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US ARMY CORPS OF ENGINEERS' COLLABORATIVE APPROACH TO 21ST CENTURY CHALLENGES POSED BY GLOBAL CHANGE

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Abstract- It is now clear that global changes, including demographic shifts, changing land use/land cover, climate change, and changing social values and economic conditions, are part of a complex system that cannot effectively be dealt with by piece-meal or sequential problem-solving. These changes can interact and combine in unpredictable ways, resulting in potentially surprising or abrupt changes that threaten public health and safety, the performance of water resources infrastructure, and the functioning of ecosystems. The US Army Corps of Engineers (USACE) sees these global changes that result in local impacts and responses as the major challenge of the 21st Century. We also recognize 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. This paper will discuss how USACE is leading the way to solve the challenges of the 21st century through our collaborative approach.

Book Title Information

Keywords: global change, climate change, collaborative approach, water resources management

1. Introduction

As the largest and oldest federal water resources management agency in the United States, the US Army Corps of Engineers oversees and administers public water resources and associated infrastructure in every state, as well as several international river basins. For more than 230 years, the USACE has supplied engineering solutions to water resources needs, including navigation, flood and coastal storm damage reduction, protection and restoration of aquatic ecosystems, hydropower, water supply, recreation, regulatory, and disaster preparedness and response. Approximately 12 million acres of land and water resources are under the jurisdiction of the USACE as part of its Civil Works portfolio of more than1600 water resources projects, programs, and systems. USACE also applies water resources management expertise to support Military program operations worldwide that promote peace and stability.

The cross-jurisdictional and multi-scale nature of USACE water resources management, combined with the wide variety of water users and their differing requirements, has resulted in management policies and procedures designed to respond to changing needs and balance competing needs. These policies and procedures improve the capacity of water managers to absorb additional disturbances without unduly impacting their basic functions.

In the past decade, it has become clear that global changes, including demographic shifts, changing land use/land cover, climate change, growing state capabilities, aging infrastructure, disappearing wetlands, and changing social values and economic conditions, represent a new set of challenges that USACE must be prepared to face. These changes are part of a complex system that is not completely understood. Global changes can vary nationally, regionally, and locally, and can confound each other and can combine in unpredictable ways to result in potentially surprising or abrupt changes that can pose a threat to public health and safety, the Nation’s water resources infrastructure, and natural ecosystems.

2. USACE Water Resources Management

2.1. HISTORICAL USACE APPROACH

Since 1802, USACE has been a leader in water resources management and the development and operation of water resources infrastructure based on best available science and technology. Up through the late 20th century, this included designing and engineering structures based on an "equilibrium paradigm" based on the assumption that natural processes (e.g., precipitation and runoff) tend toward a stable equilibrium condition. Land use, land cover, and other changes in the landscape could result in an altered equilibrium state, but this could be represented generally based on the characteristics of the equilibrium state. In the case of hydrology, where time series data provide the basis for water resources design, this meant that designers could assume stationarity if the data. In other words, the mean, variance, and autocorrelation of the time series could be assumed to be constant over time (e.g., Vandaele 1983). Therefore, observations of the past were thought to accurately represent the future (Milly et al 2008) and could be used in engineering design.

2.1.1. *Assumption of stationarity*

The assumption of stationarity allowed engineers to plan and design water resources projects against projected future conditions even where observed records were relatively short compared to the expected life of the project. This assumption allowed for substantial water resources development in a time when detailed analytical or dynamic representations of physical processes were not available and computational capabilities were limited. Though hydrologists and hydrologic engineers understood that stationarity can be an over-simplification (Chow 1964), the use of conservative design standards based on stochastic or probabilistic analysis, plus a factor of safety, resulted in conservative designs that, for the most part, were resilient to unexpected events.

2.1.2. *Evolution of problem-solving approach*

During the 20th century, not only did water resources engineers expand their knowledge of hydrology and hydraulics, they also developed standard methods for use in hydrology and hydraulic engineering (e.g., Meinzer 1942, Chow 1964, IACWD 1982). Increased observations record length and advances in modeling and computing supported increasingly detailed analyses of the uncertainties and variability in time series data and projections of future conditions. Changing social values led to increased pressure to evaluate the costs and benefits of water resources projects and reduce costly conservatism in design. At the same time, improved understanding of hydrologic and hydraulic processes, combined with the need to perform reliability analyses of aging infrastructure, led to risk-based engineering design and assessment (Cheng et al 1993).

Risk-based approaches require accurate projections of future operating conditions and consequences associated with extreme or unexpected events. The more detailed analyses required by risk assessments highlighted the complex interaction of global changes in the watershed, including climate change, land use and land cover, and evolving ecosystem structure and function. Improved numerical and computational resources allowed engineering problems to be explored in greater depth. Problem-solving no longer required as many simplifying assumptions (e.g., heterogeneous vs. homogeneous material properties or rapidly varied vs. uniform flow). Methods progressed to allow variations and perturbations in initial and boundary conditions, resulting in alternate futures and allowing the assessments of the sensitivity or physical variables and calculated parameters. The need for capacity to evaluate water resources management issues through a systems approach became evident (e.g., Haimes 1977).

3. New Global Challenges to Water Resources Management

Just as our problem-solving approach adapted to changing knowledge and technologies, our approach to developing and implementing effective solutions for current and future water resource needs changed with increased understanding of the uncertain futures. As we look to the future, our 21st century challenges include aging infrastructure, decreased availability of funding, and increased demands on the Nation's water resources caused by population expansion and changes in water demands, the need for environmental sustainability, and management of the impacts of climate change to water availability and quality.

The era of large, Federal, single-purpose water resources projects is over, as is the USACE's role as the single decision-maker and technical expert for water resources solutions. The water resources community recognizes the need for the broader, more collaborative, regional water resources planning to meet 21st century needs described below.

3.1. 21ST CENTURY CHALLENGES

As we look to the future, we see that water conflicts will persist, especially where there are already conflicts between water supply storage and flood storage, between water supply and environmental flows, and between other competing water sectors. Responsibility for water resources management will continue to be shared, requiring improved intergovernmental cooperation and improved water resources. Challenges we see ahead include:

- Demographic shifts – the U.S. population is expected to reach almost 400 million by 2050[1] (Day 1996). The population is expected to become increasingly urbanized, and concentrated in coastal communities at risk from severe weather and lack of fresh water.

- Global Challenge – The world population is expected to increase from 6.1B in 2000 to 8.9B in 2050 (UN 2004), though growth rates will decrease. Global population growth leads to increased demand for scarce water. Currently, nearly 900M people without access to clean water, and more than 2.5 billion people without adequate sanitation (World Health Organization and UNICEF 2010), and these numbers are likely to increase as population grows. Our role will be to promote regional stability, using integrated water resources management as means to promote trans-boundary cooperation.

- Aging Infrastructure – The American Society of Civil Engineers gave an overall grade of "D" to U.S. infrastructure in 2009[2]. Estimates to bring our infrastructure to an adequate level range up to $2.2 trillion. Many USACE facilities, including over half our navigation locks, are already beyond their 50-year "design life". They will require extensive maintenance and rehabilitation. Failure of this critical water resources infrastructure poses risk to human health and safety, the economy, and the environment.

- Globalization – Foreign trade is increasing share of U.S. economy, with exports reaching 12.7% of US GDP in 2008 (International Trade Administration (ITA) 2010). Though

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[1] Estimate from the "middle series;" the high series estimate is ~520M, while the low series estimate is ~280M.

[2] See http://www.infrastructurereportcard.org/

economic conditions in 2009 were difficult for exports as for other areas of the US economy, the US ITA expected that economic recovery would depend in part on exports (Massoudi 2010). The inability of ports and inland waterways to handle this increased demand could limit economic growth.

- Water-Energy-Food Nexus – The nexus between water, energy, and food is highlighted in the increasing role of sustainability in policy making. Factors include increased development of hydropower as clean source, the role of waterways in the transport of coal, petroleum and natural gas, estimates of the volumes of water needed for new sources,

- Environmental Values – Pressure from increased development, including rapidly growing demands for food, fresh water, timber, fiber, and fuel has substantially affected the natural environment (Millennium Ecosystem Assessment 2005a). Supporting sustainable water resources management will require a cultural shift including lifestyle changes as well as technical innovation.

- Climate Change – Climate change exacerbates existing global changes. Already observed changes in snowmelt, floods, and droughts are likely to progress over time, potentially affecting all aspects of water resource management.

- Declining Biodiversity – Our knowledge of ecological structure and function has evolved over time. The importance of biodiversity is being recognized at a time when global changes are resulting in decreased biodiversity. Freshwater species in particular are facing loss of habitat and increasing rates of extinction (Millennium Ecosystem Assessment 2005b). Important questions related to biodiversity, global changes, and habitat, and their relationship to water resources management, remain to be addressed.

USACE sees these global changes that result in sometimes unexpected regional and local impacts and responses as the major challenge of the 21st Century. We recognize that close collaboration, both nationally and internationally, is the most effective way to develop sound, nationally consistent, and cost-effective measures to reduce potential vulnerabilities resulting from global changes.

3.2. RECOGNIZING NONSTATIONARITY

Global change requires water resources managers to move from the equilibrium – or stationary – paradigm to one of constant evolution that recognizes the dynamic nature of physical and socio-economic processes. Successful water resources management requires us to both anticipate surprise and unexpected events, both natural and socio-economic, and to respond effectively in a timely manner. Water resource managers now and in the future must make assumptions and decisions about supply, demand, weather, climate, and operational constraints that differ in spatial and temporal scale and uncertainty. We must provide our stakeholders and partners with data and information that allows them to make risk-informed decisions as well. Over time, uncertainty may decrease as we increase our knowledge of climate change, its impacts, and the effects of adaptation and mitigation options (including unintended consequences). The use of rigorous adaptive management, where decisions are made sequentially over time, allows adjustments to be made as more information is known. The use of longer planning horizons, combined with updated economic analyses, will support sustainable solutions in the face of changing climate that meet the needs of the present without compromising the ability of future generations to meet their own needs.

3.3. NEW APPROACHES

3.3.1. *Systems Approach*

USACE has been fortunate that a systems approach has been a fundamental organizational perspective beginning with the establishment of the USACE Civil Works Divisions and Districts along hydrologic boundaries of major river basins beginning in 1802 (USACE 1998). The systems approach was confirmed when the Mississippi River Commission (MRC) was formed following catastrophic flooding in 1874 to develop plans for the areas along the Mississippi River, prevent flooding and promote navigation. The watershed approach was also specifically noted in Section 3 of the Flood Control Act of 1917: “All examinations and surveys of projects relating to flood control shall include a comprehensive study of the watershed or watersheds…” as well as later documents through the 1930’s to the 1980’s.

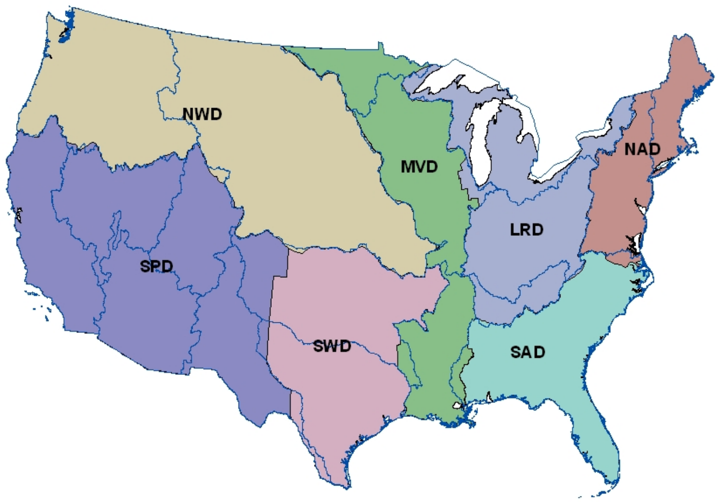

Figure 1. USACE division boundaries in the continental US are aligned with major river basins. (Divisions shown in colors with three-letter designations, with USGS HUC-2 boundaries defined by blue lines.

Following the events of Hurricane Katrina in 2005, the USACE undertook an analysis of the performance of the Southeast Louisiana Hurricane Protection System plus other information internal and external to the USACE. In response to the lessons learned, USACE renewed its efforts to implement a comprehensive systems approach in a manner that that shifts the decision-making focus from individual, isolated projects to an interdependent system and from local or immediate solutions to regional or long-term solutions (USACE 2009[3]). This approach incorporates anticipatory and adaptive management to effectively manage our aging infrastructure in an environmentally sustainable manner with explicit risk management.

The comprehensive systems approach of the USACE to meet 21st century challenges is based in part on the National Research Council (2004) definition of a systems approach: "… the essential function of a systems approach is to provide an organized framework that supports a balanced

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[3] See http://www.usace.army.mil/CECW/Pages/ipet.aspx

evaluation of all relevant issues (e.g., hydrologic, geomorphic, ecologic, social, economic) at appropriate scales of space and time.[4]" For the UASCE, this comprehensive approach entails the evaluation of projects and systems on larger geographic scales with a multi-objective perspective. USACE also re-emphasized the need to build multidisciplinary teams with other federal agencies, state and local partners, and the public to identify challenges and develop solutions that meet the widest spectrum of needs.

3.3.2. *Decisions and Decision Scales*

Water resources management agencies decision making occurs at varying spatial scales from local to national, including international river basins, and on temporal scales varying from sub-hourly to multi-decadal. Because water managers are largely concerned with resource management within surface and groundwater hydrologic boundaries, decision scales range from local to watershed to regional and can cross political, legal, and regulatory boundaries. Decision scales can vary from very general (e.g., feasibility study) to very detailed (e.g., engineering design or reoperations). The decision scale may be a function of the consequences of the decision. Decisions are subject to constraints including quality, budget, knowledge, staffing, and schedule,

Decisions about how to enhance the resilience of water resources management infrastructure requires reliable information about the variability and uncertainty of probable global change effects at the decision scale. A large portfolio of possible approaches to produce and apply global change information for water resource issues has been developed, often addressing each change component in isolation. Each of these introduces uncertainties or deficiencies, some of which are large or only partly characterized and poorly quantified. The choice of pathways among the portfolio of options depends on the decision scale.

This is particularly true with respect to climate change. For example, the spatial and temporal scales available from most climate model projections may be too coarse to be usefully mapped to the scales of climate change adaptation decisions. There is a lack of guidance on how to determine the appropriate level of complexity in the analysis of climate information with regard to a particular decision and its likely consequences. For these

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[4] See http://books.nap.edu/openbook.php?record_id=10970&page=19

reasons, USACE is working with other Federal agencies charged with water resource planning and operating missions to address whether and how to develop guidelines and principles for producing climate change information they will use to support their variously scaled decisions on adaptation measures.

Water managers are also constantly adjusting to changing needs arising from shifts in population, development, land cover, industry, ecosystems, and social values, among other changes. The cross-jurisdictional and multi-scale nature of water resources management, combined with the wide variety of water users and their differing requirements, has resulted in management frameworks designed to respond to changing needs and balance competing needs (Olsen et al 2010a). These frameworks improve the capacity of water managers to absorb additional disturbances without unduly impacting their basic functions.

3.3.3. *Global and National Assessments*

Water managers typically rely on information observed at global to local scales. Global and national scale information provides a context for long-term climate, geomorphological, and socio-economic changes impacting water supply and demand. Global assessments of change available to guide water resources management decision-making include large multi-national studies such as the Millennium Ecosystem Assessment[5] (MA 2005a, b), and the Intergovernmental Panel on Climate Change[6]. National climate change assessments for the US have been prepared by the Climate Change Science Program, now the US Global Change Research Program[7]. These assessments include regional and sectoral assessments (agriculture, water, health, forests, and coastal areas and marine resources) as well as synthesis documents.

Other US national assessments target specific areas of interest to water resources management, such as the US Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program[8] or the Natural Resources

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[5] See http://www.millenniumassessment.org/en/Index.aspx. Reports available at http://www.millenniumassessment.org/en/Reports.aspx.

[6] See http://www.ipcc.ch/

[7] See http://www.usgcrp.gov/usgcrp/default.php

[8] See http://water.usgs.gov/nawqa/

Conservation Service (NRCS) Conservation Effects Assessment Project (CEAP)[9]. The importance of changes in land use and land cover in water resources management is addressed by several national assessments. A major assessment undertaken as a collaborative activity is the Multi-Resolution Land Characteristics Consortium (MRLC)[10], consisting of representatives of Federal agencies: USGS, NRCS, Environmental Protection Agency (EPA), National Oceanic and Atmospheric Administration (NOAA), U.S. Forest Service (USFS), National Atmospheric and Space Administration (NASA) , Bureau of Land Management (BLM), National Park Service (NPS), U.S. Fish and Wildlife Service (USFWS), and the Office of Surface Mining (OSM). MLRC provides four different land cover databases, including land cover, coastal change analyses, a dataset of habitat maps combined with wildlife models, and vegetation and wildland fuel maps. Example agency programs include the USGS Land Cover Institute[11] and the NASA Land-Cover and Land-Use Change (LCLUC) Program[12].

3.3.4. *Understanding Regional and Local Responses*

The Millennium Ecosystem Assessment (2005a) demonstrated how changes in direct and indirect drivers at the global level can result in impacts to ecosystem, ecosystem services, and human well-being at the local and regional scale. But local and regional changes can also result in global impacts (Figure 2). The cross-scale interactions that occur at varying speeds and spatial scales are increasingly coupled (Holling et al 2001) and more complex. Though we may develop solutions for local problems at local scales, we must also explore the potential impacts of these solutions at larger scales of space and time. The complexity of global changes means that we can no longer apply piece-meal or sequential problem-solving, but must use methods suited to “wicked problems” (e.g., Rittel and Webber 1973, Freeman 2000, Camillus 2008, Mills 2008) that are “systemic, emergent, and participatory” (Kahane 2007). The increased success of participatory problem-solving for complex systems is a foundation of the USACE collaborative approach.

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[9] See http://www.nrcs.usda.gov/technical/nri/ceap/index.html
[10] See http://www.epa.gov/mrlc/
[11] See http://landcover.usgs.gov/
[12] See http://lcluc.umd.edu/

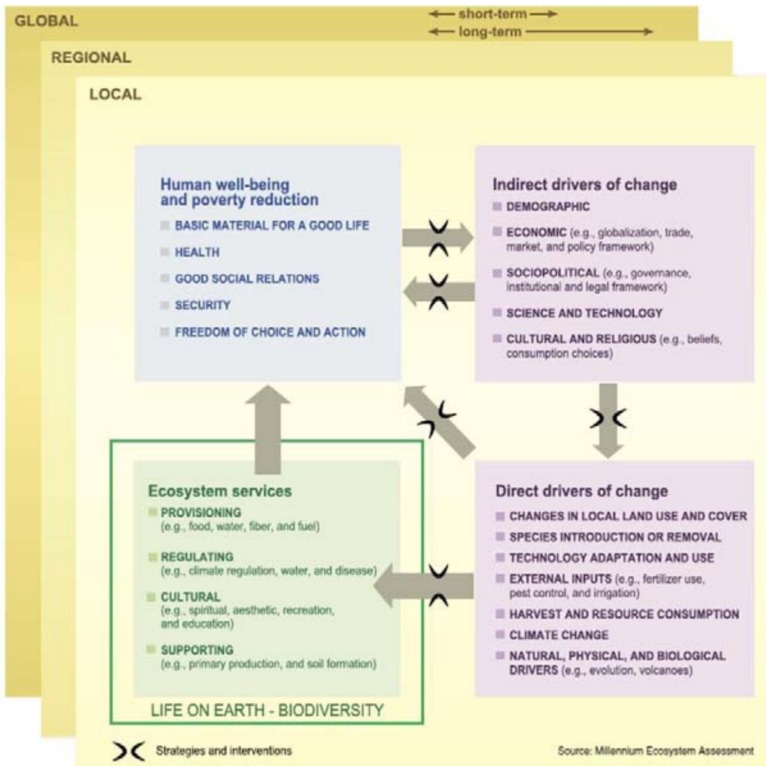

Figure 2. Drivers of change (indirect, top right) and direct (bottom right) can result in changes to ecosystems and their services (bottom left) and human well-being (top left). The interactions between the drivers and resultant changes can occur at more than one scale and can cross scales (from MA 2005a).

4. Collaboration is Key

Water resources managers in the US are facing increased challenges due to climate change because it affects fundamental drivers of the hydrological cycle. Changes to important components of the hydrologic cycle, including precipitation, evaporation, condensation, and wind, can have profound impacts to the way we manage water resources now and in the future. Four examples of collaboration are presented below.

4.1. WATER MANAGEMENT COLLABORATION: A SOURCE OF RESILIENCE

Water resources management agencies have a special incentive to collaborate on water data, science, engineering and operations: strong collaboration around water quantity and quality can result in a more secure and stable environment (Wolf et al 2003), whereas loose collaboration or competition over water can result in conflict and instability (Ravenborg 2004). This collaboration is especially important given historical evidence that water and water resources management systems have been used as both offensive and defensive weapons in conflicts throughout the world (Gleick 1993, 2008).

However, increased conflict over water due to 21st century challenges is not inevitable. The same skills used to handle 20th century challenges of changing land use, demographics, and climate provide a reservoir of institutional knowledge and experience that can help to de-escalate conflict (White et al 2010, Nordas and Gleditsch 2007, Hendrix and Glaser 2007). Water resources managers are uniquely positioned to develop and implement adaptively managed solutions to achieve positive outcomes (Delli Priscoli and Wolf 2009) through managing risks proactively rather reacting to prevailing crises and conflicts as climate changes. The UASCE has actively engaged its fellow water resources management agencies in facing the challenges of the 21st century. Four examples are provided here that demonstrate our commitment to collaboration.

4.2. BUILDING STRONG COLLABORATIVE RELATIONSHIPS

The goal of the "Building Strong Collaborative Relationships for a Sustainable Water Resources Future Initiative," begun in 2008, is to identify and leverage opportunities for collaborative efforts and to create a joint national dialogue for water priorities between states, tribes and the Federal resource agencies[13]. The initiative began by collecting and analyzing state water plans. They also brought together a variety of stakeholders to discuss critical water resources needs and

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[13] See http://www.building-collaboration-for-water.org/

potential response strategies. This initiative allows USACE to develop a comprehensive picture of water resources planning throughout the United States that identifies:

- Areas of water resource planning and management where States and regional entities feel their priority water needs are not being met;
- Regions or sectors where more integrated or comprehensive water resources planning and management within and across states is possible and advantageous;
- Topics for which the Federal government might provide enhanced support to States and regions, especially for more integrated water resources planning and management; and
- Opportunities for partnerships among States, regional entities, Federal agencies, and NGOs to more effectively address comprehensive and integrated state-wide and regional water resource and planning needs.

Three regional workshops were held in 2009, culminating in a national workshop in Washington DC in August 2009. Workshop participants included state and local representatives, interstate river basin commissions, federal agencies, nongovernmental organizations, and others involved in water resources management. The desired outcome of the workshops is to develop the strong partnerships necessary to begin working together on smart water resources investments based on a collective determination of needs and challenges. The initiative will result in:

1) The development of more connected and complementary water management solutions across all levels of government;

2) Focused efforts on high-priority state and regional needs; and

3) Reduced duplication of effort across government agencies.

These collaborative relationships and networks are being put into practice immediately in a wide range of USACE activities, a few of which are described below. In all cases, the richness of the collaborations has improved the outcomes for both USACE and its collaborators.

4.3. WATER MANAGEMENT AGENCY COLLABORATION

In 2007, the four major Federal agencies in the United States that manage water resources and water resources data and information collaborated to review climate change impacts to water resources and to lay out a path forward for how these agencies and others could collaboratively deal with climate variability and change. These four agencies, two termed “operating agencies” (the USACE and the Bureau of Reclamation (Reclamation)) and two termed “science agencies” (the US Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA)) formed an unprecedented water management agency collaboration. The result of their work was a report published as USGS Circular 1331 “Climate Change and Water Resources Management: A Federal Perspective” in February 2009 (Brekke et al 2009)[14].

This collaborative effort provides a foundation on which consistent future agency policies, methods, and processes will be based. Although geared toward the US, the findings of this report are applicable to other nations as they address climate change impacts to water resources. The key findings of Brekke et al related to climate change impacts to water resources are summarized as follows:

1) The best available scientific evidence based on observations from long-term [hydrometeorological] monitoring networks indicates that climate change is occurring, although the effects differ regionally.

2) Climate change could affect all sectors of water resources management, since it may require changed design and operational assumptions about resource supplies, system

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

demands or performance requirements, and operational constraints. The assumption of temporal stationarity in hydroclimatic variables should be evaluated along with all other assumptions [emphasis added].

3) Climate change is but one of many challenges facing water resource managers. A holistic approach to water resources management includes all significant drivers of change.

4.4. CLIMATE CHANGE AND WATER WORKING GROUP

Given the pressing needs facing water resources managers due to already observed climate change impacts, the agencies involved in Circular 1331 decided a longer-term working relationship would improve collaboration. In 2008, they formed a group called the Climate Change and Water Working Group (CCAWWG) to work with the water management community to understand their needs with respect to climate change. Demonstrating alignment with the "Building Strong Collaborative Relationships for a Sustainable Water Resources Future Initiative," CCAWWG is actively fostering collaborative federal and non-federal scientific efforts required to address these needs in a way that capitalizes on interdisciplinary expertise, shares information, and avoids duplication.

In 2009, the operating agencies of CCAWWG developed a two-phase plan to identify research priorities and opportunities for collaborative work within an integrated water resources management agency and science agency framework. In the first phase, they prepared an assessment of required capabilities, current capabilities, and gaps associated with incorporating climate change information into longer-term water resources planning. The draft report, *Addressing Climate Change in Long-Term Water Resources Planning and Management: User Needs for Improving Tools and Information*, is now in review, with joint USACE-Reclamation publication expected in summer 2010 (Brekke et al in prep). The science agencies will develop a corresponding report containing a strategy for meeting these user needs.

USACE and Reclamation are currently preparing a CCAWWG draft report document *Use of Weather and Climate Forecasts in Federal*

Water Resources Management: Current Capabilities, Required Capabilities, and Gaps. This report is the second phase of the process, with the objective to identify capabilities and gaps as they relate to water management decisions with lookaheads of days to multiple years. The intended audience is Federal and non federal partners and stakeholders that play a role in the daily delivery and multi-year scheduling of water in the United States.

In January 2010, USACE hosted an expert workshop on *Nonstationarity , Hydrologic Frequency Analysis, and Water Management* in Boulder, CO (Olsen et al 2010b). This CCAWWG workshop was planned to address critical needs identified in USGS Circular 1331 about how and when to perform nonstationary hydrological analyses. Attendees were national and international experts on climate change hydrology[15]. Discussions during the workshop addressed whether assumptions of stationarity are valid, use of different statistical models in nonstationarity conditions, trend analyses, how to use the output from global climate models (GCM), and how to treat uncertainty in planning, design, and operations. This workshop will result in a special issue of the Journal of the American Water Resources Association.

In 2010, CCAWWG added additional agency partners: Federal Emergency Management Agency (FEMA), Environmental Protection Agency (EPA), Federal Highway Administration (FHWA) and Fish and Wildlife Service (FSW). The group is in the midst of planning a second workshop for late 2010, *Assessing a Portfolio of Approaches for Producing Climate Change Information to Support Adaptation Decisions*. This workshop will help characterize the strengths, limitations, variability, and uncertainties of approaches for using climate change information to inform water resources adaptation planning and operations. This is undertaken in response to the need to develop a set of common tools for use in climate adaptation. Again, this workshop will result in a special journal issue as well as other reports.

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[15] See http://www.cwi.colostate.edu/NonstationarityWorkshop/proceedings.shtml

4.5. PARTICIPATION ON NATIONAL WORKING GROUPS

The President's Council on Environmental Quality (CEQ) convened five interagency working groups in September 2009 to assist them in developing a national strategy for climate change adaptation required under Section 16 of Executive Order 13514[16]. The five working groups were: Adaptation Science Inputs for Policy, Water Resources, Agency Adaptation Processes, Insurance, and International Resilience Efforts. USACE has actively participated in these interagency workgroups, representing the missions and needs of water resources managers.

The CEQ (2010) proposed a flexible Adaptation Process Framework to help agencies identify climate-based vulnerabilities, reduce those vulnerabilities through adaptive actions, and build greater resilience to climate change throughout agency missions and operations. The proposed framework[17] has three components: 1) a set of principles to guide agency adaptation and resilience activities, 2) a six-step approach to climate change adaptation and resilience (Figure 1), and 3) a proposed set of government-wide enabling investments to support the effective implementation of the framework.

USACE is among four agencies currently testing the flexible adaptation framework. Pilot agencies will evaluate the implementation and utility of the flexible framework and to document the outcomes and results of the pilot projects used to test the framework. The USACE is also participating in interagency teams developing a strategy for government-wide investments in basic common tools and processes to support climate change adaptation. The common tools will encompass processes, methods, and technologies that support climate adaptation. The outcome of the various CEQ working groups will be to develop a National Adaptation Strategy. Thus, USACE's collaborative approach to the pilot process should help to achieve a process that assists water resources managers as they develop strategies to meet future climate changes..

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[16] Executive Order 13514, Federal Leadership in Environmental, Energy and Economic Performance, http://www.fedcenter.gov/programs/eo13514/

[17] See http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation

5. Summary

The global challenges facing water resources managers in the 21st century are immense. At the same time, resources are constrained. Water resources managers must work together to meet these challenges in a way that in a way that capitalizes on interdisciplinary expertise, shares information, and avoids duplication. USACE has evolved over time to meet water resources challenges posed by global changes. In doing so, we have embarked on a series of collaborative initiatives, with a wide variety of partners and stakeholders, to develop 21st century solutions to 21st century challenges. Examples of this collaboration include our *Building Strong Collaborative Relationships for a Sustainable Water Resources Future* initiative to achieve regionally tailored water management adaptation strategies; the interagency report USGS Circular 1331 Climate *Change and Water Resources Management: A Federal Perspective*; the Climate Change and Water Working Group; and participation on national working groups with other agencies and the Council on Environmental Quality to develop and test methods and policies supporting the national climate change adaptation strategy.

We are putting into action our commitment to meet the global challenges of the 21st century through meaningful collaboration.

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