This update will be publicly available to our staff, partners, and stakeholders following the required review by the White House.

This USACE 2015 Adaptation Plan is an update to the 2014 Adaptation Plan. The 2014 Adaptation Plan describes activities underway to evaluate the most significant climate change related risks to, and vulnerabilities in, agency operations and missions in both the short and long term, and outlines actions that USACE is taking to manage these risks and vulnerabilities. It contains an update on climate preparedness and resilience programs, policies, and plans USACE has already put in place, as well as information about progress on additional actions that will help us manage climate risks and build resilience in the short and long term.

USACE established an overarching USACE Climate Change Adaptation Policy Statement and a governance structure to support mainstreaming adaptation in 2011, following the release of Executive Order (EO) 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) and its Implementing Instructions. Following the release of the President's Climate Action Plan and EO 13693 (Planning for Federal Sustainability in the Next Decade) in 2013, the policy was updated as shown in the 2014 Adaptation Plan.

This 2015 Adaptation Plan update reflects climate preparedness and resilience actions in the *Climate and Natural Resources Priority Agenda* and recommendations from the State, Local, and Tribal Leaders Task Force for Climate Preparedness and Resilience, released in fall 2014. This update also addresses EO 13677 (Climate-Resilient International Development), EO 13689 (Enhancing Coordination of National Efforts in the Arctic), EO 13690 (Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input), and EO 13693 (Planning for Federal Sustainability in the Next Decade).

This Update addresses the following priority areas: modernizing USACE programs and policies to support climate-resilient investments, managing USACE lands and waters for climate preparedness and resilience, supporting State, local, and tribal preparedness, providing actionable climate information, tools, and projections, and international leadership provided by USACE supporting climate preparedness.

"The activities reflected in this Adaptation Plan will permit USACE to lead in developing and adopting resiliency concepts which will serve USACE missions, other Federal agencies, civilian and military communities, as well as security cooperation interests abroad."

Lloyd Caldwell, PE, SES
Director of Military Programs

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ADAPTATION POLICY STATEMENT

The primary and overarching policy document for USACE is the *USACE Climate Preparedness and Resilience Policy Statement*, signed by Assistant Secretary of the Army Jo-Ellen Darcy in June 2014.

As the Nation's largest and oldest manager of water resources, the US Army Corps of Engineers (USACE) has long been successfully adapting its policies, programs, projects, planning, and operations to impacts from important drivers of global change and variability.

It is the policy of USACE to integrate climate change preparedness and resilience planning and actions in all activities for the purpose of enhancing the resilience of our built and natural water-resource infrastructure and the effectiveness of our military support mission, and to reduce the potential vulnerabilities of that infrastructure and those missions to the effects of climate change and variability. USACE shall continue undertaking its climate change preparedness and resilience planning, in consultation with internal and external experts and with our districts, divisions, and Centers, and shall implement the results of that planning using the best available – and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change information into the actionable basis for adapting to climate change impacts. Furthermore, USACE shall continue to consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

These actions, which USACE is now conducting and has outlined for the future, are fully compatible with the guiding principles and framework of the Council on Climate Preparedness and Resilience and its predecessor, the Federal Interagency Climate Change Adaptation Task Force; with Executive Order 13653 and its December 19, 2013 instructions *Preparing Federal Agency Climate Change Adaptation Plans In Accordance with Executive Order 13653*; and with Executive Order 13514 and the *Implementing Instructions for Federal Agency Climate Change Adaptation* issued on March 4, 2011.

USACE understands and is acting to integrate climate adaptation (managing the unavoidable impacts) with mitigation (avoiding the unmanageable impacts). USACE recognizes the very significant differences between climate change adaptation and climate change mitigation in terms of physical complexity, fiscal and material resources, level of knowledge and technical readiness, and temporal and geographic scale. These differences mean that very different knowledge, skills, and abilities are needed to understand, plan, and implement climate preparedness and resilience policies and measures as compared to the ones for implementing mitigation measures. It is the policy of USACE that mitigation and adaptation investments and responses to climate change shall be considered together to avoid situations where near-term mitigation measures might be implemented that would be overcome by longer-term climate impacts requiring adaptation, or where a short-term mitigation action would preclude a longer-term adaptation action.

Work to understand and adapt to the impacts of climate and global change is well underway at USACE, and the policy enunciated here is closely aligned with the USACE Campaign Plan and the USACE Civil Works Strategic Plan. USACE has several integrated programs directed at parts of climate change adaptation; in addition, many coordinated elements from other programs support the development of

approaches to understand and mainstream climate change adaptation. Mainstreaming climate change adaptation means that it will be considered at every step in the project life cycle for all USACE projects, both existing and planned, through a logical, rational, legally justifiable process that develops practical, nationally consistent, and cost-effective adaptation measures, both structural and nonstructural, to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure.

The magnitude and complexity of climate change impacts facing water-resource managers in the US has spurred USACE to embark on closer, more fruitful interagency cooperation for developing methods supporting climate change adaptation. Close collaboration, both nationally and internationally, is the most effective way to develop the measures to identify and reduce the USACE mission vulnerabilities to potential future climate changes. USACE has demonstrated its commitment to engage and lead such collaboration through efforts including the "Building Strong Collaborative Relationships for a Sustainable Water Resources Future Initiative" and the Federal interagency Climate Change and Water Working Group (CCAWWG).

It is the policy of USACE that these and other productive collaborative efforts around climate and global change adaptation shall continue.

This policy establishes the Assistant Secretary of the Army for Civil Works as the Agency official responsible for ensuring implementation of all aspects of this policy. This policy does not alter or affect any existing duty or authority and recognizes that USACE has established the USACE Committee on Climate Preparedness and Resilience to oversee and coordinate agency-wide climate change adaptation planning and implementation. The Committee is chaired by the USACE Chief, Engineering and Construction, and reports regularly to the Assistant Secretary of the Army for Civil Works.

This policy statement reaffirms and supersedes the commitment made by USACE in its June 3, 2011 Climate Change Adaptation Policy Statement. This policy shall be effective beginning June 27, 2014, for all USACE missions, operations, programs, and projects and shall remain in effect until it is amended, superseded, or revoked.

Signed,

Jo-Ellen Darcy
Assistant Secretary of the Army for Civil Works

"Climate-resilient systems are sustainable systems."

Mr. Steven L. Stockton, PE, SES, Director of Civil Works
American Water Resources Association conference, New Orleans, 15 June 2015

WHAT'S NEW SINCE THE 2014 ADAPTATION PLAN

This 2015 Adaptation Plan updates information in the 2014 Adaptation Plan and provides new information stemming from two significant Administration actions: the release of the Climate and Natural Resources Priority Agenda in October 2014, and recommendations from the State, Local, and Tribal Leaders Task Force for Climate Preparedness and Resilience in November 2014. Also, since the 2014 Adaptation Plan was submitted, several related Executive Orders (EOs) have been released: EO 13677 (Climate-Resilient International Development) in September 2014, EO 13689 (Enhancing Coordination of National Efforts in the Arctic) in January 2015, and EO 13690 (Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input) in February 2015, and EO 13693 (Planning for Federal Sustainability in the Next Decade) in March 2015.

Climate and Natural Resources Priority Agenda

In response to Section 3 of Executive Order 13653 (Preparing the United States for the Impacts of Climate Change) the interagency Council on Climate Change Preparedness and Resilience convened a Climate and Natural Resources Working Group (CNRWG). The CNRWG includes the Departments of Agriculture, Defense, and Interior, the Environmental Protection Agency, the Federal Emergency Management Agency, the National Oceanic and Atmospheric Administration, and the U.S. Army Corps of Engineers.

This interagency working group developed a report titled Priority Agenda: Enhancing the Climate Resilience of America's Natural Resources. The report, released by the administration on 8 October 2014, identifies four priority strategies to make the Nation's natural resources more resilient to a changing climate:

- Foster climate-resilient lands and waters
- Manage and enhance U.S. carbon sinks
- Enhance community preparedness and resilience by utilizing and sustaining natural resources
- Modernize Federal programs, investments, and delivery of services to build resilience and enhance sequestration of biological carbon

For each strategy, the Agenda documents significant progress and provides a roadmap for future actions. In the future, USACE and other relevant Federal agencies will provide resources and technical assistance to State, tribal, local, and private sector partners to enhance the resilience of America's natural resources to the impacts of climate change.

State, Local, and Tribal Leaders Task Force

In 2013, the President established the State, Local, and Tribal Leaders Task Force (SLTL TF) as part of his Climate Action Plan. The Task Force is made up of governors, mayors, county executives, and tribal leaders from across the United States who, on 17 November 2014, presented

recommendations to Vice President Biden and Senior White House Officials on how the Federal Government can respond to the needs of American communities dealing with the impacts of climate change. In response to early recommendations from the SLTL TF, the Administration developed a *Climate Resilience Toolkit website*.

EO 13677, Climate-Resilient International Development

On 23 September 2014, President Obama signed EO 13677, which calls for agencies to consider climate-resilience in all United States international development work and encourage multilateral entities to take a similar approach. The order builds on EO 13514 (Federal Leadership in Environmental, Energy, and Economic Performance) and EO 13653 (Preparing the United States for the Impacts of Climate Change). EO 13677 seeks to: (1) improve the resilience of the Federal Government's international development programs, projects, and investments, (2) promote knowledge sharing, including data and tools, in incorporating resilience considerations, and (3) complement efforts by the Federal Government to reduce greenhouse gas emissions at home and globally.

EO 13689, Enhancing Coordination of National Efforts in the Arctic

On 21 January 2015, President Obama signed EO 13689, which establishes an Arctic Executive Steering Committee. Steering Committee membership consists of persons from the Office of Science and Technology Policy, the Council on Environmental Quality, the Domestic Policy Council, and the National Security Council, various Federal departments, the Office of the Director of National Intelligence, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Arctic Research Commission, the Office of Management and Budget, and the Assistant to the President for Public Engagement and Intergovernmental Affairs. The committee is tasked with providing guidance; establishing a working group; working on Arctic policies and practices with various stakeholders including Alaska Native organizations and Federal, State, and Local governments; and identifying a Federal Arctic Point of Contact.

EO 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input

EO 13690, signed by the President on 30 January 2015, amends EO 11988 (Floodplain Management), and establishes a Federal Flood Risk Management Standard (FFRMS). This EO addresses the requirement in the June 2013 President's Climate Action Plan for Federal agencies to update their flood-risk reduction standards. The new FFRMS will help ensure that federally-funded buildings and infrastructure are constructed to withstand the impacts of flooding (now and in the future), improve the resilience of communities, and protect Federal investments. The FFRMS builds on the work of the Hurricane Sandy Rebuilding Task Force, which recommended that the Federal Government create a national flood risk standard for federally-funded projects beyond the Sandy-affected region.

EO 13693, Planning for Federal Sustainability in the Next Decade

On 19 March 2015, President Obama signed EO 13693. This EO replaces EO 13423 (Strengthening Federal Environmental, Energy, and Transportation Management), and EO 13514 (Federal Leadership in Environmental, Energy, and Economic Performance). This EO calls for Federal agencies to increase the efficiency of their operations and improve their environmental performance with the goal of reducing agency direct greenhouse gas emissions by a minimum of 40 percent over the next decade. EO 13693 seeks to achieve this goal through improved efficiency and management in the following areas: (1) energy, (2) water, (3) fleet, and (4) buildings. With respect to climate preparedness and resilience, EO 13693 requires that new and existing Federal buildings include consideration of climate change resilience and employee and visitor wellness (Sections 3, 4, 7, and 13); ensure regional agency actions consider and are consistent with climate preparedness priorities of States, local governments, and tribal communities where agency facilities are located (Section 7); and include climate preparedness and resilience into Federal leadership and educational programs in courses and training (Section 11).

In alignment with EO 13653, EO 13693 also stresses that agencies should conduct regional coordination in the areas of water resource management and drought response opportunities and climate change preparedness and resilience planning in coordination with State, local, and tribal communities (Section 10).

MODERNIZING USACE PROGRAMS AND POLICIES TO SUPPORT CLIMATE-RESILIENT INVESTMENTS

Section 2 of EO 13653 requires Federal agencies to work with the White House Council on Climate Preparedness and Resilience (CCPR) to modernize their programs and policies to support climate-resilient investments at all levels, while ensuring continued protection of public and environmental health. Examples of modernizing actions include identifying, removing, or reforming barriers that discourage investments to increase climate change resilience or that increase the vulnerability of natural and built systems, economic sectors, natural resources, or communities to climate change. This includes developing and encouraging smarter investment strategies for use by States, local communities, and tribes.

USACE activities underway to modernize agency guidance to increase climate change preparedness and resilience are guided by the USACE Committee on Climate Preparedness and Resilience and supported by the O&M Remaining Items programs Responses to Climate Change (RCC) and Actions for Change. Our modernized policies, guidance, tools, and methods not only allow us to understand our vulnerabilities, but they support improvements to resilience internally and can assist State, local, and tribal communities as well.

New Policy and Guidance to Support Climate Preparedness and Resilience

By involving internal and external experts; district, division, lab, center, and USACE HQ staff; other agencies; NGOs; and the private sector in this process; we support and encourage the transfer of knowledge between our partners and stakeholders at all levels necessary to reduce vulnerability and improve resilience to the effects of climate and extreme weather. Through our work with the State, Local and Tribal Leaders Task Force established under Section 7 of EO 13653, USACE is developing an improved understanding of their needs and working to provide solutions as appropriate.

The lessons learned from these interactions will help guide the development of USACE policy, guidance, tools, and methods in this critical area. Our goal is to develop practical, nationally consistent, legally justifiable, and cost effective measures, both structural and nonstructural, to reduce vulnerabilities and improve the resilience of our water resources infrastructure impacted by climate change.

Policy and Guidance to Adapt to Changing Sea Levels

On 30 June 2014, USACE issued Engineer Technical Letter (ETL) 1100-2-1, *Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation*, which explains how USACE staff will account for the direct and indirect physical and ecological effects of projected future sea level change on USACE projects and systems of projects, including considerations for adapting to those effects.

This ETL provides guidance for USACE staff on how they will plan and implement adaptation to changing sea levels for every USACE coastal activity as far inland as the extent of estimated tidal influence. The ETL presents a broadly applicable method with special attention to four USACE mission areas (Flood Damage Risk Reduction, Coastal Storm Damage Reduction, Navigation, and Ecosystems) as well as insight into application to multipurpose projects.

The information presented in the technical letter is applicable to the full range of USACE projects and systems, from simple to complex, from small to very large, and over the full life cycle.

The procedure recommends three sea level change curves for use ranging from the extrapolated historical sea level trend to a higher curve that incorporates additional ocean warming and ice melt. The tiered approach acknowledges the potential significant impacts of extremes, and cumulative and system effects. USACE is encouraging the movement away from designing and evaluating projects in isolation and instead considering projects from a system perspective. Emphasis is placed both on how the project operates within a larger system as well as how project decisions now can influence future impacts. An essential task is to identify key elevations, weak links, and thresholds in the system. With changing loading conditions throughout the project lifetime, the identification of a wide array of possible thresholds and tipping points (both physical and social) can affect the actual project performance and alternative acceptability.

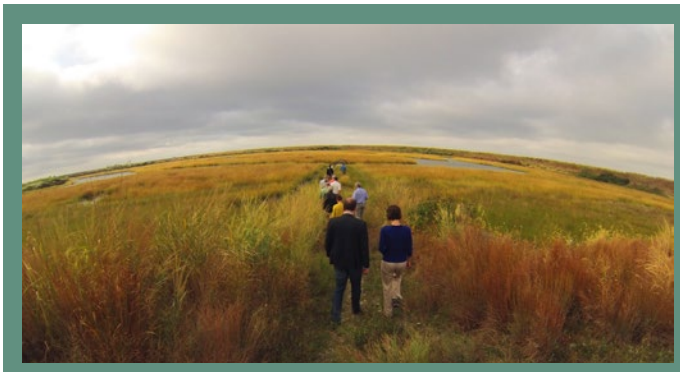
This technical guidance is suitable for use by State, local, and tribal governments and by the private sector to help better prepare them for changing sea levels.

Policy and Guidance for Paleoflood Hydrology

On 31 October 2014, the U.S. Army Corps of Engineers (USACE) issued Engineer Technical Letter ETL 1100-2-2 establishing guidance for the appropriate use of paleoflood analyses and information to support USACE hydrology and hydraulics (H&H) decision making.

Paleohydrology describes the evidence of the movement of water and sediment in stream channels before the time of continuous hydrologic records or direct measurements. Paleofloods can provide direct and useful information about stage histories and can be used, given caution, to estimate discrete event discharge values. However, there is limited evidence to support using paleoflood information to estimate a series of hydrologic events with multiple peaks, flood volumes, or durations.

ETL 1100-2-2 provides guidance for the application of paleoflood information to H&H decision making. Information in its appendices includes a summary of the appropriate use of paleoflood information specifically for USACE H&H decision making, examples of paleohydrological studies, methods for calculating paleoflood discharge, and calculation of paleoflood volume.



USACE's Approach to Resilience

In simple terms, resilience is the capacity of a system to absorb disturbance and still retain its basic function and structure. In the current popular context, "resilience" is being used to describe a more holistic approach to community capacity building in the face of increased extreme natural disasters, globalization, and urbanization. Increasing community ability to successfully manage expected and unexpected shocks and stresses is a proactive way to avoid loss of life and precious resources, including fiscal and natural.

USACE defines resilience as "the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions." USACE has adopted this definition from Executive Order 13653, "Preparing the U.S. for Climate Change." USACE's approach to resilience is comprised of four actions – plan, absorb, recover, and adapt – to address shocks from adverse events such as superstorms and stresses from changing conditions such as sea level rise.

Even with the increased national focus on community resilience, USACE has long incorporated resilience into our projects through planning and project design features. The Mississippi River & Tributary (MR&T) system is a great example of USACE's application of resilience principles. The MR&T was designed and built after the devastating Mississippi River floods of 1927. With the 2011 Mississippi River Flood, the MR&T was tested like never before and it performed as designed. In great contrast to 1927, no lives were lost in 2011 and the system prevented flooding in 62 percent of the land flooded in 1927. The system cost $14B (adjusted) to build and avoided an estimated $230B in damages in 2011.

Moving forward, USACE is developing our internal strategy on resilience, in the current context, to clearly lay out how we can leverage our expertise to prepare for climate change; collaborate more extensively with stakeholders, academia, other agencies, nongovernmental organizations, and industry; and develop/adopt approaches to measure resilience in greater support of community resilience.

MANAGING USACE LANDS AND WATERS FOR CLIMATE PREPAREDNESS AND RESILIENCE

Section 3 of EO 13653 requires the heads of the DoD, DOI, USDA, EPA, NOAA, FEMA, USACE, and other agencies as recommended by the Council to complete an inventory and assessment of proposed and completed changes to their land- and water-related policies, programs, and regulations necessary to make the Nation's watersheds, natural resources, and ecosystems, and the communities and economies that depend on them, more resilient in the face of a changing climate.

Water Resources Management

USACE reservoirs are operated according to water control manuals, including reservoir rule curves and drought contingency plans. USACE operations have proved relatively robust to observed climate changes. When combined with the deviation process, there is a great deal of flexibility to respond to short-term and long-term needs based on best available information and science. Two current efforts will improve our ability to manage water resources for climate preparedness and resilience. The first effort is developing and implementing methods to update drought contingency plans to account for climate change. The objective of the second effort is to enhance reservoir sediment information for climate preparedness and resilience. Reservoir sediment information can help identify current and future reservoir sediment volumes, which can impact flood and water supply storage.

Updating Drought Contingency Plans to Account for Climate Change

Requirements for developing Drought Contingency Plans (DCPs) were first put in place following the drought of the late 1970s. These are detailed in Engineer Regulation (ER) 1110-2-1941, Drought Contingency Plans, dated 15 September 1981. Systematic preparation and revision of DCPs was last undertaken in the 1980s and early 1990s. The high-level vulnerability assessment performed by USACE under the Implementing Guidelines for EO 13514 identified drought as a source of continuing vulnerability in the future. The DCP Update team has established a geospatial portal to document, store, and disseminate information relative to droughts and drought contingency plans. This includes a complete library of digitized DCPs (142 DCPs covering 301 USACE projects) and summaries of each. Projected climate hydrology for helping characterize specific drought threats to different regions of USACE operations. Updated policy and guidance regarding DCP updates to account for climate change is a planned product of this effort.

Enhancing Reservoir Sediment Information to Support Climate Preparedness and Resilience

Adaptation pilots conducted by USACE staff in the upper Missouri and Rio Grande watersheds, and two tributaries to the Great Lakes, have shown that climate impacts to reservoir sediment is likely to vary widely across the Nation. Proper evaluation of reservoir vulnerabilities to sedimentation effects is critical to their long-term management and reliable performance in providing authorized purposes. The reservoir sediment effort conducted pilots to determine the general extent of reservoir data types and availability as well as to identify gaps in knowledge; developed a method and tool to streamline data input to the interagency RESSED database supported by USGS; and developed "report cards" of reservoir volume, volume loss due to sedimentation, and loss due to sedimentation in the different reservoir zones. The team is conducting a national assessment of the relationship between hydrologic indicators and reservoir sedimentation that should support identification of projects at risk and help prioritize sediment data collection.

Updating System Boundaries

USACE owns more than 7.6 million acres and manages an additional 4.1 million acres of land, together with about 26 million acres of water at full pool. We operate and maintain 13,000 miles of deep draft navigation channels and another 12,000 miles of inland navigation channels. As part of our continued efforts to better manage these land and water resources for climate preparedness and resilience, we requested each USACE district to identify the top 20 most important projects in their districts. We are collecting information on each of these projects to better place them in a systems context for further evaluations supporting climate preparedness and resilience. This effort will also help us to identify flagship or exemplar sites as requested in the *Priority Agenda.*

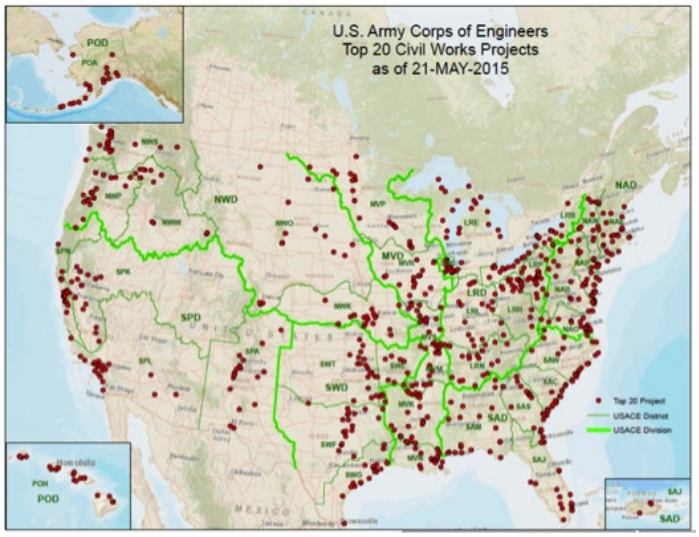


Figure 1. USACE Top 20 Civil Works Projects as of May 21, 2015

Biosequestration

USACE projects can contribute significantly to carbon sequestration, primarily through the long-term burial of organic carbon. In 2012-2013, we conducted a pilot study to assess biosequestration potential in Upper Mississippi River using rapid assessment techniques based on established science and existing information. This pilot allowed us to develop a land-cover modeling approach to characterize sequestration potentials that are fully generalizable and could be applicable to a wide range of public and private lands and waters.

We followed up with additional pilot studies in 2013-2014 in the USACE New England, Omaha, and Savannah Districts. These pilots yielded new insight into how reservoirs contribute to carbon sequestration: the initial, rough estimates for carbon sequestration in reservoir sediments are much greater than the estimate for carbon sequestration in the associated terrestrial areas. These surprising results require careful study, so we continue to test estimation techniques for reducing input and parameter uncertainty in the assessment of sequestration potential. We are obtaining and developing higher precision inputs to the approach for estimating sequestration potentials, starting with high priority projects on the national listing. CONUS-wide testing and review is beginning in 2015. We are now considering how to develop methods and metrics for estimating sequestration potentials and managing carbon.

USACE Roots in Climate Change Adaptation: Programmatic Support to Civil Works

Prompted by the droughts of the late 1970s, the USACE Institute for Water Resources (IWR) undertook a series of studies related to climate change and its implications for water resources planning. The *Economic Impacts of Climate Change research program* was initiated in 1992 to examine the effects of global warming on reservoir operations. One product was the first national conference on climate change and water resources held in 1991, which addressed current knowledge, potential future impacts, and adaptation policy and implementation. As the USACE continued to examine the potential impacts of climate change and variability to water resources management, attention turned to the need for adaptation, appropriate adaptation policies, and how to appropriately manage the adaptation process in the face of uncertainty. In a foundational 1998 paper on the topic of policy implications of climate change impacts on water resources management, IWR's Dr. Eugene Stakhiv identified three approaches to adapt to the impacts of climate change: reactive, anticipatory, and adaptive management - these approaches have been widely accepted and are in use today. USACE first addressed the possibility that climate variability impacted distribution of flood flows in the Upper Mississippi, Lower Missouri, and Illinois Rivers beginning in 1999, laying a solid foundation for later statistical analyses of nonstationary conditions. The incorporation of new and changing conditions, including sea level change, land subsidence, and hydrologic climate change, received increased attention following Hurricane Katrina under the auspices of the Actions For Change Program. By 2007, when changes to western snowpack-dominated watersheds were the subject of increasing documentation, the USACE Director of Civil Works directed the development of an interagency evaluation of climate change impacts to water resources (*USGS Circular 1331*). The Responses to Climate Change (RCC) Program was established in 2009 to reduce vulnerabilities and improve resilience to climate change, and has been the major supporter of USACE climate preparedness and resilience activities.

SUPPORTING STATE, LOCAL, AND TRIBAL PREPAREDNESS

In 2013, the President established the State, Local, and Tribal Leaders Task Force (SLTL TF) as part of his Climate Action Plan. The Task Force is made up of governors, mayors, county executives, and tribal leaders from across the United States.

North Atlantic Coastal Comprehensive Study

The North Atlantic Coast Comprehensive Study (NACCS) was submitted to Congress in January 2015. This report details a two-year study to address coastal storm and flood risk to vulnerable populations, property, ecosystems, and infrastructure in the North Atlantic region of the United States affected by Hurricane Sandy in October 2012. The study, authorized by Congress in January 2013 in the Disaster Relief Appropriations Act of 2013 (Public Law 113-2), brought together experts from Federal, State, and local agencies, as well as non-governmental organizations and academia, to assess the flood risks facing coastal communities and ecosystems, and collaboratively develop a coastal storm and flood risk management framework to address increasing risks which are driven in part by climate and sea level change.

In addition to the NACCS framework, numerous technical products generated by USACE and others are identified for each step of the process. The various technical products advanced by the NACCS to further the state of the science include but are not limited to the following: the Environmental and Cultural Resources Conditions Report, a planning and aid report prepared by the U.S. Fish and Wildlife Service called the North Atlantic Coast Comprehensive Study: Biological Resources and Habitats Vulnerable to Sea Level Rise and Storm Activity in the Northeast U.S.; the Coastal Hazards System (CHS) that provides information about future storms and sea level change to inform future studies and analyses; a report titled Use of Natural and Nature-based Features for Coastal Resilience; the Coastal Program Guide; and enhanced depth-damage functions for coastal storms.

Climate Champion Award

For the second year in a row, USACE was recognized for our progress in adapting to climate change and increasing our preparedness and resilience through the awarding of a 2014 GreenGov Presidential Climate Champion Award. The 2014 award went to the late Mr. William D. Goran from the Engineer Research and Development Center (ERDC). Mr. Goran, who retired from the USACE earlier this year, is universally recognized as a pioneer in Federal agency efforts to integrate the impacts and risks of climate change into Federal planning processes. His work began in 2007 when he proposed a technical focus area on climate change within the Center for the Advancement of Sustainability Innovations at the Engineer Research and Development Center. Also in 2007, he co-founded with NASA the Interagency Forum on Climate Change Impacts and Adaptation. That group provides an opportunity for the Federal community to share technical information and best practices related to the impacts of climate change on Federal agencies' resources and missions. The effectiveness of Mr. Goran's leadership in the Interagency Forum and his contribution to ensuring incorporation of climate change consideration into climate change adaptation planning are a testament to his skill and commitment. Mr. Goran's commitment to advancing knowledge of climate change impacts and adaptation are a model for continuing efforts supporting State, local, and tribal leader preparedness.

The NACCS report also references the need to continually improve climate preparedness and resilience with adaptation to climate change. The NACCS advocates using a scenario planning approach across the full range of future conditions to address uncertainty associated with climate change. The NACCS framework incorporates climate change adaptation considerations associated with future coastal storm and flood risk, including the magnitude and frequency of future storm events along with the range of potential impacts associated with forecasted sea level change. The report notes that coastal storm and flood risk management strategies must include periodic and ongoing review and revision to incorporate new science and climate scenarios as they develop. To access the full report and study products available online click *here*.

Resilient Lands and Waters (RLW) Initiative

The Priority Agenda - Enhancing the Climate Resilience of America's Natural Resources, released by the Climate Natural Resources Working Group (CNRWG) of the White House Council on Climate Preparedness and Resilience in October 2014, included a key theme to foster climate-resilient lands and waters. During spring 2015, the CNRWG identified several locations for multi-agency participation in improving the resilience of lands and waters. One of the sites selected for the RLW initiative is California's North-Central Coast and Russian Watershed. In the Russian River watershed, Federal, State, and local partners are all working to provide data and tools to enhance resilience to climate and extreme events. USACE is working closely with NOAA, the Sonoma County Water Agency, the U.S. Geological Survey (USGS), Bureau of Reclamation, the California Department of Water Resources, and the Scripps Institution of Oceanography to develop actionable science and methods to support Forecast-Informed Reservoir Operations (FIRO). The FIRO research will include using Lake Mendocino as a pilot to determine whether more sophisticated hydro-meteorological forecasting data can be used to better inform water management decisions in a manner which reflects current and forecasted conditions. The research is projected to be a five year effort.

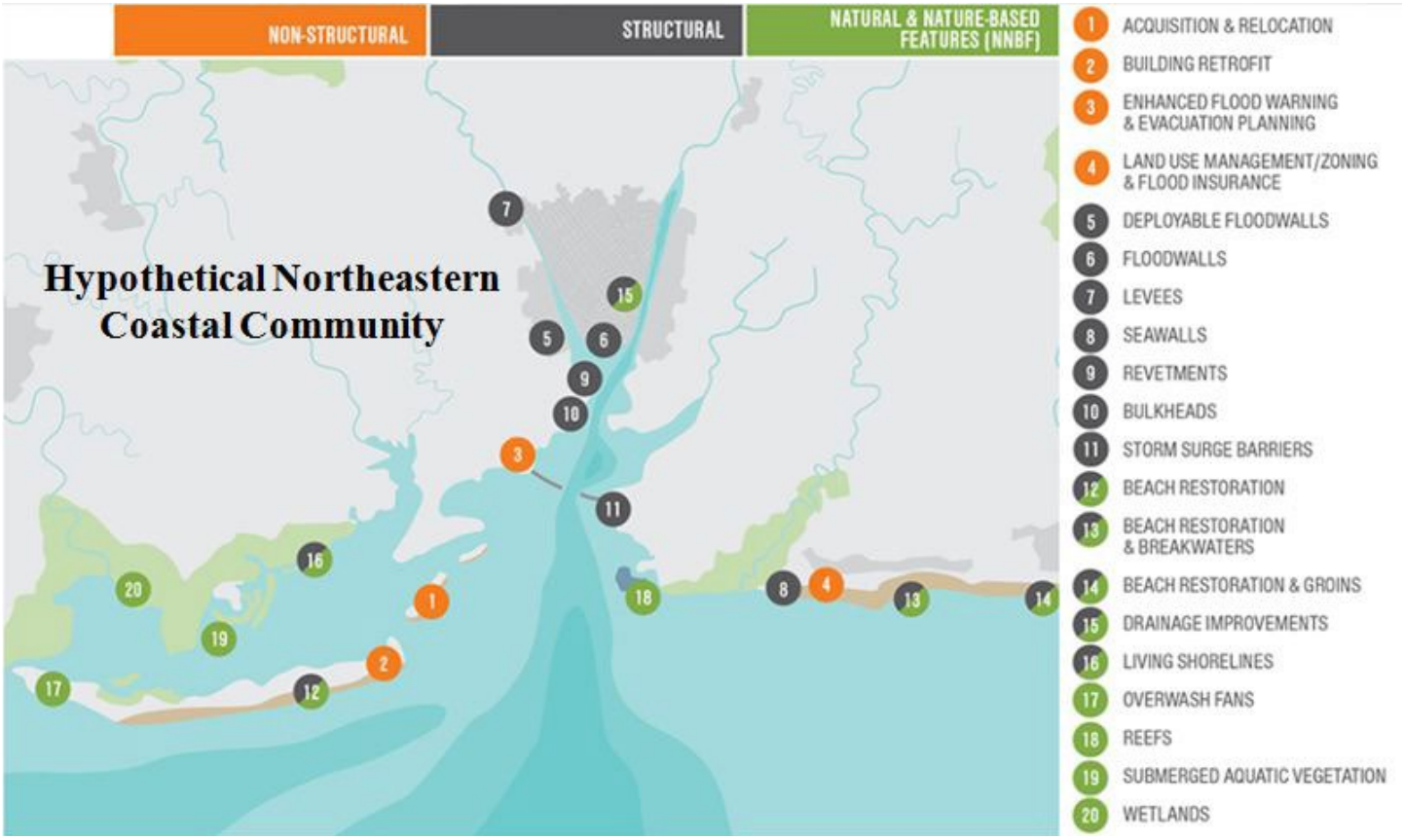


Figure 2. The North Atlantic Coast Comprehensive Study identified a number of ways to improve community climate preparedness and resilience. Shown here is an example of the use of a variety of risk reduction measures.

PROVIDING ACTIONABLE CLIMATE INFORMATION, TOOLS, AND PROJECTIONS

Section 4 of EO 13653 requires a group of Federal agencies to work together to develop and provide authoritative, easily accessible, usable, and timely data, information, and decision-support tools on climate preparedness and resilience to support Federal, regional, State, local, tribal, private sector and nonprofit sector efforts to prepare for the impacts of climate change. Named agencies include the DoD, DOI, USDA, US Department of Commerce (DOC), US Department of Health and Human Service (HHS), US Department of Housing and Urban Development (HUD), DOT, US Department of Energy (DOE), DHS, EPA, NASA, and any other agencies recommended by the Council. This activity will support CEQ, the Office of Science and Technology Policy (OSTP), and OMB as they oversee the development of a web-based portal on data.gov consistent with EO 13642 (Making Open and Machine Readable the New Default for Government Information).

Information: Regional Literature Syntheses

Between late 2014 and May 2015, USACE has developed and released sixteen regional Climate Change and Hydrology Literature Syntheses directed at topics of interest to water resources managers. The reports, which will eventually include 21 in total, provide context and climate information at the scale of 2-digit U.S. Geological Survey (USGS) Water Resources Regions across the continental United States, Alaska, Hawaii, and Puerto Rico. Each of these regional reports summarizes observed and projected climate and hydrological patterns cited in reputable peer-reviewed literature and authoritative national and regional reports, and characterizes climate threats to USACE business lines (e.g., flood risk management). They also provide context and linkage to other agency resources for climate resilience planning, such as downscaled climate data for subregions and watershed vulnerability assessment tools. The reports are *publically available*, and positive feedback has been received by non-USACE users.

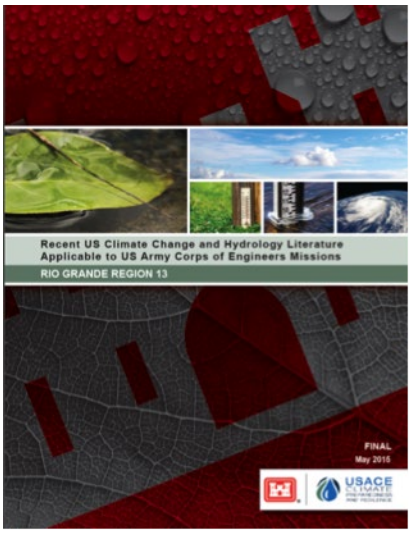


Figure 3. One of a series of 21 regional climate literatures syntheses being published by USACE to aid water resources adaptation planning.

Projections: Interagency Archive of Downscaled Climate Data and Information

The *archive of simulated historical and future climatology and hydrology* maintained at Lawrence Livermore National Lab is maintained by a consortium of Federal and non-Federal partners including USACE, an early supporter. The information available there is free and open to all. Several archive updates are planned for June 2015, including an expanded set of climate hydrology supported by USACE in collaboration with DOI's Bureau of Reclamation, the National Center for Atmospheric Research, and other experts. The new hydrology information is prepared using the USGS Precipitation-Runoff Modeling System (PRMS) and the Community Land Model (CLM). The addition of these two sets of climate hydrology to the previous data, developed using the Variable Infiltration Capacity (VIC) model, helps to reveal additional uncertainty in projected future conditions.

Tools

USACE continues to develop and test new tools to support climate preparedness and resilience decision-making in conjunction with the published guidance. All tools are designed to place the emphasis on analysis and decision-making rather than on data management for the substantial amount of climate data required for effective decision-making. All USACE tools are made available to the Climate Data Initiative and the Climate Resilience Toolkit as appropriate.

A web tool has been developed to assist in performing the steps required in Engineering and Construction Bulletin (ECB) 2014-10 (*Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects*). The tool accesses data from the interagency archive of downscaled climate data and information and stream gage station observations by USGS in a single location, removing the need to download and manage the data. Currently in agency review, the tool will be undergoing external review before being released publically in 2015.

A second tool to detect nonstationarities in annual maximum and minimum observed flows is in draft form and will be released in concurrence with the planned guidance on "Detection of Nonstationarities in Annual Maximum and Minimum Discharges," also in draft at this time. This tool addresses a fundamental issue of climate hydrology: detection of nonstationarity in observed hydrological time series data, and represents a significant step forward in hydrological studies.

Training

USACE continues to develop and deploy technical training for managing water resources under climate changed futures in partnership with other Federal partners in the Climate Change and Water Working Group (CCAWWG; *https://ccawwg.us*) and with the COMET program of the University Corporation for Atmospheric Research (UCAR). USACE, DoI's Reclamation, and COMET have produced and delivered a series of courses titled "*Assessing Natural System Impacts Under Climate Change.*" The courses in this series deliver technical training to water resources professionals to support incorporation of climate science and climate change information into impact assessments. This collaborative team has now developed and delivered courses five times to an array of Federal and non-Federal professionals whose work includes assessing water resource-related impacts under climate change conditions.

In 2013, courses were taught to a total of 36 professionals from ten local, State, and Federal agencies. In 2014, 78 professionals from 25 different agencies attended courses either in person or through the online course. Additionally, in the first four months of 2015, 12 professionals from seven agencies participated in the course developed for sedimentation impacts under climate change futures. The team is also building the next two courses in this series, one to teach climate change and water resources issues to a general, non-technical audience, and the other to teach implementation of approaches for calculating coastal impacts from sea-level change. These courses are planned to be available to Federal, State, local, and tribal agency staff, academics, and the private sector in 2016. Online, self-directed learning tools based on these courses are also being prepared.

> "Adaptation is not optional."
>
> Mr. James C. Dalton, PE, SES, Chair of the USACE Climate Change Adaptation Steering Committee, 19 January 2012

PLANNING FOR CLIMATE CHANGE RELATED RISKS TO USACE MISSIONS AND OPERATIONS

This 2015 Adaptation Plan update describes updates to the 2014 Adaptation Plan. We have made progress in evaluating the most significant climate change related risks to, and vulnerabilities in, agency operations and missions in both the short and long term. Our new policies and guidance ensure that all new projects incorporate assessments of climate risk as well as adaptation measures supporting climate preparedness and resilience. Our progressively more detailed vulnerability assessments of existing projects, programs, missions, and operations identify and assess climate risks. We are continuing to develop, implement, and update comprehensive adaptation plans that integrate consideration of climate change into agency operations and overall mission objectives. These plans have been submitted to CEQ and OMB for review in June 2011, 2012, 2013, and 2014.

Pursuant to Section 5 of EO 13653, this June 2015 Adaptation Plan reports that USACE has not yet identified a climate risk during the adaptation planning process that is deemed so significant that it impairs USACE's statutory missions or the operations addressed.

Planning

USACE policy requires that climate change preparedness and resilience be mainstreamed in all phases of the life cycle. In 2014, the Climate Preparedness and Resilience Community of Practice established and certified a number of Subject Matter Experts (SMEs) to perform technical and policy reviews for all projects. Over the past year, these SMEs have conducted a formal agency technical review of the climate preparedness and resilience of approximately 20 projects reaching Headquarters at various stages of the planning process. The objectives of the review process are to achieve a climate-resilient plan that is compliant with policy and technical guidance, addresses a systems approach, and includes cost estimates for adaptation measures in the cost and schedule risk analysis.

Plan formulation is a very complex process, and the SMEs find that early involvement can save time and cost later on. They noted that more (and more sophisticated) questions on climate-related issues are being brought up by public and independent external peer reviewers. Progress has been made in improving how planning studies address climate risk and preparedness. Additional planning-specific guidance and tools are planned for 2015-2016 to facilitate climate-resilient planning. These include the addition of a new planning guidance to ensure that datums are established at the beginning of the planning process and an added planning capability to the coastal vulnerability assessment tool.

Supply Chain

The 2014 Adaptation Plan listed several climate change related supply chain issues from the customer side and from the supply side. We are currently dealing with many of these types of disruptions now due to extreme weather events, and thus have fairly robust policies, guidance, and contingency plans in place to address these disruptions.

Supply chain disruptions due to drought are a focus of two efforts described in the previous report section titled "Managing Land and Water Resources for Climate Preparedness and Resilience: Updating Drought Contingency Plans to Account for Climate Change and Enhancing Reservoir Sediment Information to Support Climate Preparedness and Resilience."

A more tailored program to understand and address supply chain impacts began in 2014 to evaluate supply chain effects and possible responses to improve climate adaptation and resilience. In 2015, this program initiated a preliminary study to explore the effects of both flood and drought on navigation efficiency. A second related effort pulled information from the interagency archive of downscaled climate data and information to develop projections of future heat stress. This information will be made available in a web tool to support performing analyses and help determine when projected heat waves may begin to impact construction scheduling.

Figure 4. Tools developed by USACE to assess cliemate risks can be transferred to others as in this example of a tool being modified for use by the Army.

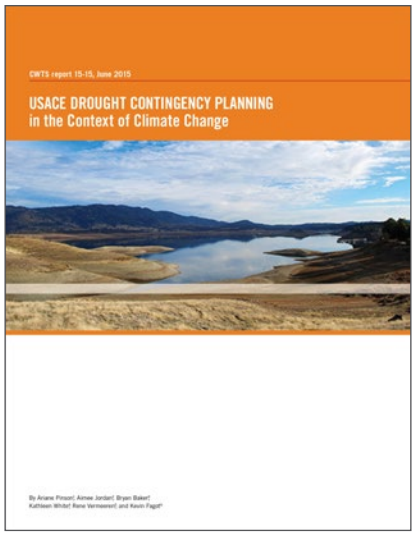


Figure 5. Drought has been identified as a source of risk to supply chains. USACE has begun an effort to update drought contingency plans to account for climate change.

Planning for Climate-Related Risks

USACE is conducting a series of progressively more detailed climate vulnerability assessments to better understand the risks posed by climate change to our missions and operations. In late 2014, we completed a screening-level assessment of our coastal projects using a web-based tool that interfaces with USACE geospatial databases. This Comprehensive Evaluation With Respect to Sea Level (CESL) web tool relies on information developed by other agencies, including the Federal Emergency Management Agency (FEMA), National Oceanic and Atmospheric Administration (NOAA), and the US Geological Survey (USGS). CESL tool results help us to identify projects with the highest consequences, and allow for prioritization of projects which require more detailed assessments. This information is critical to planning for climate-related risks. This web-based tool, used in USACE screening-level analyses, can be made available to others who wish to perform similar coastal vulnerability assessments. This technical transfer has already begun, with the transfer of the technology to Army staff for Installations, Environment, and Energy in 2015.

INTERNATIONAL LEADERSHIP PROVIDED BY USACE SUPPORTING CLIMATE PREPAREDNESS

International leadership supporting climate preparedness in one of the three key pillars of the PCAP released in 2013 and EO 13677, Climate-Resilient International Development, released in 2014. Through its Civil Works and Military Programs support activities, USACE is quite active internationally in water resources management, a key sector impacted by climate change. For example, USACE has long been involved with the international community for inland and maritime navigation, PIANC. Our work supporting the international Permanent Task Group on Climate Change will be highlighted at the United Nations Climate Change Conference, COP21, to be held later in 2015 in Paris, France.

One mechanism for international leadership in climate preparedness is the International Center for Integrated Water Resources Management (ICIWaRM), a UNESCO Category 2 water center headquartered at the USACE Institute for Water Resources (IWR) in Alexandria, Virginia, USA. The objective of ICIWaRM is to advance the science and practice of Integrated Water Resources Management (IWRM) to address water security and other water-related challenges. ICIWaRM is the global secretariat for UNESCO's Global Network on Water and Development Information in Arid Lands (G-WADI) network (www.gwadi.org), focusing on droughts and floods in climate-sensitive regions. USACE plays a leading role, along with the World Bank and Conservation International, in the Alliance for Global Water Adaptation (AGWA), an international consortium focused on developing practical guidance for planning and design decision-making in the face of climate uncertainty. The AGWA method combines traditional approaches for planning and design with a 'decision scaling' approach. The goal is to work with stakeholders to first assess system vulnerabilities to changes in climate parameters and additional stressors (e.g., population growth, development). Given the vulnerabilities, water managers can then evaluate the observed and projected climate information to develop adaptation strategies that are reflective of the vulnerability of the system and the level of confidence in the available information.

USACE currently collaborates with the U.S. Agency for International Development (USAID)'s Mekong-Building Climate Resilience in Asian Cities (MBRACE) program on AGWA pilot studies in Thailand and Vietnam, and with the UN Economic Commission for Europe (UNECE) and the Organization for Security and Co-operation in Europe (OSCE) on Climate Adaptation through Transboundary Water Management in the Dniester River Basin (Ukraine and Moldova).

USACE personnel are working with US Combatant Commands (COCOMs) and select countries to assess, interpret, plan for, and mitigate impact from climate change. The objective of these efforts is to collaborate with host countries in the transition of existing science and engineering tools to support vulnerability assessments and develop an understanding of potential impacts that is sufficient to inform adaptation planning. For example, the US Army is supporting efforts by USACE scientists and engineers to work with African nations, including Gabon, Ghana, South Africa, Namibia, and Botswana, to develop approaches for measuring adaptive capacity.