USACE 2013 Climate Change Adaptation Plan

US Army Corps of Engineers ®

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USACE 2013 Climate Change Adaptation Plan and Report

Executive Summary

USACE has established an overarching *USACE Climate Change Adaptation Policy Statement* and a governance structure to support mainstreaming adaptation, with an *Adaptation Steering Committee.* Our policy requires USACE to mainstream climate change adaptation in all activities to help enhance the resilience of our built and natural water-resource infrastructure and reduce its potential vulnerabilities to the effects of climate change and variability. USACE is mainstreaming climate adaptation through four strategies: with a focus on priority areas, we engage in external collaboration to improve our understanding of climate change impacts and vulnerabilities so that we can develop new policy and guidance to support adaptation implementation based on the best available and actionable science.

This USACE 2013 Adaptation Plan, prepared at the direction of the Adaptation Steering Committee, presents information about our vision, goals, and strategic approaches; progress on priority areas; and information about how we plan, integrate, and evaluate adaptation. The plan will be updated annually and will be publicly available to our staff, partners and stakeholders. USACE tracks adaptation through annual metrics that address external collaboration, improving knowledge about climate impacts and adaptation, progress assessing vulnerability, and development of policy and guidance.

In accordance with our four strategies to achieve mainstreaming of climate adaptation, we first identified adaptation ***priority areas***. Our progress on these priorities benefits from ***external collaboration*** and an active program to ***improve our knowledge*** about climate change and adaptation so we can ***develop policies and guidance*** to support adaptation planning and implementation.

One result of our strategic approach is our first technical guidance for adaptation, "*Procedures to Evaluate Sea-Level Change Impacts, Responses, and Adaptation*," which completed a wide internal and external review on 1 June 2013. This adaptation implementation guidance was drafted by an extensive interagency, international and multi-disciplinary team, incorporating team members from USACE, partner agencies, and other experts in academia and the private sector. Other successes are detailed in this 2013 Adaptation Plan and Report.

USACE will continue implementing our plan to improve resilience and reduce vulnerabilities through adaptation to climate change. We will continue to expand the incorporation of climate uncertainty considerations into planning, design, construction, operation, and management of new or modified infrastructure. We expect that our priority areas will evolve as we gain understanding and experience in adapting to climate change and identify new challenges. USACE continues to work closely with science agencies, the US Global Research Program, the Federal Agency Adaptation Community of Practice, the Climate Change and Water Working Group, and others to identify future challenges and develop solutions to these challenges.

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1. Introduction

1.1. Adaptation Policy Statement

The primary and overarching policy document for USACE is the USACE Climate Change Adaptation Policy Statement1, signed by Assistance Secretary of the Army Ms. Jo-Ellen Darcy on 3 June 2011, in accordance with the *Implementing Instructions for Federal Agency Climate Change Adaptation*[2](Council on Environmental Quality (CEQ) and Office of Management and Budget (OMB) 2011), and also the Guiding Questions contained in the companion *Support Document to the Implementing Instructions* (CEQ 2011).

The 2011 USACE Climate Change Adaptation Policy Statement remains in force in 2013 and provides the USACE policy framework for climate change adaptation. The USACE Climate Change Adaptation Policy Statement complies with Section 8(i) of *Executive Order 13514*[3] and in accordance with the *Guiding Principles* put forth in the Federal Interagency Climate Change Adaptation Task Force in its October 2010 *Report to the President*[4] and provided in Appendix A.

1.2. Mainstreaming Adaptation

Effective climate change adaptation is especially important for USACE because the hydrologic processes underlying water resources management are very sensitive to changes in climate and weather. Our Civil Works Program and associated water resources infrastructure represent a tremendous Federal investment that supports public safety and local and national economic growth, and hence, we have a compelling need to understand and adapt to climate change and variability.

For this reason, the USACE Climate Change Adaptation Policy Statement requires USACE to mainstream climate change adaptation in all activities to help enhance the resilience of our built and natural water-resource infrastructure and reduce its potential vulnerabilities to the effects of climate change and variability. Mainstreaming means to integrate and incorporate climate change and variability considerations for missions and operations in all phases of the project lifecycle for both new and existing projects. The policy statement also requires USACE begin adaption now based on the best available and actionable science to consider the impacts of climate change when planning for the future. Our goal is to successfully perform our missions, operations, programs, and projects despite the challenges of global and climate change.

1.3. Governance Framework

The Assistant Secretary of the Army for Civil Works is the designated USACE Senior Adaptation Point of Contact responsible for ensuring implementation of the USACE Climate Change Adaptation Policy Statement issued 3 June 2011. The Statement also established the USACE Climate Change Adaptation

[1] See http://www.corpsclimate.us/adaptationpolicy.cfm

[2] Issued jointly on 4 March 2011 by the Executive Office of the President's Council on Environmental Quality/Office of the Federal Environmental Executive (CEQ/OFEE) and the Office of Management& Budget (OMB)

[3] See http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/pdf/E9-24518.pdf

[4] See http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf

Steering Committee (ASC), chaired by the USACE Chief, Engineering and Construction, to oversee and coordinate agency-wide climate change adaptation planning and implementation. The ASC acts as the highest level of Adaptation Authority in USACE. The ASC establishes strategic direction; reviews/monitors existing adaptation programs, activities and policy implementation; provides critical decisions related to the implementation of adaptation across USACE, and coordinates the integration of adaptation and mitigation activities with the USACE Strategic Sustainability Committee.

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

1.4. Climate Change Adaptation Plan

The USACE 2013 Climate Change Adaptation Plan represents an update of the 2012 USACE Climate Change Adaptation Plan. Our plan incorporates all actions undertaken to support our objective to mainstream climate change adaptation in all activities to help enhance the resilience of our built and natural water-resource infrastructure and reduce its potential vulnerabilities to the effects of climate change and variability. The Plan is incorporated in both the USACE Campaign Plan and the Army Campaign Plan. Based on our high-level assessments of vulnerability to climate change, the USACE Adaptation Plan employs four primary strategies to achieve our objective:

- Focus on priority areas
- Engage in meaningful external collaboration
- Improve USACE knowledge for water resources management and infrastructure resilience
- Develop policy and guidance for infrastructure resilience

Each of these strategies is described in detail below, together with a description of current status. The USACE military support activities will be guided by the DoD Adaptation Plan and Department plans, policies, and guidance.

Two programmatic efforts are the primary supporters of the USACE Adaptation Plan. These are the Interagency Performance Evaluation Task Force (IPET)/Hurricane Protection Decision Chronology (HPDC) Lessons Learned Implementation Team and the Responses to Climate Change program. These programs are charged with developing methods, tools, and guidance to improve the resilience of our built and natural infrastructure benefits through a collaborative, proactive, nationally consistent, and regionally sensitive framework and program of actions. These actions include improving our understanding of climate impacts to missions and operations, assessing vulnerabilities, and identifying specific actions to minimize risk and capitalize on opportunities to improve infrastructure resilience.

1.5. USACE Adaptation Plan Strategies Focus on Priority Areas

Climate change poses numerous challenges to USACE missions and operations. Based on the best available and actionable science, our high-level vulnerability analyses, and USGS Circular 1331, we identified six adaptation priority areas as requested in the 29 February 2011 *Statement on Preparing*

Adaptation Plans, in the 2011 USACE Adaptation Plan and Report[5]. Focusing our energy on priority areas helps us to make progress faster and more effectively. In 2013, we added a seventh to more explicitly address the main fundamental reason for mainstreaming adaptation: infrastructure resilience. These priority areas represent core issues supporting our fundamental need to improve infrastructure resilience in changing conditions: assess vulnerability, support risk-informed decision making, develop technical information necessary to plan and design implementation measures, continue to improve our ability to assess vulnerabilities, begin to measure success, and support cross-cutting programs:

1. Infrastructure Resilience
2. Vulnerability Assessments
3. Risk-Informed Decision-Making for Climate Change
4. Nonstationarity
5. Portfolio of Approaches
6. Metrics and Endpoints
7. National Action Plan to Manage Freshwater Resources in a Changing Climate

Our progress on these priorities benefits from external collaboration and an active program to improve our knowledge about climate change and adaptation so we can develop policies and guidance to support adaptation planning and implementation. Additional priorities will be identified in the future as we gain understanding and experience in adapting to climate change.

1.5.1. Infrastructure Resilience

The US Army Corps of Engineers (USACE) Civil Works Program and its water resources infrastructure – built and natural, structural and nonstructural – represents a tremendous Federal investment that supports public health and safety, regional and national economic development, and national ecosystem restoration goals. The hydrologic and coastal processes underlying this water resources management infrastructure are very sensitive to changes in climate and weather. Therefore, USACE has a compelling need to understand and adapt to climate change and variability to continue providing authorized performance despite changing conditions. Our objective is to mainstream climate change adaptation in all activities to help enhance the resilience of our built and natural water-resource infrastructure and reduce its potential vulnerabilities to the effects of climate change and variability. The activities undertaken to support the climate change adaptation are planned to help improve infrastructure resilience related to climate change affecting other important USACE infrastructure programs.

1.5.2. Vulnerability Assessments

Climate vulnerability assessments are necessary to help guide adaptation planning and implementation so that USACE can successfully perform its missions, operations, programs, and projects in an increasingly dynamic physical, socioeconomic, and political environment. USACE has completed several activities in connection with high level assessments of vulnerability to climate change. These include a preliminary assessment presented in USGS Circular 1331[6] and a high-level analysis of the vulnerability of USACE missions and operations to climate change required by CEQ[7] summarized in Appendix B.

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[5] See http://www.corpsclimate.us/adaptationpolicy.cfm

[6] See http://pubs.usgs.gov/circ/1331/

[7] In accordance with the *Implementing Instructions for Federal Agency Climate Change Adaptation* (Council on Environmental Quality (CEQ) and Office of Management and Budget (OMB) 2011), and also the Guiding Questions contained in the companion support document to the *Implementing Instructions* (CEQ 2011).

USACE is currently conducting two nationwide screening-level assessments of the vulnerability of USACE mission, operations, programs, and projects to climate change. These screening-level vulnerability assessments are designed to be conducted in phases (so the initial assessment can be refined) using a modular approach (so new and updated information can replace initial information) and supported by district-acceptable tools and visualizations. The analyses build on existing, national-level tools and data, including specific indicators of vulnerability representing USACE business lines.

For watersheds, we completed a proof-of-concept study focused primarily on the potential exposure to climate change-induced changes in freshwater discharge at the level of HUC-4 watersheds. This is now updated to include updated information based on the latest general circulation models used for the IPCC's Fifth Assessment Report, due in 2014. The second is an initial vulnerability assessment of projects to coastal climate change, including sea level change. Future refinements and more detailed vulnerability assessments for high priority projects are planned.

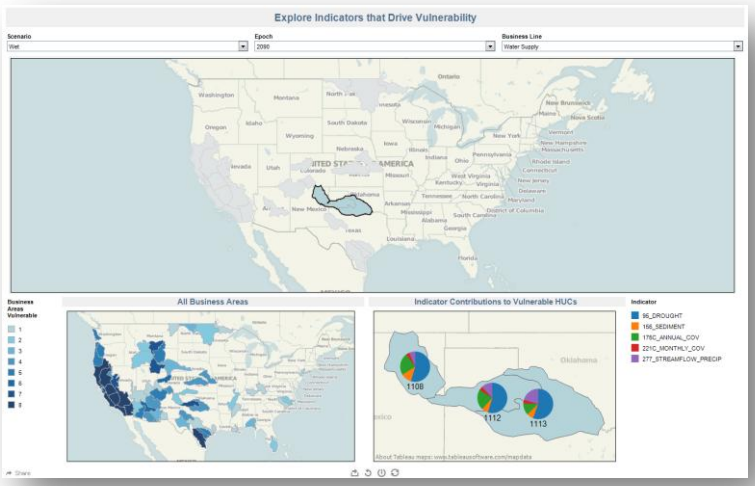
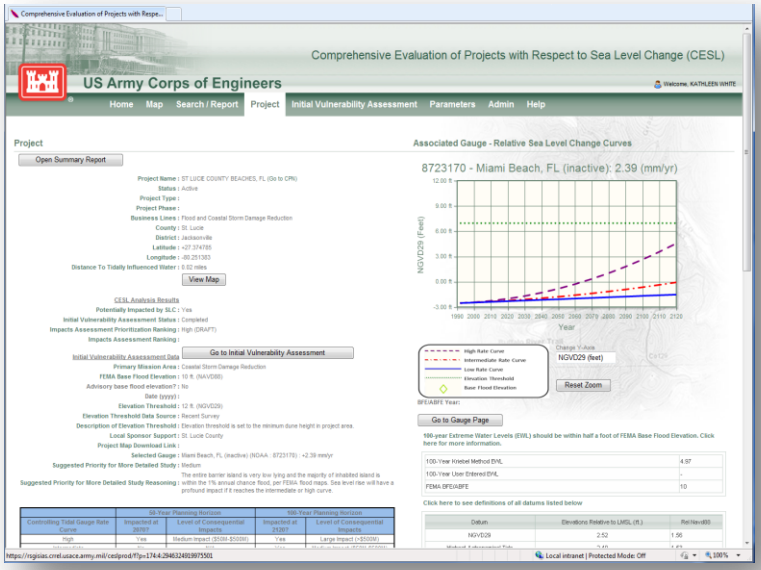


Figure 1. Example visualization of USACE nationwide screening assessment of vulnerability to climate change at the HUC-4 level. Top depiction shows the top 10% most vulnerable HUC-4 watersheds for the far future (30 year period 2070-2100) for the Water Supply business line in a wetter future. Bottom left aggregates vulnerability across all business lines. Bottom right shows contribution of indicators to vulnerability for the selected watersheds

Figure 2. Example of output from USACE nationwide screening assessment of vulnerability to coastal climate change at the project level. Data is entered by USACE district staff into a web tool tied to USACE geospatial databases and NOAA tide gauge information. The tool considers a 100-year planning horizon and allows for estimates of impacts due to sea level change and extreme water levels.



1.5.3. Risk-Informed Decision-Making for Climate Change

Risk-informed decision making is a critical component of USACE adaptation to climate change. Since climate change uncertainty may require making sequential decisions over time and updating design and plans to incorporate new and changing information 2011, we have been testing a draft framework that addresses the entire project life cycle, since. Risk assessment includes both consequence and likelihood assessment, and the framework recognizes the potential challenges of assigning probabilities to uncertain future conditions. Formulation of risk management alternatives under changing conditions is a critical component of the approach. The framework emphasizes the need for stakeholder involvement throughout the decision process.

Several climate-change adaptation pilot projects are testing the framework. The Hamilton Wetland Restoration Project (HWRP) is testing the proposed risk framework and evaluating its application to the USACE planning phase. The West Maui Watershed Study is using the framework to collaboratively identify climate risks and to develop adaptation strategies. The Lower Columbia River Estuary pilot study is applying the framework to ecosystem restoration. The risk framework is now under revision based on preliminary results from pilot studies and an internal review. The risk management framework will be a foundation for developing strategies to incorporate climate change into the decision making processes of USACE.

1.5.4. Nonstationarity

Stationarity, or the assumption that the statistical characteristics of hydrologic time series data are constant through time, enables the use of well-accepted simplified statistical methods in water resources planning and design. Climate change is undermining this fundamental assumption, and as pointed out in the influential paper by Milly et al in 2008, "Finding a suitable successor is crucial for human adaptation to changing climate."

Developing methods and procedures to address nonstationarity throughout the project life cycle is a high priority action for the USACE, since planning for continued and resilient performance under future water resources conditions is fundamental to our missions and operations. Considerable progress has been made in this area, as highlighted in Table 2. Since our 2010 international and interagency workshop on nonstationarity, followed by a proceedings and a special collection of journal papers, USACE has made progress in the critical area of nonstationary hydrology. The team includes interagency collaborators (USGS, the Department of Homeland Security (DHS) Federal Emergency Management Agency (FEMA), DOI's Bureau of Reclamation, and the Department of Transportation (DOT) Federal Highways Administration (FHWA)) as well as academic experts. The team also includes interagency collaboration with the agencies that work under the Advisory Committee for Water Information Subcommittee for Hydrology.

Our approach to obtain external peer review for critical aspects on nonstationarity that will support policy and guidance. Two journal papers by team members have been peer-reviewed and accepted for publication in 2013. The first paper[8] assesses what general circulation models underlying the IPCC 5th Assessment Report indicate about precipitation events with annual exceedance probabilities of 0.1 and 0.01, concluding that projections indicate that the more remote probability (0.01) events may be changing more than the less remote probability (0.1) events. This is very important for flood-related planning and engineering design. In keeping with the USACE role as a provider of public water resources

[8] "Projections of Heavy Rainfall over the Central US based on CMIP5 Models" by Villarini, Scocciamarro, and Gualdi, accepted for publication in Atmospheric Science Letters (as of May 2013)

infrastructure, the second paper[9] looks at how societies may respond to global change. Currently, the team is near completion of an annotated bibliography of relevant peer reviewed literature on methods for detecting and attributing non-stationarity as well as methods for incorporating non-stationarity into future portrayals of hydrology.

1.5.5. Portfolio of Approaches

The wide portfolio of possible approaches for producing and using climate science and climate change information for water resource adaptation questions can bewilder planners and engineers because each method or analytical technique in this portfolio brings uncertainties and particular deficiencies, some of which are large or only partly characterized and poorly quantified. USACE, together with Reclamation, the National Center for Atmospheric Research (NCAR), and academic experts, began a joint 2012-2014 project to answer two questions of particular importance in making decisions about which methods are more or less appropriate for use in a particular decision environment. These are: how are the portrayals of weather impacts under climate change sensitive to downscaling method? And, how are the portrayals of hydrologic impacts sensitive to hydrologic evaluation method? The work should help operating and resource management agencies looking to use these techniques to inform their climate adaptation planning currently lack good practice guidelines for helping them assess the approaches and choose appropriate ones for particular adaptation decisions.

1.5.6. Metrics and Endpoints

Appropriate frameworks and metrics for assessing the efficiency and effectiveness of climate change adaptation activities are crucial for achieving our combined objectives of developing practical, nationally consistent, legally justifiable, and cost effective climate change actions, both structural and nonstructural; and reducing the vulnerabilities and improving the resilience of water-resource infrastructures at risk from climate change threats. To date, USACE has instituted and is reporting annually on metrics and endpoints in the USACE Campaign Plan (Action 2d.2, Improve CW Portfolio Performance in Changing Climatic Conditions) and the Army Campaign Plan (three actions addressing external collaboration, vulnerability assessments, and policy and guidance).

1.5.7. The US National Action Plan to Manage Freshwater Resources in a Changing Climate

The Federal Interagency Climate Change Adaptation Task Force (ICCATF) released the *National Action Plan Priorities for Managing Freshwater Resources in a Changing Climate*[10] (NAP). The NAP makes six major recommendations, each with supporting actions led by different agencies (Appendix B). USACE is the lead agency to implement the three supporting actions for Recommendation 5, *Integrated Water Resources Management.* The team is using the definition of IWRM from the report *Building Strong Collaborative Relationships for a Sustainable Water Resources Future National Report: Responding to National Water Resources Challenges*[11] as shown in the inset box. USACE is co-leading three other actions of the NAP.

[9] "Likelihood of Societal Preparedness for Global Change" by Vogel, Rosner, and Kirshen, accepted for publication in Natural Hazards Earth Systems Science Discussions (as of May 2013)

[10] Interagency Climate Change Adaptation Task Force 2011, see http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf

[11] See http://www.building-collaboration-for-water.org/Documents/nationalreport_final.pdf

1.5.7.1. USACE-Led NAP Actions

Action 17 addresses working with States and interstate bodies (e.g., river basin commissions) to incorporate IWRM into their planning and programs with attention to climate-change adaptation issues. The goal is to develop practices supporting an IWRM framework for climate change adaptation.

- USACE is funding several climate change adaptation pilot studies that address certain aspects of IWRM. The goal of one pilot study was to collaboratively develop a climate change adaptation strategy to improve the overall quality of the West Maui Watershed, from the summit of Pu`u Kukui to the outer coral reef. Partners in the plan include USACE-Honolulu District, the State of Hawaii Department of Land and Natural Resources (DLNR) and the Department of Health (DOH) with support from NOAA and EPA. Another pilot study involves regional collaboration with the Ohio River Basin (ORB) Alliance. The alliance includes representatives from Federal agencies, States, non-governmental organizations (NGOs) and universities. The aim of the pilot study is to collaboratively develop mitigation and adaptation strategies with the ORB Alliance to counteract the anticipated water resources, ecological and infrastructure impacts of climate change. One intended product is the formation of a permanent climate change working group within the ORB Alliance.
- USACE has also agreed to do an IWRM pilot study with the Delaware River Basin Commission (DRBC). Climate change adaptation would be one component of this study. This pilot study is in the scoping phase.

__Integrated Water Resources Management__ is characterized by:

- ***Sustainable outcomes**—the practice of making decisions and taking coordinated actions for outcomes and benefits that use or affect current economic, environmental and quality of life resources conditions in ways that preserve these resources for future generations.*
- ***Collaborative planning**—a process that avails collaboration to secure the input of all stakeholders about their interests and needs.*
- ***A systems perspective**—a systems approach that arrays interests and needs as input variables, modeling a system of interdependent variables with multiple outputs.*
- ***A geographic context**—a geographic perspective that examines who is doing what where at a broad geographic scale, e.g., a river basin, watershed or coastal zone.*
- ***Balanced aims**—a process that seeks to balance multiple objectives as diverse desired outputs producing multiple benefits.*

Action 19 involves working with states to identify their flood risk and drought management "best practices" to prepare for hydrologic extremes so these can be shared among the States and Federal agencies.

- The first component consisted of a review of 50 FEMA State Hazard Mitigation Plans followed by a report describing the findings of the review with respect to a series of themes related to Action 19. The project team then reviewed the resulting materials to identify best practices and effective coordination mechanisms.

- Based on these results, the next step was to survey state flood officials to obtain their perspectives on Federal and State agency coordination and their views on innovative policies. A draft report is in review, with plans for publication as a joint USACE-FEMA report in 2013.

Action 20 is to "develop benchmarks for incorporating adaptive management into water project designs, operational procedures, and planning strategies." An interagency technical team including USACE, Department of the Interior (DOI) US Geological Survey (USGS), US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), US Environmental Protection Agency (EPA), and the National Oceanic and Atmospheric Administration (NOAA), and Forest Service, is working on this action.

- The first product is a report containing an inventory of Federal agencies' adaptive management practices and policies that support adaptive management strategies in the Federal government. The CEQ publications policy is for NAP documents to be published by the lead agency for each action and to follow the lead agency's review process. The report, "*Federal Agency Inventory of Adaptive Management Practices and Policies*" is in review and will be published in 2013.
- The second product is a report containing recommendations for implementation of adaptive management for climate change adaptation. The report, "*Recommendations for Federal Agency Implementation of Adaptive Management for Climate Change Adaptation*" is in review and will be published by USACE in 2013.

1.5.7.2. USACE Participation in Other NAP Actions

USACE is co-leading three other actions concerned with climate and water data supporting Recommendation 2 (Improve Water Resources and Climate Change Information for Decisionmaking). Please ID actions and something about them. These actions will provide an opportunity to integrate other Federal sources of data and tools with the Federal Support Toolbox.

USACE is also co-lead on an action developing training for water managers on climate change supporting Action 21 "Establish a core training program on climate change science for local, Tribal, and State water resources managers" of Recommendation 6 (Support Training and Outreach to Build Response Capability). In this activity, the Climate Change and Water Working Group (CCAWWG, see section on External Collaboration) agencies in cooperation with the University Corporation for Atmospheric Research (UCAR) COMET Program and the Western Water Assessment have developed a pilot training program that includes both an online course for self-paced training, and a set of subsequent residence courses where students apply what they learned through the online training. The on-line training became available in late 2012, and the first two residential courses were conducted in January and March 2013. Two additional training modules are in development.

1.5.7.3. Related Cross-Cutting Action Plans

Two other cross-cutting action plans[12] have been developed by CEQ and interagency working groups: The *National Ocean Policy Implementation Plan* (NOPIP) and the *National Fish, Wildlife and Plants Climate Adaptation Strategy* (FWP). USACE staff participated in the development of both plans.

The NOPIP, authored by the National Ocean Council, includes climate change in several of its recommendations to address key ocean challenges. Among these are:

[12] See http://www.whitehouse.gov/administration/eop/oceans/implementationplan

- Enhancing the Safety and Security of Ports and Waterways: Assess the vulnerability of our ports and waterways to sea-level rise and extreme weather events or other natural disasters and enable actions that more effectively reduce risks and impacts.
- Preparing for Change: Assess the vulnerability of coastal communities and ocean environments to climate change and ocean acidification and, in partnership with tribes, coastal communities and States, design and implement adaptation strategies to reduce vulnerabilities.
- Providing Tools for Regional Action: Assess the vulnerability of communities and ocean environments to climate change and ocean acidification and support and implement adaptation strategies to promote informed decisions.

Through its phased vulnerability assessments, USACE is addressing climate issues identified in the NOPIP. Our sea level guidance program represents a collaborative effort to develop and disseminate methods, best practices, and standards for assessing coastal resilience in a changing climate. Through the use of the Social Vulnerability Index[13], USACE is able to identify vulnerable populations. Several of our pilot projects have assessed the impacts of sea level change on ecosystem restoration projects. Informed decision-making is at the core of the sea level change adaptation guidance.

The FWP is entirely directed at climate change, and includes seven major goals with strategies and actions to be taken over the next five to ten years. The FWP goals are:

- Goal 1: Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.
- Goal 2: Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.
- Goal 3: Enhance capacity for effective management in a changing climate.
- Goal 4: Coordinated observation, information management, and decision support systems can help management strategies to be adaptive and adjust to changing conditions.
- Goal 5: Increase knowledge and information on impacts and responses of fish, wildlife, and plants to a changing climate.
- Goal 6: Increase awareness and motivate action to safeguard fish, wildlife, and plants in a changing climate.
- Goal 7: Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.

These goals are entirely compatible with the USACE Environmental Operating Principles[14] established in 1992, and are tied to actions of the NAP and NOPIP. Our climate change adaptation plan and its supporting strategies are aligned with FWP goals. We include focus areas that address issues of concern in the FWP goals, emphasize collaboration and improving our knowledge, and are developing policy and guidance to support adaptation, including flexible, adaptive, effective management for changing conditions.

[13] See http://www.iwr.usace.army.mil/Media/NewsStories/tabid/11418/Article/13535/usace-iwr-advances-consistent-methodological-approach-for-considering-social-vu.aspx

[14] See http://www.usace.army.mil/Missions/Environmental/EnvironmentalOperatingPrinciples.aspx

1.6. Engage in Meaningful External Collaboration

USACE understands that close collaboration, both nationally and internationally, is the most effective way to develop practical, nationally consistent, and cost-effective measures to reduce potential vulnerabilities resulting from global changes (Stockton and White 2011). That is why we are working closely with other agencies having aligned mission areas as we work to understand climate change impacts and to develop measures to adapt to these impacts. Our appreciation for the benefits of collaboration is also why we have provided support in the form of our senior engineers and scientists to the Federal Interagency Climate Change Adaptation Task Force (ICCATF) working groups, to the ICCATF Adaptation Community of Practice, and to US Global Change Research Program, among others.

1.6.1. Interagency Climate Change Adaptation Task Force

The USACE has played an active role in the ICCATF since its inception in spring 2009. The Assistant Secretary of the Army for Civil Works is the USACE representative to the ICCATF, which is composed of more than 20 Federal agencies and Executive branch offices and co-chaired by the CEQ, the National Oceanic and Atmospheric Administration (NOAA), and the Office of Science and Technology Policy (OSTP). In fact, the ICCATF was described in Section 16 of Executive Order 13514[15] signed by President Obama on October 5, 2009, as "already [being] engaged in developing the domestic and international dimensions of a U.S. strategy for adaptation to climate change…"

The ICCATF formed a number of working groups to help develop recommendations to support agency climate change adaptation planning and implementation. USACE actively participated in many of these, including the Agency Adaptation Processes working group (which developed recommendations for the *Implementing Instructions* (CEQ and OMB 2011)), the Water Resources Working Group (which developed the *National Action Plan Priorities for Managing Freshwater Resources in a Changing Climate*), the Fish, Wildlife and Plants Working Group (which developed the draft *Fish, Wildlife and Plants Climate Adaptation Strategy*[16]*),* and Coasts (which provided input to the *National Ocean Policy Implementation Plan*[17]).

> *"Managing water resources as a collaborative endeavor is becoming increasingly crucial as society faces demographic, economic, institutional, and climate changes manifesting across the U.S. and around the globe. These changes portend a different understanding of the risks associated with the occurrence, location, intensity and impacts of extreme events—including floods and droughts.."*
>
> *- Mr. Steven L. Stockton, Director of Civil Works, U.S. Army Corps of Engineers, in "Responding to National Water Resources Challenges"*

[15] See http://www.gpo.gov/fdsys/pkg/FR-2009-10-08/pdf/E9-24518.pdf
[16] See http://www.wildlifeadaptationstrategy.gov/
[17] See http://www.whitehouse.gov/administration/eop/oceans/implementationplan

1.6.2. Federal Agency Adaptation Community of Practice

The Federal Agency Adaptation Community of Practice is a spin-off from the ICCATF's Agency Adaptation Processes working group that provides a forum for interagency collaboration on facilities and climate change adaptation. The types of knowledge sharing fostered by the CoP include staff training and capacity building, methods for agencies to evaluate or measure progress, communication strategies, approaches to integrating adaptation into existing programs, and how to apply climate change scientific information in agency decision making. The USACE serves as an active member of both the working group and the CoP, and supported information exchange workshops before and after the CoP began. The types of knowledge sharing fostered by the CoP include staff training and capacity building, how agencies are evaluating or measuring progress, communication strategies, approaches to integrating adaptation into existing programs, concrete examples of agency adaptation projects and results, how to apply climate change scientific information in agency decision making, and providing agency-specific briefings about progress under their plans.

1.6.3. US Global Change Research Program Adaptation Science Working Group

Since 1989, the U.S. Global Change Research Program (USGCRP) has coordinated and integrated federal research around global changes, including climate change. Though USGCRP has focused primarily on science to date, there is an increasing emphasis on supporting adaptation planning and implementation. In 2012, USACE was appointed to co-chair this Working Group along with the US Department of Agriculture. High priority activities of this working group for USACE are:

- Advancing "actionable science" and evaluation frameworks and measures for adaptation efforts. "Actionable science" is the theory, data, analysis, models, and other tools available, relevant, reliable, and understandable for supporting multiple scales of decision-making around climate adaptation and mitigation questions. Actionable science can support decisions across wide spatial, temporal, and organizational ranges, including those of time-sensitive operational and capital investment decision-making. In many cases, climate science and climate change information must undergo a translation step to maximize its visibility, relevance, and utility for decision-makers to see it as actionable and to use it. The near-term focus is on Federal science products and services and the translation of these, where necessary, to be more accessible and more actionable for consistent Federal agency decisions around climate adaptation and mitigation.
- Helping to produce and test candidate evaluation frameworks and metrics appropriate for measuring the efficiency and effectiveness of adaptation and mitigation measures, first for Federal agencies' decisions and actions, then for the wider sets of decision makers.

1.6.4. Climate Change and Water Working Group

The Climate Change Water Working Group (CCAWWG) is an informal federal agency group that provides engineering and scientific collaboration in support of water management under a changing climate. Founded by USACE, DOI's Reclamation and USGS, and NOAA, CCAWWG has been an effective working-level forum since 2007 among federal agencies that fosters communication, operational, and research partnerships around user needs across the water resources and science communities of practice. CCAWWG now also includes FEMA, EPA, the National Atmospheric and Space Administration (NASA), and the USDA Agricultural Research Service. Other agencies with interests in water resources also participate (e.g., DOT FHWA). CCAWWG has established a joint web site[18] to provide information on

[18] See http://ccawwg.us/index.php/home

their activities, which include examinations of user needs for climate and weather information for long (>5 yrs) and short –term water resources planning and management (described in the section on Improving Knowledge below), as well as training classes supporting the NAP.

1.6.5. National Climate Assessment

The National Climate Assessment (NCA) is an important and official resource for understanding and communicating climate change science and impacts in the United States. The Global Change Research Act of 1990 mandates that periodic national climate assessments be conducted. A number of USACE staff have contributed to this 3rd draft National Climate Assessment since 2010, participating in forums and workshops, contributing to technical support reports, serving on author teams, helping to shape the ongoing assessment work, providing agency review comments on the draft released for comment in February 2013, and working to resolve the public comments in the NCA chapters. Several of the technical support documents participation have or will be released as interagency reports.

1.7. Improving Our Knowledge for Water Resources Management and Infrastructure Resilience

USACE is improving our knowledge about climate change impacts and adaptation through the use of targeted pilot studies to test new ideas and develop information needed to develop policy and guidance, assessments of our needs for climate information in decision-making, and developing training to support staff capabilities and foster interagency relationships that will support collaborative networks to address climate challenges and opportunities.

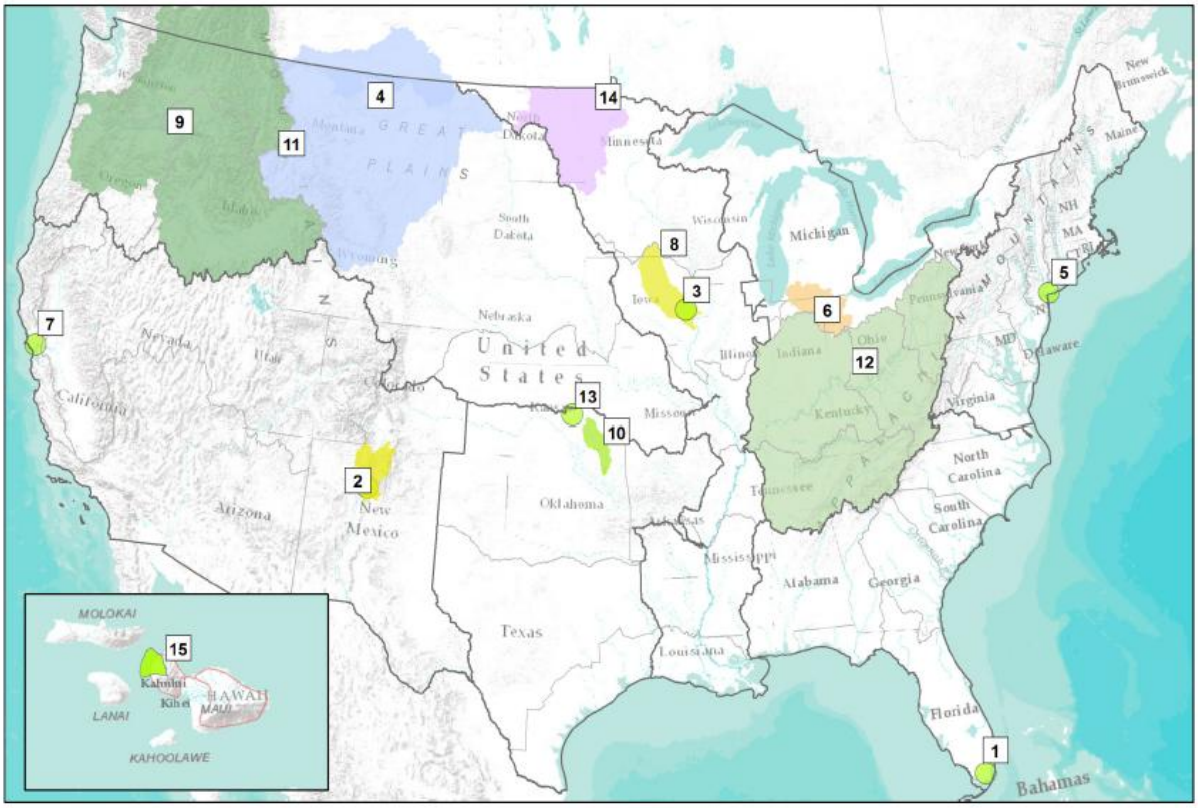
1.7.1. Pilot Studies

We are in our fourth year of testing methods and frameworks for adapting to climate change through the use of pilot studies[19]. These pilots help us develop and test alternative adaptation strategies to achieve specific business management decisions; identify new policies, methods, and tools to support adaptation for similar cases; learn how to incorporate new and changing climate information throughout the project lifecycle; to develop, test, and improve an agency level adaptation implementation framework; and to implement lessons learned in next pilot phase. The pilot projects span a diverse geographic and spatial scale as well as covering different business lines and functional areas. Each of these pilot studies addresses a central question that will help guide us as we develop policy and guidance to mainstream adaptation, including the following:

- How do we allow for shoreline retreat to preserve critical tidal and nearshore ecosystems in a long-term regional planning context?
- What is the relationship between changing climate conditions and reservoir sedimentation, and could this relationship shorten the lifetime of the infrastructure project or impact its flood control pool?
- How do we incorporate climate change considerations into reservoir operating policies that will be robust and adaptive to potential climate changes?
- How will dredging cost requirements at Great Lakes harbors vary in the future as the climate potentially changes precipitation regimes and runoff characteristics?

[19] See https://corpsclimate.us/rccpad.cfm for more information on the pilot studies

Figure 3. Pilot Study Locations



KEY

[1] Application of Sea-Level Change Guidance to **C-111 Spreader Canal**, Florida

[2] Climate Change Associated Sediment Yield Impacts on the Rio Grande, **Cochiti Dam and Lake**

[3] Climate Change Impacts on the Operation of **Coralville Lake**, Iowa

[4] Climate Change Associated Sediment Yield Impacts and Operation Evaluations at **Garrison Dam**, North Dakota

[5] **East Rockaway Inlet to Rockaway Inlet**, New York, Collaboration Framework Development

[6] Upland Sediment Production and Delivery in the **Great Lakes Region** under Climate Change

[7] Risk-Informed Decision-Making for Potential Sea-Level Rise Impacts on the **Hamilton Wetland** Restoration Project, California

[8] Climate Modeling and Stakeholder Engagement to Support Adaptation in the **Iowa-Cedar Watershed**

[9] Framework for Building Resiliency into Restoration Planning – **Lower Columbia River Estuary**

[10] Climate Change Impacts on Water Supply in **Marion Reservoir Watershed**, Kansas

[11] **Missouri River Basin** Mountain Snowpack – Accumulation and Runoff

[12] Formulating Mitigation/Adaptation Strategies through Regional Collaboration with the **Ohio River Basin** Alliance

[13] Utilization of Regional Climate Science Programs in Reservoir and Watershed Risk-Based Assessments, **Oologah Lake and Watershed**

[14] **Red River of the North** Flooding at Fargo, North Dakota

[15] Risk-Informed Decision-Making for Integrated Water Resource Management Planning, **West Maui Watershed**

- Can we develop a conceptual framework for how climate change information might be incorporated into ecosystem restoration projects?
- Is mountain snowpack and subsequent runoff changing due to changes in climate, and is the Missouri River Basin, therefore, more susceptible to droughts and floods?
- How do we facilitate well-designed and inclusive multi-stakeholder collaboration with the local decision makers for the purpose of identifying vulnerability to sea-level change impacts, acceptable levels of risk, and the most acceptable alternatives over the project lifecycle?

The pilot projects have provided a body of knowledge and tested methods that can be used to successfully adapt projects to projected climate change. The pilots also demonstrate that in many cases, there is sufficient actionable science now to permit assessment of climate change impacts to projects and to support planning and design of measures to adapt to or avoid these impacts. Instead of waiting for highly technical adaptation guidance, broad initial policies could reduce the time and cost of adaptation by providing the legal and technical justification for action, narrowing the range of potential alternatives and guiding planning and study approaches to support the desired decisions. Lastly, the pilot projects showed that costs and benefits are dynamic and will change over time, just as climate does. Consideration of dynamic changes over time can guide adaptive management decisions.

1.7.2. Identifying User Needs for Adaptation

We are also improving knowledge through assessments of our needs for climate information in decision-making in association with agencies having aligned missions and operations. By providing those needs to science agencies, we can help shape science to meet our needs. In 2011, USACE and Reclamation published the report, *Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information*[20]. This report builds on the needs identified in USGS Circular 1331 and seeks to focus research and technology efforts to address information and tool gaps needed for longer-term water resources planning and management. The report concluded that there are gaps in the information and tools to help water managers understand how to use climate change information to make decisions, how to assess the responses of natural systems to climate change, and how to communicate the results and uncertainties of climate change to decision-makers. A follow-on report now being prepared by science agencies will present a strategy on how to meet the identified user needs.

In 2013, CCAWWG members USACE, Reclamation, and NOAA's National Weather Service (NWS) published a report about user needs for weather and climate information for short-term water management decisions. This report (*Short-Term Water Management Decisions: Use Needs for Improved Climate, Weather, and Hydrologic Information*[21]) describes short-term water management decision processes within USACE and Reclamation, including how assumptions of climate change and variability influence decisions. The report presents the types of monitoring and forecast information that is available from NWS and other agencies to support water resources management and discusses the characteristics and constraints on the development and use of this information. The draft report also contains a description of how information is currently used by USACE and Reclamation within its short-term water resource management activities. This report helps to identify opportunities to improve water resources management by communicating to the broad community of information providers and the research and development communities the needs of the management agencies within the mission authorities currently available. It will be followed by a science-agency prepared report laying out a strategy to meet the user needs expressed.

1.7.3. Training to Support Adaptation

Reclamation is leading Action #21 (Establish a core training program on climate change science) of Recommendation 6 (Support Training and Outreach to Build Response Capability), of the National Action

[20] See http://www.ccawwg.us/index.php/activities/addressing-climate-change-in-long-term-water-resources-planning-and-management

[21] See http://www.ccawwg.us/index.php/activities/short-term-water-management-decisions-user-needs-for-improved-climate-weather-and-hydrologic-information

Plan Priorities for Managing Freshwater Resources in a Changing Climate. Together with USACE, NOAA, EPA, USGS, Denver Water Board, Water Utility Climate Alliance, and the University Center for Atmospheric Research's COMET Program, Reclamation has developed climate hydrology training. Two courses were offered as a pilot effort to help test and refine the curriculum: Part I is a 3-4 hour online training module that was released to the public in November 2012, and Part II is a resident course that was held at the University Corporation for Atmospheric Research (UCAR) in Boulder, CO in January 2013. 17. Course attendees are providing feedback to help us better target the course materials[22]. See http://ccawwg.us/index.php/preparing-hydro-climate-inputs-for-climate-change-in-water-resource-planning for more information. A crop water demand course was presented in March 2013, and two additional courses are in preparation.

1.7.4. Coupling Science and Engineering

USACE implements its Climate Change Adaptation Policy through close coupling of science and engineering to aggregate and translate science into actionable engineering information supporting adaptation policy and actions. This process allows USACE to take best advantage of the highly dynamic science of climate and climate change produced by the experts in other agencies, while leveraging and increasing our traditional capabilities in water resources engineering. USACE sets the questions, problems, and agenda of work in cooperative partnerships between scientists and engineers. Examples of this work follow:

- USACE, with support from the American Recovery and Reinvestment Act of 2009 (PL 111–5) joined with Climate Central, Lawrence Livermore National Laboratory (LLNL), Reclamation, Santa Clara University, Scripps Institution of Oceanography and USGS to support statistical downscaling of general circulation models supporting the 2007 Intergovernmental Panel on Climate Change (IPCC) known as the CMIP3 data set. The temperature and precipitation results were made available to the public in 2010 and 2011 through a web site hosted by LLNL (http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html).
- In 2012, NOAA, USGS, USACE and the Strategic Environmental Research and Development Program, published "Global Sea Level Rise Scenarios for the United States National Climate Assessment" which provides the expert consensus on how to account for sea level rise and serves as technical input to the 2013 National Climate Assessment.

1.8. Developing Policy and Guidance for Infrastructure Resilience

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. Here, we categorize policy and guidance for datums, sea level change, and hydrology.

1.8.1. Policy and Guidance for Consistent Vertical Datums

The vertical datum is the base foundation for nearly all civil and military design, engineering, and construction projects in the USACE—especially those civil projects that interface with water. Elevations or depths may be referred to local or regional reference datums. The use of consistent nationwide vertical datums is a fundamental underpinning of adaptation to a changing environment, particularly where the combination of land subsidence and global sea level rise could result in rapidly changing

[22] See http://ccawwg.us/index.php/preparing-hydro-climate-inputs-for-climate-change-in-water-resource-planning

conditions that impact USACE coastal infrastructure providing coastal storm risk reduction, flood risk reduction, navigation, and ecosystem benefits. In 2006, USACE began working to establish a consistent nationwide datum and subsidence standard to provide a foundation for all activities, but especially in coastal areas where datum conversions can be tricky and subsidence can have a large effect on project elevations. This includes a Comprehensive Evaluation of Project Datums (CEPD) and Compliance Database to ensure that all Corps projects are tied to the correct datum, and if they are not currently, require transition to current vertical datum. This program also developed the USACE Survey Marker Archive Retrieval Tool (U-SMART) Database to store project control information in a standard database referenced to the National Spatial Reference System. Following a number of interim guidance products, in December 2010, USACE published comprehensive guidance in the form of Engineer Manual 1110-2-6056, *Standards and Procedures for Referencing Project Evaluation Grades to Nationwide Vertical Datums*[23].All USACE projects are working to meet a 2014 datum compliance deadline.

1.8.1.1. Policy and Guidance for Sea Level Change

USACE has long recognized the potential of changing sea levels to impact our projects. Since 1986, USACE guidance has recognized the need to incorporate changing tide gauge information into planning and design of our projects. Since 2009, we have required the use of three scenarios of potential relative sea level change to be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence[24] Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative sea-level change in the starting water surface elevation for such profiles, where appropriate. The guidance is used not only throughout USACE, but by other agencies as well, including the State of Florida[25]. A web-based tool enables users of the guidance to develop the three required scenarios at appropriate NOAA tide gauges[26]. EC 1165-2-212 is cited as an example of Federal policy supporting adaptation planning in several publications (e.g., Tebaldi et al 2012 and Bierbaum et al 2012).

The development of sea-level change adaptation implementing guidance is the focus of an interagency and international team developing a USACE Engineering Technical Letter (ETL) in the Global Change Series (1100): *Procedures to Evaluate Sea Level Change, Impacts, Responses, and Adaptation*. The expert team includes representatives from USACE districts, divisions, labs, and centers, and also from NOAA, USGS, Reclamation, Navy, Coast Guard, FHWA, FEMA, National Park Service, US Naval Academy, HR Wallingford (UK), University of Southampton (UK), and Moffat and Nichol Engineers. This collaborative process supports rapid incorporation of new and changing information and provides rapid knowledge transfer between agencies.

This draft implementing guidance includes the development of thresholds and tipping points to guide adaptive, flexible adaptation and detailed implementation guidance on how to include sea-level change impacts and adaptation into USACE planning, engineering, construction, operation, and maintenance. The guidance integrates the recommended planning and engineering approach at the regional and project level necessary for understanding and adapting to impacts of projected sea-level change. A hierarchy of decisions supports an appropriate level of analysis. Key decision matrix concepts address sustainability, resilience, adaptive and anticipatory planning, and system and cumulative effects. External review was complete 1 June 2013, with comments from USGS, GSA, NOAA, Reclamation, and

[23] See http://publications.usace.army.mil/publications/eng-manuals/EM_1110-2-6056/

[24] See http://publications.usace.army.mil/publications/eng-circulars/EC_1165-2-212.pdf

[25] See http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_PL/FDOT_BDK79_977-01_rpt.pdf

[26] See http://www.corpsclimate.us/ccaceslcurves.cfm

FHWA in addition to other comments. The team is in the process of resolving the comments prior to approval and release of the guidance.

1.8.1.2. Climate Change and Inland Hydrology Guidance

Incorporating climate change considerations within our wide array of inland hydrology guidance is a priority action for USACE. Beginning in 2012 and continuing in 2013, we are developing an overarching enabling guidance document to address climate impacts to the hydrologic aspects of USACE projects and programs. This guidance builds on the core principles of scalable frameworks and scenarios to enable assessments of future project performance against the uncertainties of climate change. The scalable framework requires differing amounts and types of information, level of detail, and complexity of analyses depending on the questions being asked on a case-by-case basis (e.g., there are no "one size fits all" approaches). The scenario approach provides a range of plausible future outcomes against which project performance can be assessed.

The uncertainty associated with future climate provides an opportunity to use information from the very distant past to help frame characteristics of flood possibilities. This must be done in a manner that is consistent with USACE mission and goals as well as with considerations for the underlying assumptions associated with paleoflood information. USACE is developing policy and guidance addressing how and where paleoflood hydrology methods are relevant to USACE design and operations, including decisions such as estimating flood peak magnitudes, volumes and durations for flood damage assessments, or evaluating design criteria using the minimum essential guidelines.

2. Report of Progress to Mainstream Climate Adaptation

USACE has been working for five years now to identify what we know, what we don't know, and what we can do to fill the knowledge gaps and develop the policy and guidance we need to adapt to climate change. We have analyzed our vulnerability to climate change, including identification of risks and opportunities, and continue to refine these analyses. We understand that our projects are part of a dynamic and evolving system, and that they can change continuously over time (vs. achieving and maintaining a single equilibrium state). Our experience with "wicked water resources" problems has shown us that we must be careful when we implement changes, because our incomplete understanding increases the potential for unintended consequences resulting from actions taken in isolation.

We understand the complexities of adaptation because our water resources engineers and managers — and our military staff — are already accustomed to making decisions under deep uncertainty of the kind that climate change brings. It is precisely this engineering ability to adapt to changing problems and conditions that provides a source of institutional and organizational resilience and experience to guide our climate change adaptation. For example, USACE made many difficult choices in 2011 alone in the interests of public safety – choices that were possible only because engineers in the 1920s and 1930s understood that future could bring changing conditions – and they designed options into the system that allowed us to adapt to these conditions.

2.1.1. Progress in the Context of the Flexible Framework for Adaptation

Our progress to date to support mainstreaming climate change adaptation has focused on clarifying our adaptation mission and goals and developing new policy and guidance to support adaptation implementation at multiple scales, from project-specific to nationwide. We are applying our strategic

approaches to the priority areas identified in previous years, with a heavy emphasis on external collaboration and pilot tests to help improve our knowledge so we can make progress on the policy and guidance needed to mainstream adaptation.

USACE progress on adaptation is presented below in the context of the CEQ flexible framework for adaptation (Fig 4). All of these activities build awareness and skills within the USACE and for our partners and stakeholders.

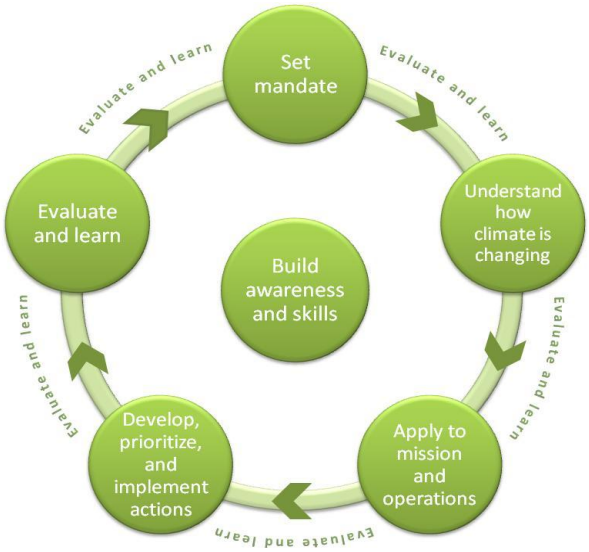


Figure 4. CEQ's flexible framework for adaptation.

Table 1. USACE adaptation progress for the "Set Mandate" component of the CEQ flexible framework for adaptation.

Component of Flexible Framework for Adaptation	USACE Adaptation Action	Status
Set Mandate	Overarching Policy Statement	2011-present
	Adaptation Steering Committee	2011-present
	Civil Works Strategic Plan "Sustaimable Solutions to America's Water Resources Needs."	2011-2015
	Technical Mandate - Datums: Datum and subsidence standard ER 1160-2-8160	2009
	Technical Mandate - Coastal: Extrapolate gauge record but consider change, HQ Memo Extrapolate gauge and assess sensitivity to high rate of change, ER 1105-2-100 Consider three scenarios (lowest is extrapolate gauge) EC 1165-2-211 superseded by EC 1165-2-212 Adaptation to sea level and coastal change ETL 1100-2-xxx	 1986 2000 2009-2011 2013, completed review
	Technical Mandate - Hydrology: General hydrologic approach Appropriate use of paleoflood hydrology	 2013, draft 2013, in preparation

Table 2. USACE adaptation progress for the "Understand How Climate is Changing" component of the CEQ flexible framework for adaptation.

Component of Flexible Framework for Adaptation Component	USACE Adaptation Action	Status
Understand How Climate Is Changing	Report providing overview of climate change and variability impacts to water federal resources management, USGS Circular 1331	2009
	Targeted climate change adaptation pilots	2009-present
	Nonstationarity Workshop and proceedings to establish legal and scientific justification for future policy and guidance	2010
	Nonstationarity Journal Paper Special Collection, to establish scientific justification for approach	2011
	Participate in and now co-lead US Global Change Research Program Adaptation Science Working Group	2010-present
	ARRA project developing statistical downscaling for public archive at Lawrence Livermore National Laboratory, leveraged Reclamation and NOAA funds	2010-2011
	Portfolio of Approaches Workshop to lay out issues in how to select and use climate information to support future science and guidance	2011
	NOAA Report: Sea Level Rise Scenarios technical support to NCA	2011-2012
	USGS Report: Water Resources technical support to NCA	2011-2013, in publication
	Report on Appropriate Uses of Paleoflood Information in CW Programs	2011-2013
	Authoring chapters of National Climate Assessment (NCA) Report	2011-present, resolving review comments
	HUC-4 CMIP5 BCSD VIC hydrology for CONUS – gives standard set of hydrology for use in initial adaptation decisions	2012-2013
	Annotated bibliography of nonstationarity to inform decisions and future guidance	2011-2013, draft
	Interagency expert group assessing nonstationarity to support future guidance	2012-present

Table 3. USACE adaptation progress for the "Apply to Mission and Operations" component of the CEQ flexible framework for adaptation.

Component of Flexible Framework for Adaptation Component	USACE Adaptation Action	Status
Apply to Mission and Operations	Identify key vulnerabilities and adaptation options, USGS Circular 1331	2009
	Targeted climate change adaptation pilots covering range of missions, life-cycle phases, geographic locations, and spatial scales	2009 – present
	Proof of concept inland vulnerability assessment, with associated tools and methods	2010-2012
	Report on User Needs for Long-Term Water Resources Planning and Management –what information and science do we need to know so we can make better long-term decisions?	2011
	Initial screening-level coastal vulnerability assessment with associated tools and methods	2011 – present:
	Screening-level inland vulnerability assessment, with updated information and enhanced tools	2012 – present:
	Report on User Needs for Short-Term Water Management Decisions – –what information and science do we need to know so we can make better short-term decisions?	2013

Table 4. USACE adaptation progress for the "Develop, Prioritize, and Implement Actions" component of the CEQ flexible framework for adaptation.

Component of Flexible Framework for Adaptation Component	USACE Adaptation Action	Status
Develop, Prioritize, and Implement Actions	Datums: Comprehensive Evaluation of Project Datums (CEPD) CEPD Compliance Tracking Tool All project datums in compliance	 2006-2008 2008-present Scheduled 2014
	Coastal: Incorporate three sea level scenarios in project planning, design, and implementation Incorporate adaptation to sea level change in project planning, design, and implementation Provide supporting tools (e.g., sea level calculator)	 2009-present Begin 2013 2011-present
	Hydrology: Compile drought contingency plans, develop strategy to update to account for climate change, prioritize and conduct updates for high priority projects/systems Compile reservoir sediment information, develop strategy to update to account for climate change, prioritize and conduct updates for high priority projects/systems	 2011-present 2011-present

Table 5. USACE adaptation progress for the "Evaluate and Learn" component of the CEQ flexible framework for adaptation.

Component of Flexible Framework for Adaptation Component	USACE Adaptation Action	Status
Evaluate and Learn	Targeted adaptation pilots to provide lessons learned learn about climate impacts and vulnerabilities and how to adapt	2009-present
	Lessons Learned from applying EC 1165-2-211, including how to plan with multiple future scenarios, level of effort tied to decision and consequences, vulnerabilities and adaptation tied closely to project purposes	2009-present
	Training:	2012-present
	Army Campaign Plan Metrics	2012
	USACE Campaign Plan Metrics	2013
	Participation in R&D projects for DoD	2010-present

2.1.2. Selected Examples of Mainstreaming Adaptation

USACE has been working to mainstream climate change adaptation for several years so that adaptation is integrated into policy, budget, engineering design, implementation and ongoing evaluation in a way that establishes adaptation as standard practice. Adaptation encompasses a continuum of actions that may progress in a linear fashion, may involve iteration, or may end without implementation.

Examples of adaptation actions include understanding climate change impacts, assessing vulnerabilities to climate, planning various responses, engineering design of adaptation measures, and implementing adaptation. Decisions made at each step are adaptation decisions – a physical or operational change is not the only appropriate end point when mainstreaming adaptation. Example projects of where and how adaptation has been integrated into the USACE are presented here. These are both coastal and inland projects. The distinction is important because there is existing guidance supporting planning and design for coastal projects, whereas for riverine projects, guidance is not yet available.

- Neuse River Basin, NC alternatives were formulated on the historic rate of sea level rise and sensitivity analyses were conducted for the other curves. As a result, the rock sill design height is set to account for some accelerated sea level rise. Under the low and intermediate scenarios, the sill remains functional. Under the high scenario, the sill would still function as desired, but at a reduced level as higher sea levels occur.
- Walton County, FL project includes adaptation to changing sea levels through the beach renourishment cycle.
- The Fargo-Moorhead Metropolitan Area Flood Risk Management study used an interagency and academic Expert Opinion Elicitation (EOE) panel to develop a statistical approach to incorporate climate variability into the discharge-frequency curve for Fargo. The EOE was conducted using the technical guide for use of EOE developed by the Risk Management Center. The EOE identified a change in hydrology. The hydrologic information developed through this process is

used in the on-going Red River Basin Feasibility study, which is developing detailed hydrologic and hydraulic models to determine the impact of various flood storage alternatives.

- Jacksonville Harbor Mile Point, FL found that the potential effects of sea level rise would be much less severe under the with-project condition. The selected plan was the only alternative capable of addressing and successfully improving the direction of the water flowing out of the Intracoastal Waterway under the existing tidal conditions while retaining adaptive capacity to preserve performance under future sea level scenarios.
- The climate change and modeling data for an analysis of sediment impacts to Cochiti Dam and Lake is being used in several ongoing studies in the Albuquerque District:
    a. Santa Clara Pueblo Watershed Assessment (Section 203) considers observed climate trends and projected climate changes to address likely future changes to watershed hydrology on the Pueblo's lands, with particular attention to flood risk and water resources development at the Pueblo.
    b. Española, NM (General Investigation) includes climate trends and projected climate projections in planning sustainable ecosystem restoration for flood risk reduction and watershed management restoration for three Tribes in the Española region of northern New Mexico.
    c. Middle Rio Grande Endangered Species Collaborative Program: Under the CESPA Collaborative Program Authority, the District is collecting and disseminating information on regional climate trends and future climate projections to the 16 member agencies of the Collaborative Program to inform ecosystem restoration projects required by the USFWS Middle Rio Grande Water Operations Biological Opinion (2003).
- The LRD Water Management staff has been participating on a task team appointed by the International Joint Commission (IJC) to address future extreme water levels in the Great Lake-St. Lawrence River system. That task team has recently released a draft Adaptive Management Plan for public review and comment and by the end of May 2013 will be submitting a final version of the Adaptive Management Plan to the IJC for consideration. This bi-national Adaptive Management Plan responds to changing climate and the limited ability to alter lake levels through regulation of flows from Lake Superior and Lake Ontario.

2.1.3. Public Comment on 2012 USACE Climate Change Adaptation Plan and Report

In accordance with the March 2011 Implementing Instructions, USACE prepared and submitted a 2012 Climate Change Adaptation Plan and Report to CEQ and OMB in June 2012. This Plan and Report is included as an Appendix to the USACE FY12 Sustainability Plan. CEQ and OMB had no comments on the USACE plan, and requested that it be released to the public for a 60-day comment period beginning 7 February 2013. Two public comments were received, both of whom applauded the USACE on its proactive approach and leadership in adaptation. The public comments and USACE responses are summarized in Table 6.

Table 6. Summary of public comments and USACE Response.

Commenter	Commenter's recommendation	USACE response
The Nature Conservancy	Include non-Federal public and private partnerships in collaborative efforts	Concur
	Provide web-based tools and data to share information with state, local, and NGO partners	USACE is actively doing so (e.g., sea level rise calculator, https://corpsclimate.us/ccaceslcurves.cfm)
	Continue and expand pilot projects	Concur, as funds permit
	Consider incorporating lesson learned in the Quality Management System (QMS)	USACE will examine appropriate forums for lessons learned
	Incorporate natural solutions in adaptation	Concur. The North Atlantic Coast Comprehensive Study emphasizes natural solutions
Georgetown Climate Center	Expand consideration of sea level change in the regulatory program	Concur
	Collaborate with other Federal agencies around sea level rise (e.g., FEMA)	Concur. USACE, FEMA, NOAA, USGCRP, and CEQ have teams to provide and integrated tool for use in considering projected sea level impacts to coastal flood zones

3. Summary and Conclusions

The US Army Corps of Engineers (USACE) understands that climate change is among the major challenges of the 21st century, and can impact all areas of our missions and operations. For more than five years now, we have made progress on a comprehensive approach to climate change that incorporates new knowledge and changing conditions about vulnerabilities, risks and opportunities into our missions, operations, programs, and projects. Our approach enhances the capacity of our planning, design, construction, operations, and maintenance to adapt to changing climate and other global changes.

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. We are taking a collaborative approach that takes advantage of different perspectives and expertise so that our progress on adaptation reflects the best available and actionable science. But in turn, we are working to help guide the science to better meet our needs and the needs of other land and water resources agencies.

This USACE Climate Change Adaptation Plan and Report provides the information requested by the Council on Environmental Quality in their *Implementing Instructions for Federal Agency Climate Change Adaptation* issued on 4 March 2011 and the 29 February 2012 statement on *Preparing Federal Agency Climate Change Adaptation Plans In Accordance with Executive Order 13514*.

We believe that this *2013 USACE Adaptation Plan and Report*, prepared at the direction of the USACE Adaptation Steering Committee, demonstrates a broad understanding of the challenges posed by climate change to our mission, programs, and operations, and a commitment to undertake specific

actions in FY 2013 and beyond to better understand and address those risks and opportunities. We present information about how we plan and evaluate agency adaptation planning, describe programmatic activities supporting climate change adaptation, and describe efforts to both better understand and to address climate change risks and opportunities. We are pilot-testing adaptation methods, sharing lessons learned within and outside the agency, and refining our adaptation based on the new knowledge. Working within a risk-informed framework that considers all of the challenges facing us will enable USACE to implement integrated water resources management solutions to the impacts of climate change.

This document also provides additional information on current USACE adaptation planning and implementation progress. The scope, collaboration, and resources we have applied to understand climate change and make progress on adaptation planning and implementation. Our work demonstrates the importance we place on this critical challenge to the long-term sustainability of our mission, operations, programs and projects, which oversee and administer public water resources and associated infrastructure in every state, as well as several international river basins, and support military operations worldwide that promote peace and stability.

4. References

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Appendix A: Guiding Principles for Adaptation

PROGRESS REPORT OF THE INTERAGENCY CLIMATE CHANGE ADAPTATION TASK FORCE - 2010

Guiding Principles for Adaptation

Adopt Integrated Approaches: Adaptation should be incorporated into core policies, planning, practices, and programs whenever possible.

Prioritize the Most Vulnerable: Adaptation plans should prioritize helping people, places and infrastructure that are most vulnerable to climate impacts and be designed and implemented with meaningful involvement from all parts of society.

Use Best-Available Science: Adaptation should be grounded in the best-available scientific understanding of climate change risks, impacts, and vulnerabilities.

Build Strong Partnerships: Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.

Apply Risk-Management Methods and Tools: Adaptation planning should incorporate risk-management methods and tools to help identify, assess, and prioritize options to reduce vulnerability to potential environmental, social, and economic implications of climate change.

Apply Ecosystem-based Approaches: Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services on which humans depend to reduce vulnerability of human and natural systems to climate change.

Maximize Mutual Benefits: Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.

Continuously Evaluate Performance: Adaptation plans should include measureable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

From http://www.whitehouse.gov/sites/default/files/microsites/ceq/Interagency-Climate-Change-Adaptation-Progress-Report.pdf

Appendix B: Climate Change Impacts to Missions and Operations.

Projected Climate Change	Potential Impacts	Potential USACE Vulnerabilities/Opportunities
Increasing air temperatures	Increases to average temperature, which will vary regionally and over time; increasing frequency and intensity of extreme heat; increasing length of frost-free season; changes in form of precipitation (snow vs. rain); reduced ice volume and extent on lakes, rivers, oceans, and in glaciers; increased permafrost temperatures and permafrost thawing; changes in water and energy demand; altered habitat suitability; increasing water temperature and associated lake stratification and water quality; changes in invasive species or pest distribution; warmer sea surface temperatures and potentially altered circulation patterns; changed evapotranspiration impacting reservoirs and soil moisture; increased risk of wild fires; alterations in material properties	Increases in worker safety limitations due to extreme heat and intensified air pollution; increased heat-related illnesses; increased risk of wildfire; potential increases in the length of the ice-free shipping season; potential increases in shoreline erosion where shorefast ice no longer exists; altered environmental windows; greater uncertainty of water supply and demand affecting navigation, ecosystem restoration, hydropower, recreation, and water supply; potential changesthat affect the delineation of the waters of the US; wetland and other impacts to the regulatory mission; potential increases in energy costs for cooling facilities and potential offsets for heating; potential decreases in the reliability of energy; potential for coastal extreme high water events associated with altered ocean circulation; potential changes in vertical construction equipment, material, and operating responses to increased temperature; threatened and endangered species may be adversely affected or benefit.
Changing precipitation	Changes in seasonal precipitation that vary regionally and seasonally :in general, the northern US is projected to see more winter and spring precipitation and the South is projected to see less precipitation in the spring, and increased precipitation is projected for Alaska in all seasons; increase in the frequency and intensity of heavy and very heavy precipitation events, including in the Southwest, where overall precipitation will be decreasing (=greater potential for flash floods); increasing frequency, duration, and extent of drought; summer droughts are expected to intensify in most regions of the U.S., especially in the Southwest, Southeast, and Hawaiʻi in response to both rising temperatures and changes in precipitation; changes in snow volume and onset of snowmelt; more variable stream flow and lake levels; altered habitat suitability; changes in invasive species or pest distribution; change in magnitude and frequency of flooding and low flows; altered sediment regimes, streambank erosion, aggradation, and degradation; changes in	Increasing uncertainty in projected precipitation and/or nonstationary hydrology could alter design standards and criteria; more variable reservoir inflow, lake levels, and channel depths could impact performance of flood risk, navigation, ecosystem restoration, hydropower, recreation, and water supply missions; more intense flooding over most of the US, but especially in the Midwest and Northeast requires increased need for emergency preparedness, response and recovery; changes in the delineation of the waters of the US; wetland and shoreline impacts within the scope of the regulatory mission; increasing need for drought preparedness; potential mismatch of water supply and demand could impact existing and planned water allocation and reallocation; ; increasing very heavy precipitation may alter reservoir sediment conditions and changes in dredging requirements for rivers and harbors; increasing potential for wildfire with increased drought; changes in soil moisture could alter infiltration and impact rainfall-runoff relationships; more intense precipitation and

Projected Climate Change	Potential Impacts	Potential USACE Vulnerabilities/Opportunities
	stormwater magnitude and frequency and levels of pollutants in runoff; altered groundwater recharge and consumptive uses;	runoff generally increase sediment, nitrogen, and pollutant loads, shifts in ecosystem structure and function may adversely impact or benefit threatened and endangered species.
Increases in extreme weather	Increasing variability, altered seasonality, and changing intensity or frequency of heat waves, floods and droughts, depending on location; warming sea surface temperatures are projected to result in increasing tropical storm intensity for the largest storms.	Increases in extreme weather and storms will require increased emergency preparedness, response, and recovery; increasing uncertainty in the magnitude and frequency of extreme floods could impact life safety and alter design standards and criteria; more variable reservoir inflow and lake levels could impact performance of flood risk, navigation, ecosystem restoration, hydropower, recreation, and water supply missions; impacts to wetlands shorelines that impact the regulatory missions; more intense and/or frequent heat waves will impact worker safety, potentially limiting construction and operations; increased floods, droughts, and storms impact sedimentation and shoaling, altering dredging requirements; more intense floods and droughts will impact navigation reliability; increased flooding will impact transportation, electrical power, medical, and communications infrastructure.
Sea level change and associated tides, waves, and surges	In Alaska and the Pacific Northwest, locations experiencing glacial rebound may be impacted by falling local relative sea levels, increasing shoreline erosion and the need for dredging. Elsewhere, rising local relative sea level will cause more frequent inundation of low-lying land; increased shoreline erosion and changes to barrier islands and inlets; increased storm waves, surges, tides; loss of or changes to coastal wetlands; changes in estuarine structure and processes; increased saline intrusion into coastal aquifers; altered sedimentation and shoaling in channels and harbors; changes in ecosystem structure and species distributions, including invasive species and pest; altered frequency and extent of harmful algal blooms and coastal hypoxia events;	Increased need for emergency preparedness, response, and recovery for more frequent inundation; increasing uncertainty in the magnitude and frequency of storm tides and surges could alter design standards and criteria; higher average and extreme water levels could impact performance of navigation, coastal risk reduction, ecosystem restoration, and missions; changes in sedimentation and shoaling could impact dredging; decreases in harbor and port performance reliability; changes in delineation of the waters of the US; impacts to wetlands that affect the scope of the regulatory mission.

Appendix C. Recommendations and Actions in the National Action Plan Priorities for Managing Freshwater Resources in a Changing Climate

Recommendation 1	**Establish a Planning Process**
Action 1	Establish a planning process with the capability to identify priority adaptation actions and promote their implementation
Action 2	Establish an organizational framework to promote effective management of water resources in a changing climate
Recommendation 2	**Improve Water Resources and Climate Change Information for Decisionmaking**
Action 3	Strengthen data for understanding climate change impacts on water resources
Action 4	Create a program to align "hydroclimatic" statistics with today's climate and anticipate future changes
Action 5	Implement surveillance system for tracking waterborne disease/health threats relevant to climate change
Action 6	Provide coastal states/communities with information to identify areas likely to be inundated by sea level rise
Action 7	Establish interagency effort to expedite implementation of the newly developed wetlands mapping standard
Recommendation 3	**Strengthen Assessment of Vulnerability of Water Resources to Climate Change**
Action 8	Publish guidance on the use of modeled projections for water resources applications
Action 9	Develop a Federal internet portal to provide information on water resources and climate change
Action 10	Develop a pilot climate change vulnerability index for a major category of water facilities
Action 11	Continue development of tools and approaches that build capacity for water institutions to conduct vulnerability assessments and implement appropriate responses
Action 12	Assess vulnerability of watersheds and aquatic systems in National Forests and Grasslands
Action 13	Promote free and open access to authoritative climate change science and water resources data
Recommendation 4	**Expand water use efficiency**
Action 14	Develop nationally consistent metrics for water use efficiency in key sectors
Action 15	Consider making water use efficiency an explicit consideration in the revision of Principles and Standards for water resources projects and in the new NEPA guidance on climate change
Action 16	Enhance coordination among current Federal water efficiency programs and create a "toolbox" of key practices
Recommendation 5	**Support Integrated Water Resources Management**
Action 17	Work with States and interstate bodies (e.g., river basin commissions) to provide assistance needed to incorporate IWRM into their planning and programs, paying particular attention to climate change adaptation issues
Action 18	Revise Federal water project planning standards to address climate change
Action 19	Work with States to review flood risk management and drought management planning to identify "best practices" to prepare for hydrologic extremes
Action 20	Develop benchmarks for incorporating adaptive management into water project designs, operational procedures, and planning strategies
Recommendation 6	**Support Training and Outreach to Build Response Capability**
Action 21	Establish a core training program on climate change science for local, Tribal, and State water resources managers
Action 22	Focus existing youth outreach programs on climate change and water issues
Action 23	Engage Water Resources Research Institutes at land grant colleges in climate change adaptation research
Action 24	Increase graduate level fellowships in water management and climate change