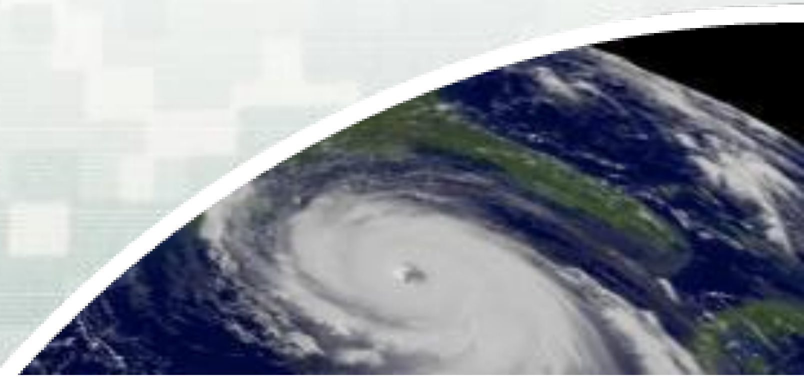
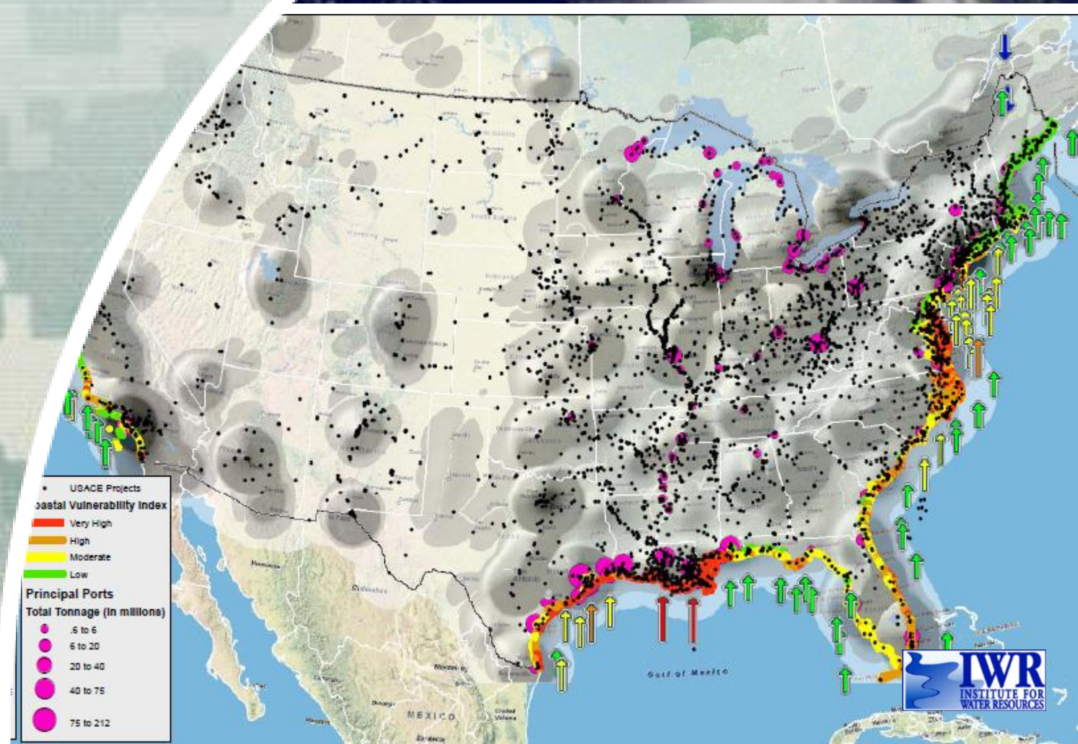
Climate Change Activities within the United States Army Corps of Engineers





Christopher Dunn, Director, P.E., D.WRE
Hydrologic Engineering Center, CEIWR-HEC
7 December 2011

2011 International Conference on Climate Change
Taipei, Taiwan

US Army Corps of Engineers
BUILDING STRONG®

Objectives

1. Climate Change Impacts
   - Mitigation
   - Adaptation
   - What is climate science saying
2. EO 13514 – CEQ Implementing Instructions
3. How has the Corps answered?
   - CC Adaptation Plan and Report
     - Pilot Studies
     - Vulnerability Assessments
     - CC Adaptation Steering Committee
   - CC Adaptation Task Force
     - National Action Plan
   - CC and Water Working Group

SPECIAL REPORT GLOBAL WARMING
TIME
BE WORRIED. BE VERY WORRIED.
Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well
EARTH AT THE TIPPING POINT
The Economist
The Blair leadership crisis
The new boss at Ford
An honest in-flight announcement
Catastrophe looms in Darfur
Fancy a Swedish model?
The heat is on
A special report on climate change
SCIENTIFIC AMERICAN
Why Does Time Only Move Forward?
Therapies That Beat BREAST CANCER
Ethics and Economics of Climate Change
Balancing Current Costs against Future Well-Being
Meteor Mystery
What Really Happened 100 Years Ago in Siberia
Trust Hormone
Science
The New York Times Magazine
The Perfect Drought
Science
POLAR SCIENCE
The Atlantic
HOT PROSPECTS
WHO LOSES—AND WHO WINS—IN A WARMING WORLD
by GREGG EASTERBROOK
COMING SOON
GREENHOUSE ACRES
Sports Illustrated
SPORTS AND GLOBAL WARMING
As the Planet Changes, So Do the Games We Play
Time to Pay Attention
PLUS
AGGIES ON A RUN
BARRY ZITO MEETS BARRY BONDS
THE HEART OF WRESTLING
BILL WALSH'S WORLD
BioScience
Audubon
SINK or SWIM on the ARCTIC

Climate change mitigation is about CARBON

Mitigation is to avoid the unmanageable conditions that come with atmospheric warming exacerbated by continued or even increasing greenhouse gases


Climate change adaptation
is about WATER
Adaptation is to manage the unavoidable changes that are already occurring as a result of past emissions and will continue into the future

Global Water Stressors

- Supply vs Demand
  - Population growth & urbanization
  - Land use change
  - Economics, governance, & finance
  - Climate change
- Climate change uniquely affects water supply & hydrologic cycle
  - Quantity and quality
  - Timing of precipitation and flow

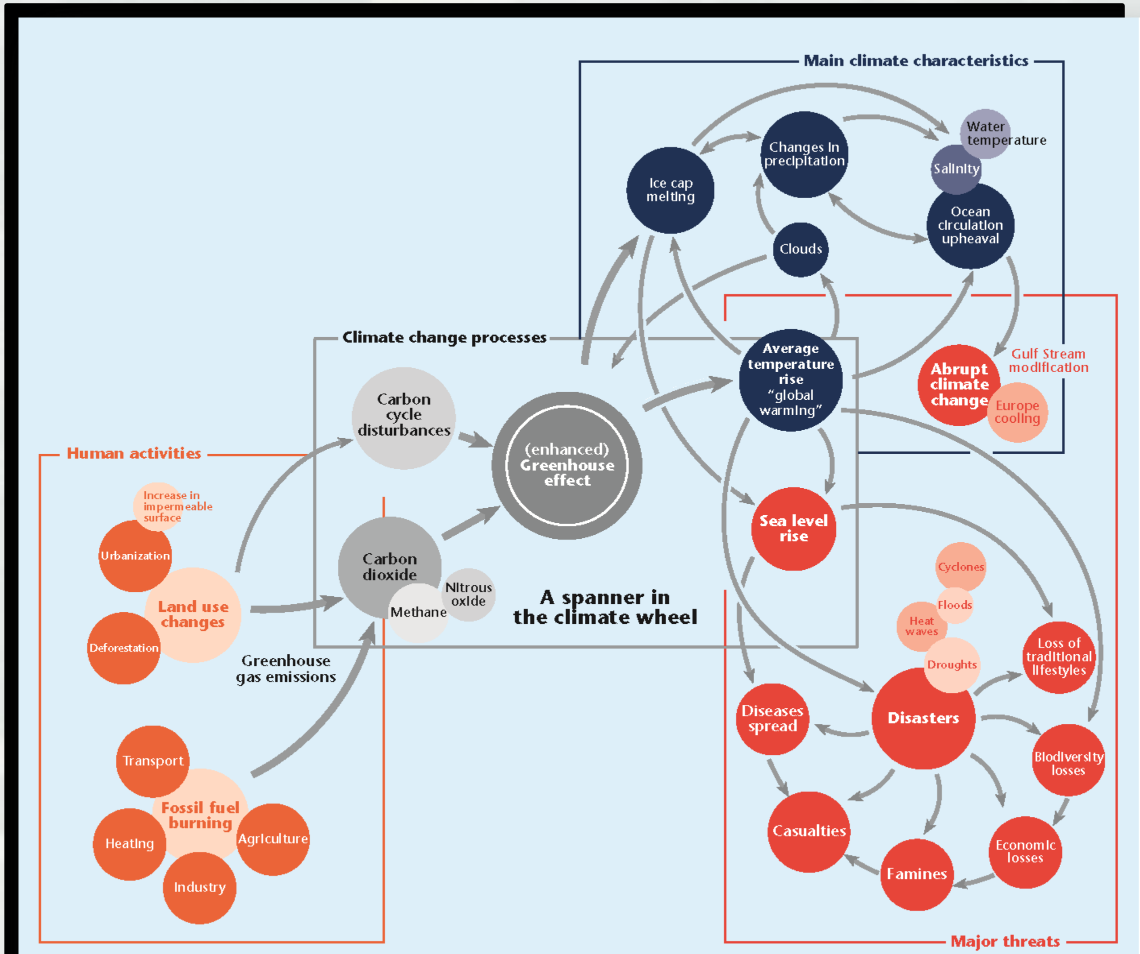
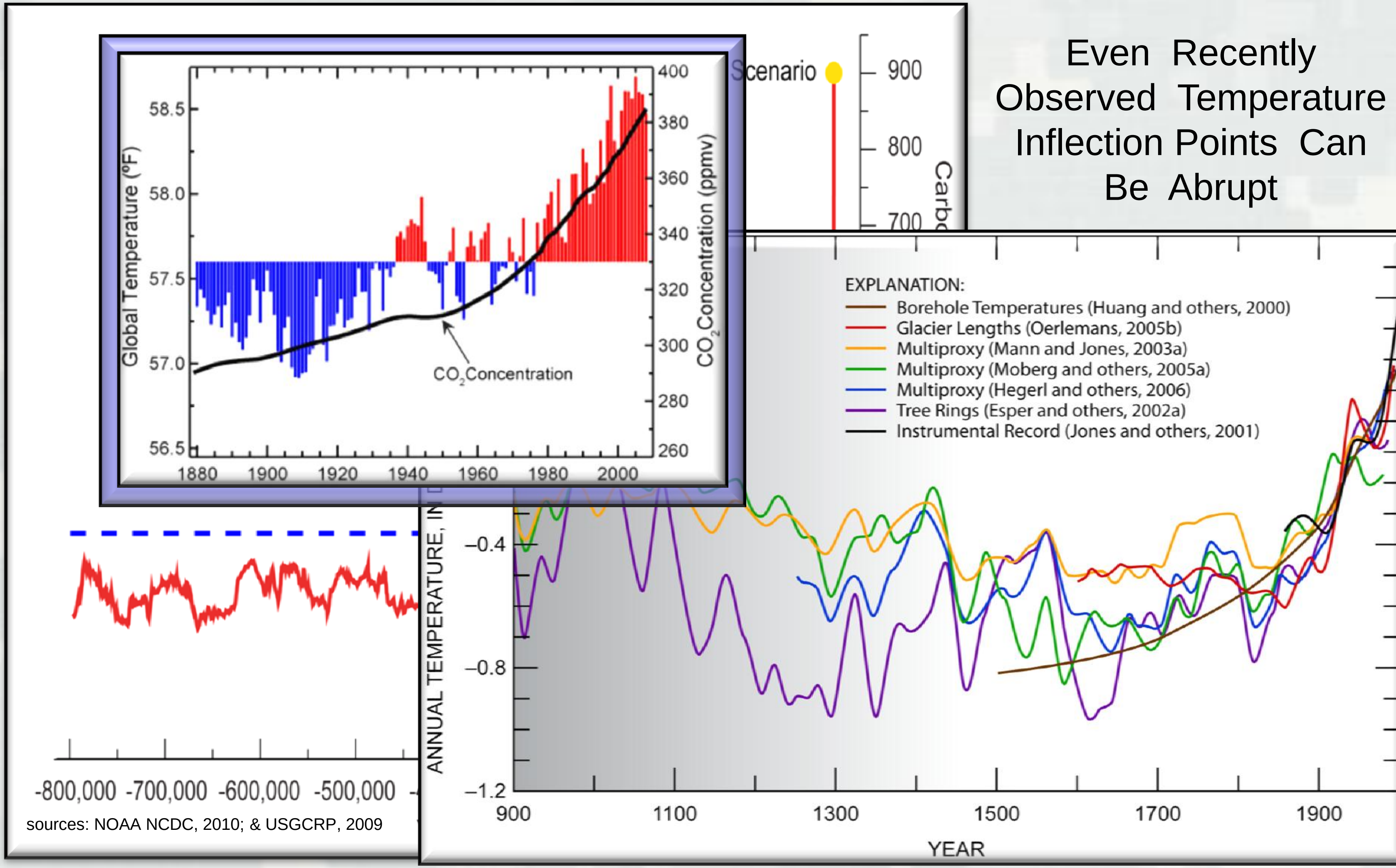


figure from UN World Water Development Report 3, 2009.

What is Climate Science Saying

Moved Outside Range of Observed Variation

Even Recently Observed Temperature Inflection Points Can Be Abrupt

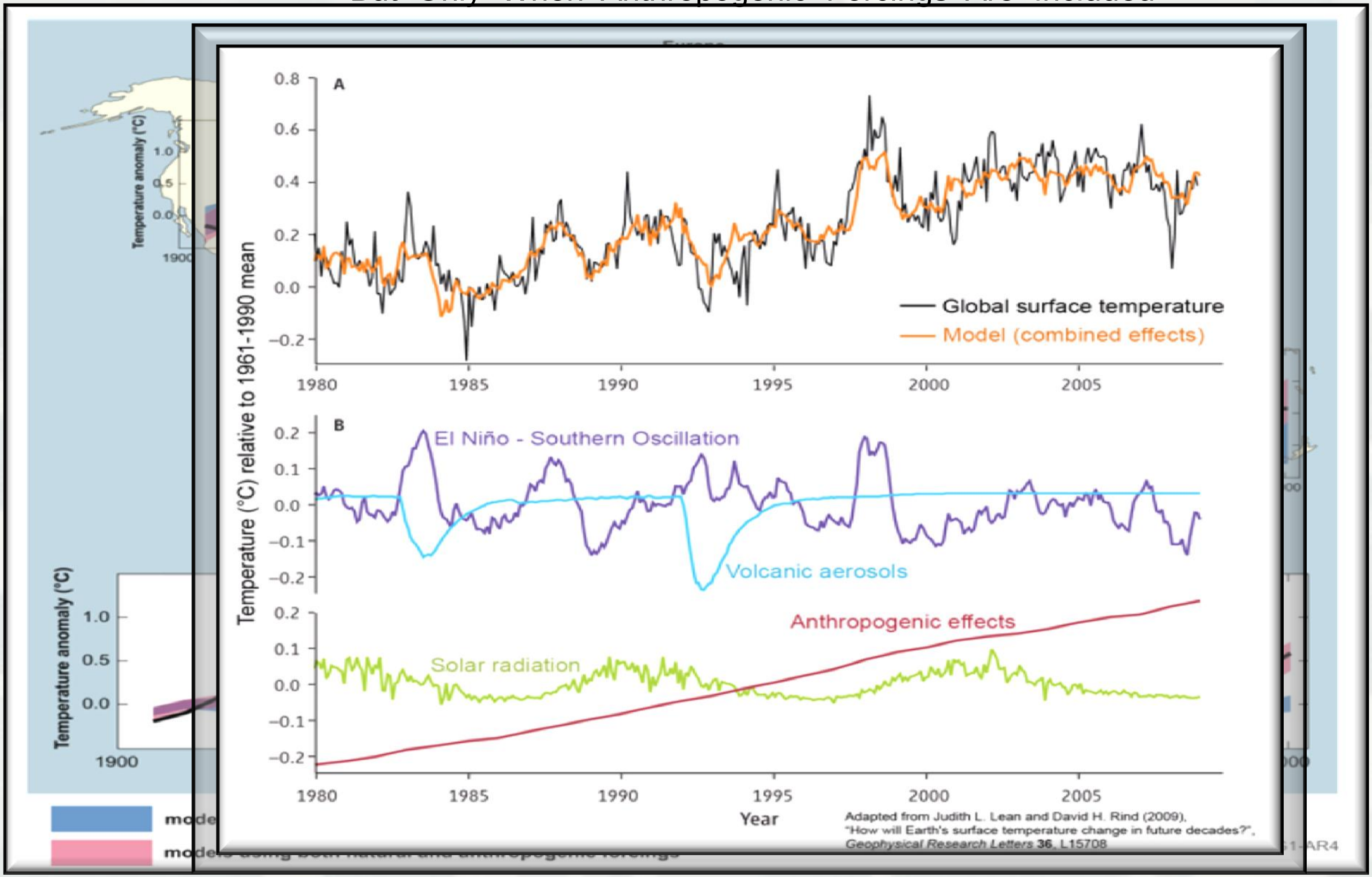


sources: NOAA NCDC, 2010; & USGCRP, 2009

Observed Temperature Changes Differ Regionally

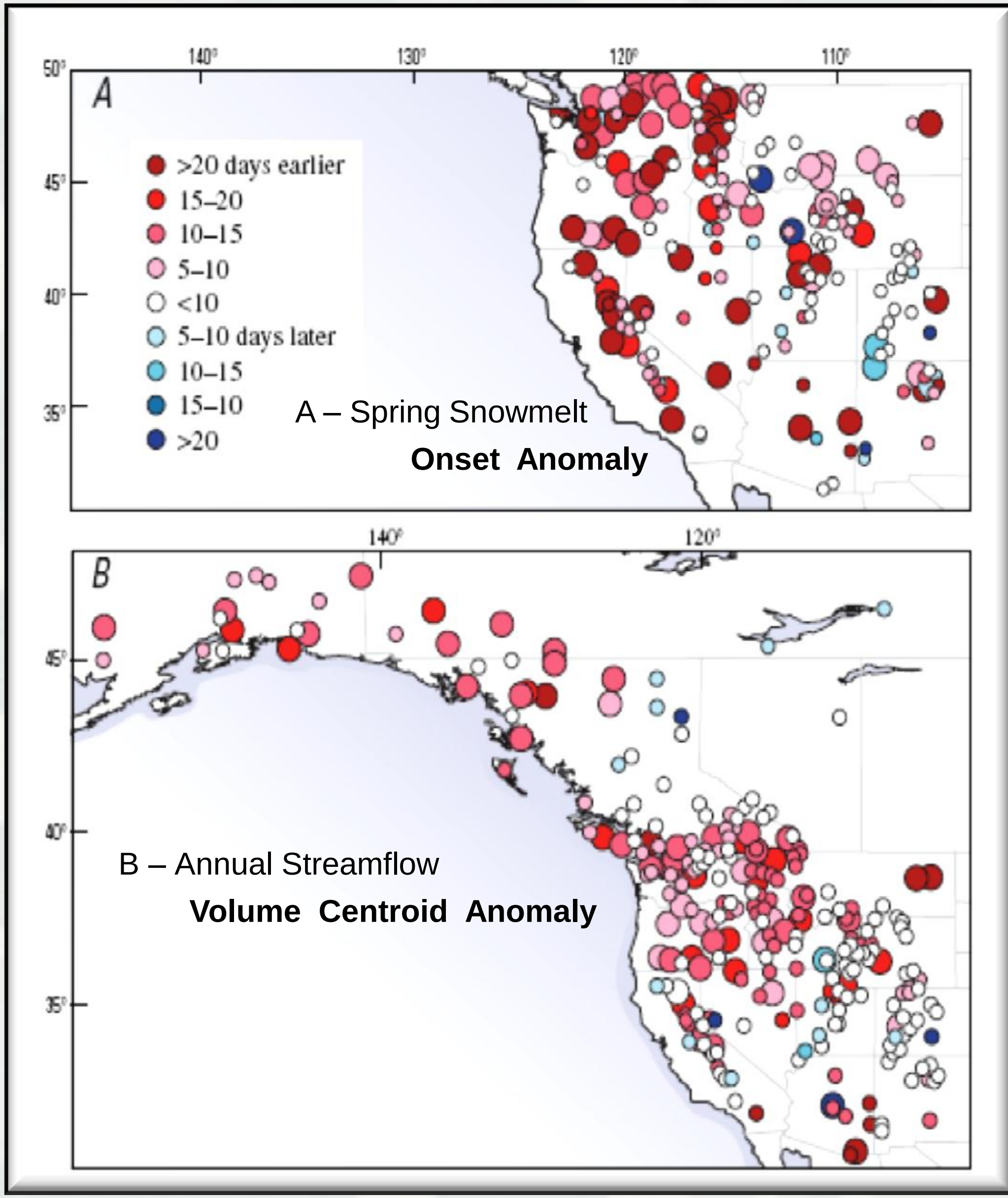
Numerical Models Track Changes & Differences on Land & Water

But Only When Anthropogenic Forcings Are Included



Adapted from Judith L. Lean and David H. Rind (2009), "How will Earth's surface temperature change in future decades?", *Geophysical Research Letters* **36**, L15708

Observed Hydrologic Changes Differ Regionally

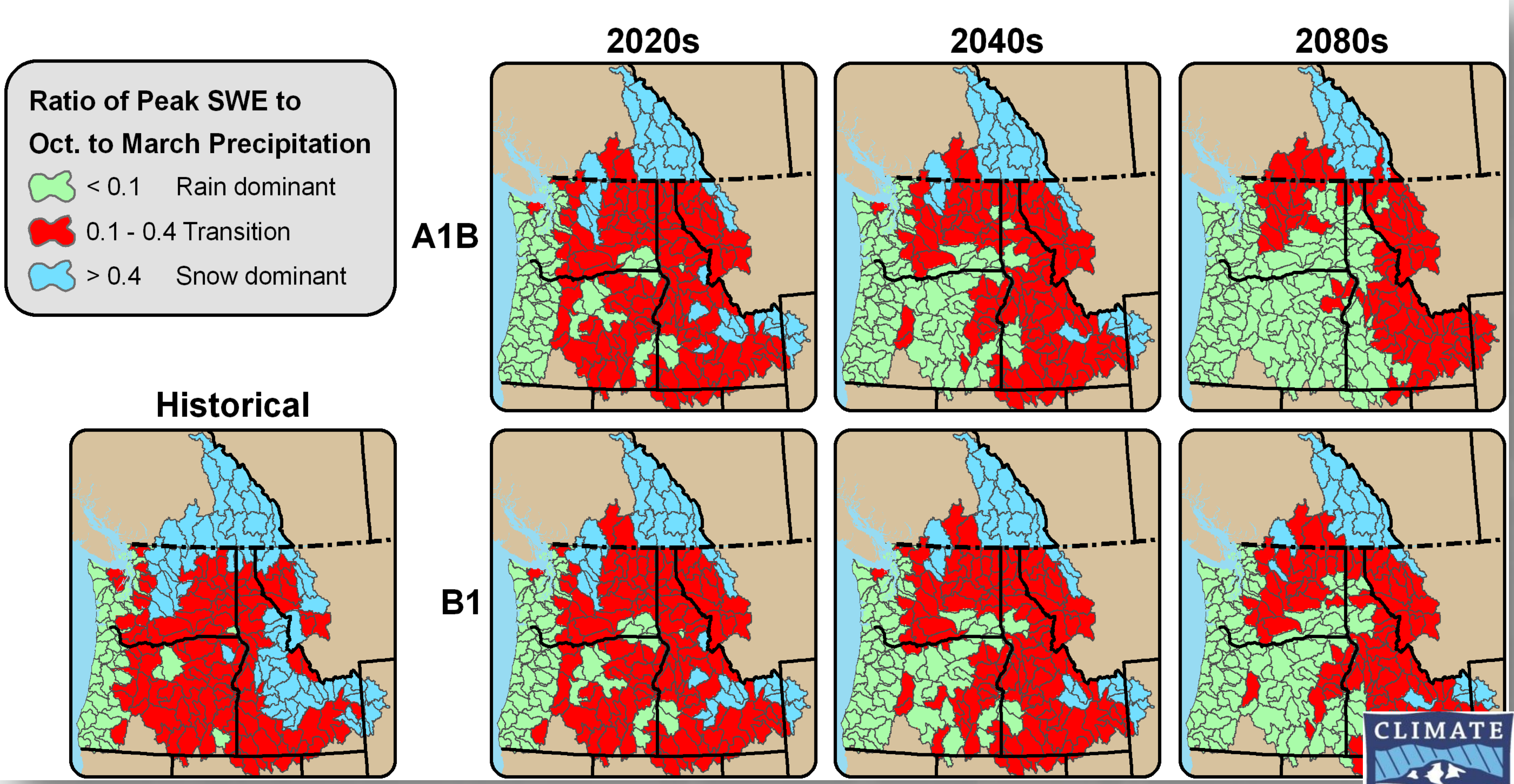


Large circles at sites with significantly non-zero effects at ninety percent CI. Small circles at sites with effects not confidently identified.

adapted from Stewart et.al, 2004 &
Dettinger et al., 2005

Watershed Classes Will Continue to Change

Example: Snow to Rain Dominated HUCs in PacNW



* Based on Composite Delta Method scenarios (multi-model average change in T & P)

figure adapted from A. Hamlet & R. Norheim, U Washington

BUILDING

CLIMATE IMPACTS GROUP

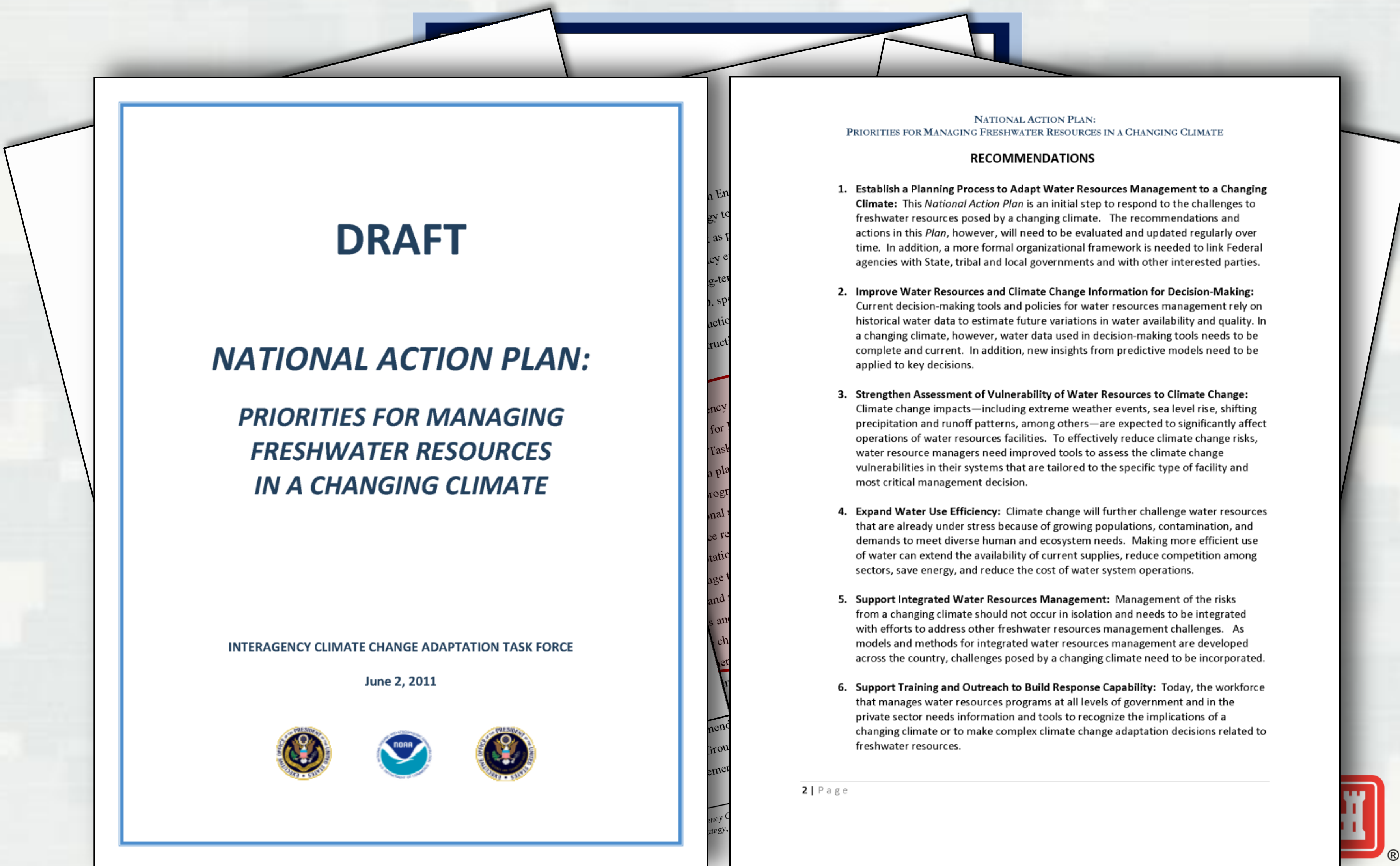
What are the Federal Action Drivers?

1. Internal and external reviews following Hurricane Katrina – IPET-HPDC Report (2006)

2. Executive Order 13514 (October, 2009) Federal Leadership in Environmental, Energy, and Economic Performance

Executive Order 13514

Defined Work for the Federal Inter-Agency Climate Change Adaptation Task Force



DRAFT

NATIONAL ACTION PLAN:

PRIORITIES FOR MANAGING FRESHWATER RESOURCES IN A CHANGING CLIMATE

INTERAGENCY CLIMATE CHANGE ADAPTATION TASK FORCE

June 2, 2011

NATIONAL ACTION PLAN:
PRIORITIES FOR MANAGING FRESHWATER RESOURCES IN A CHANGING CLIMATE

RECOMMENDATIONS

1. **Establish a Planning Process to Adapt Water Resources Management to a Changing Climate:** This *National Action Plan* is an initial step to respond to the challenges to freshwater resources posed by a changing climate. The recommendations and actions in this *Plan*, however, will need to be evaluated and updated regularly over time. In addition, a more formal organizational framework is needed to link Federal agencies with State, tribal and local governments and with other interested parties.

2. **Improve Water Resources and Climate Change Information for Decision-Making:** Current decision-making tools and policies for water resources management rely on historical water data to estimate future variations in water availability and quality. In a changing climate, however, water data used in decision-making tools needs to be complete and current. In addition, new insights from predictive models need to be applied to key decisions.

3. **Strengthen Assessment of Vulnerability of Water Resources to Climate Change:** Climate change impacts—including extreme weather events, sea level rise, shifting precipitation and runoff patterns, among others—are expected to significantly affect operations of water resources facilities. To effectively reduce climate change risks, water resource managers need improved tools to assess the climate change vulnerabilities in their systems that are tailored to the specific type of facility and most critical management decision.

4. **Expand Water Use Efficiency:** Climate change will further challenge water resources that are already under stress because of growing populations, contamination, and demands to meet diverse human and ecosystem needs. Making more efficient use of water can extend the availability of current supplies, reduce competition among sectors, save energy, and reduce the cost of water system operations.

5. **Support Integrated Water Resources Management:** Management of the risks from a changing climate should not occur in isolation and needs to be integrated with efforts to address other freshwater resources management challenges. As models and methods for integrated water resources management are developed across the country, challenges posed by a changing climate need to be incorporated.

6. **Support Training and Outreach to Build Response Capability:** Today, the workforce that manages water resources programs at all levels of government and in the private sector needs information and tools to recognize the implications of a changing climate or to make complex climate change adaptation decisions related to freshwater resources.

2 | Page

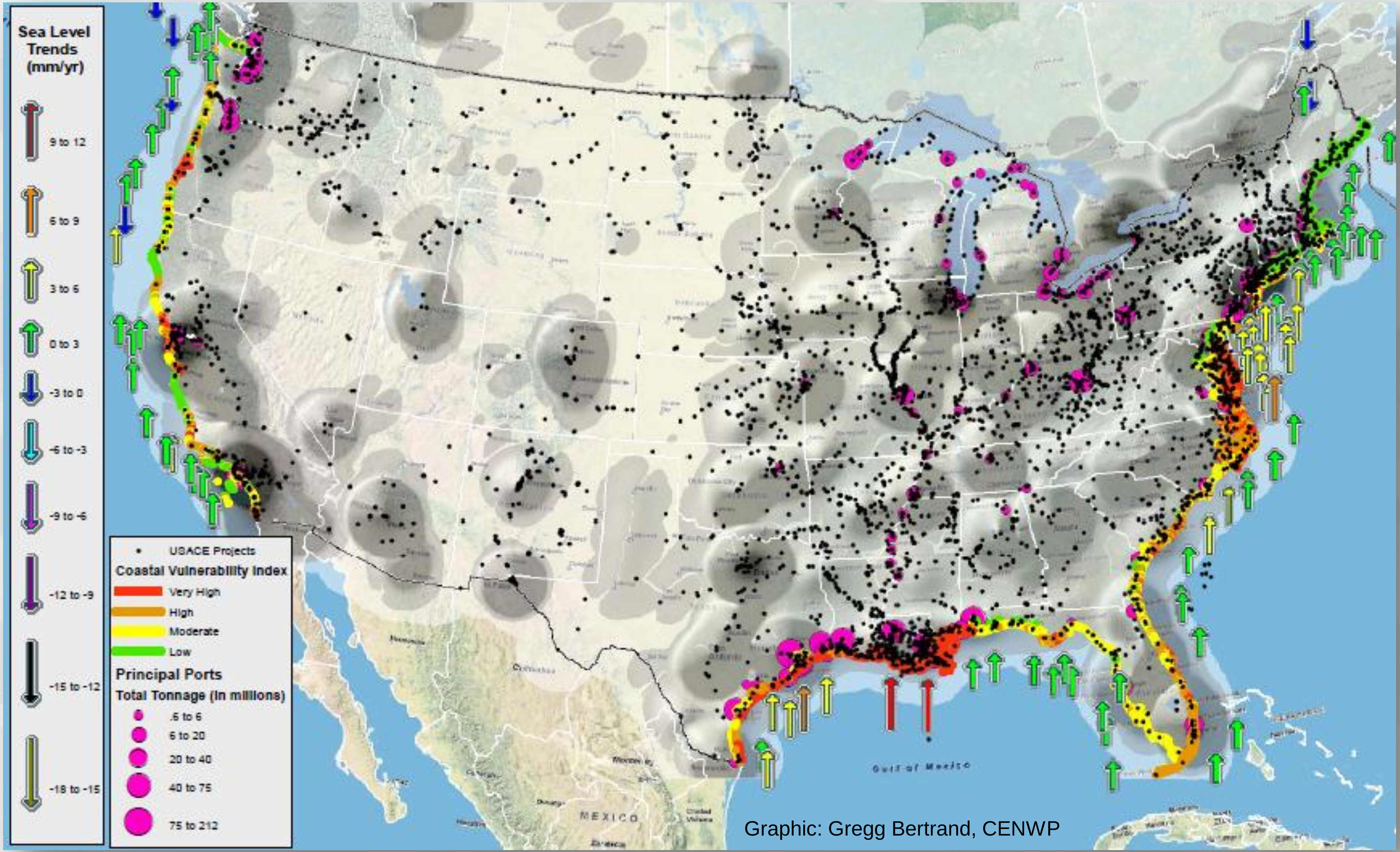
http://whitehouse.gov/adminsitration/eop/ceq/sustainability


Climate Change and Water Resources Management: A Federal Perspective
Circular 1331
Workshop on Nonstationarity, Hydrologic Frequency Analysis, and Water Management
January 13-15, 2010
Boulder, Colorado
Colorado Water Institute Information Series No. 109
USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011
Addressing Climate Change in Long-Term Water Resources Planning and Management
User Needs for Improving Tools and Information
What do we know?
What don't we know?
What can we do?

Guidance

Sea Level is Changing

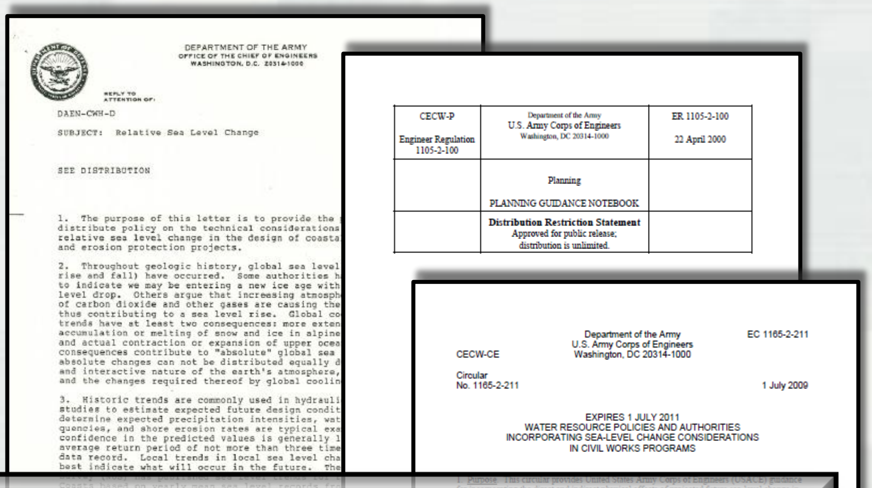
Observed sea-level trends (NOAA), Coastal Vulnerability Index (USGS), USACE Projects, and Port Tonnage on map of Population Density (Census)

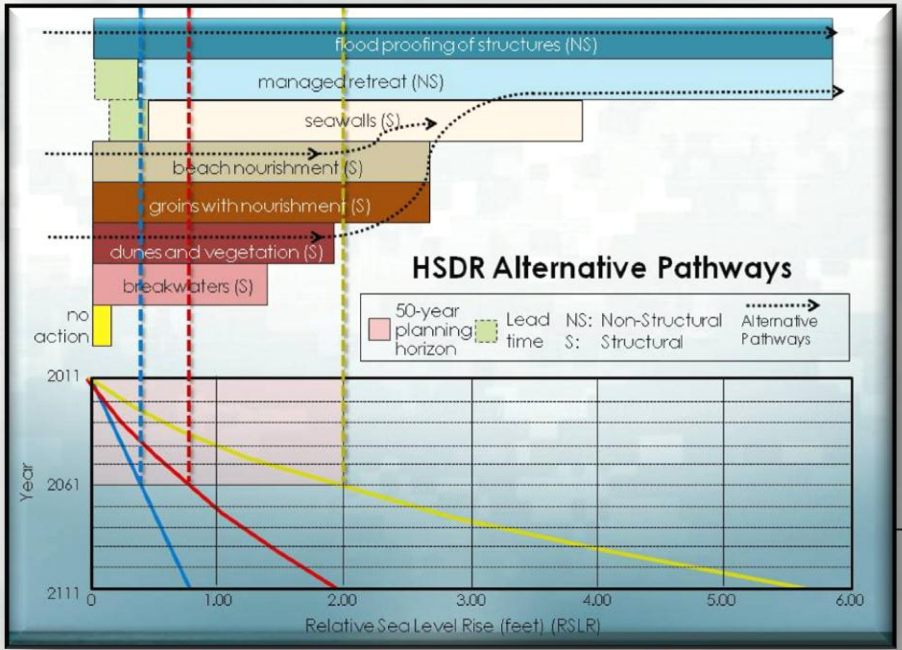


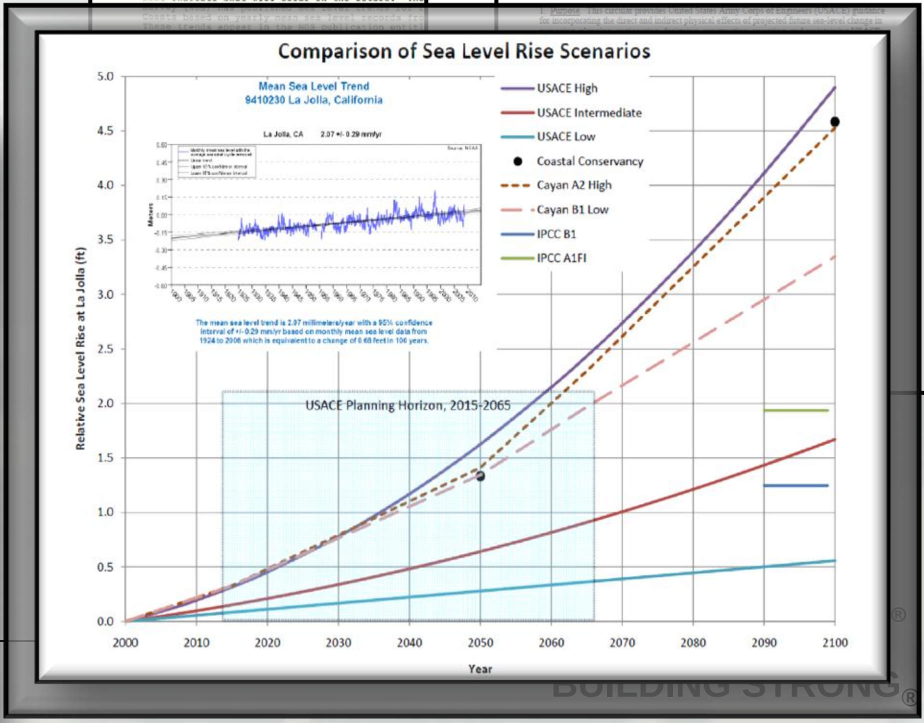
Graphic: Gregg Bertrand, CENWP

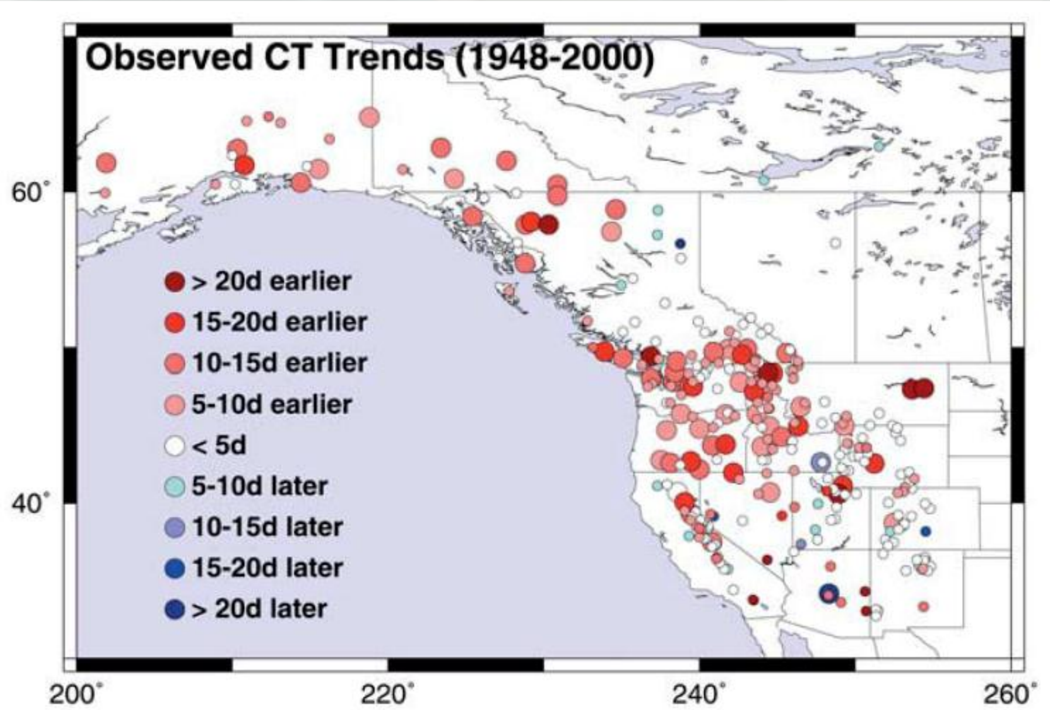
Actionable Science for Sea-Level Vulnerabilities

- 1986: characterize observed trends
- 2000: USACE planners consider potential for increased global sea-levels
- 2009: use three scenarios
- 2011: adds more recent science
- 2012: project-scale adaptation engineering begins







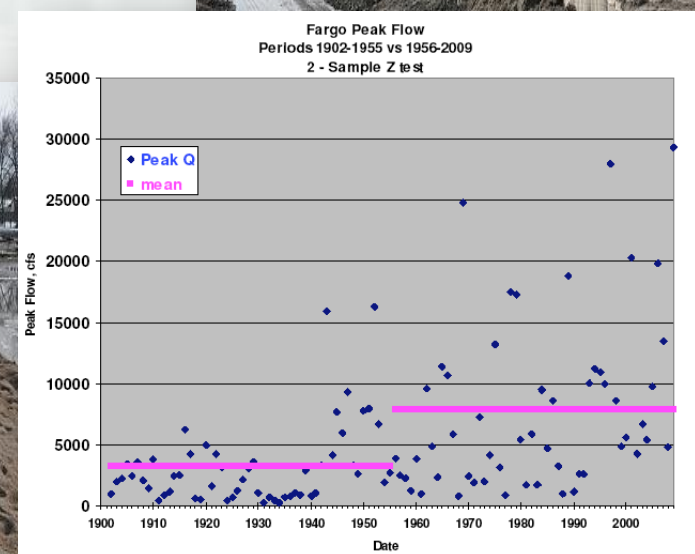


CT= Center of mass of annual flow
From Stewart et.al 2004

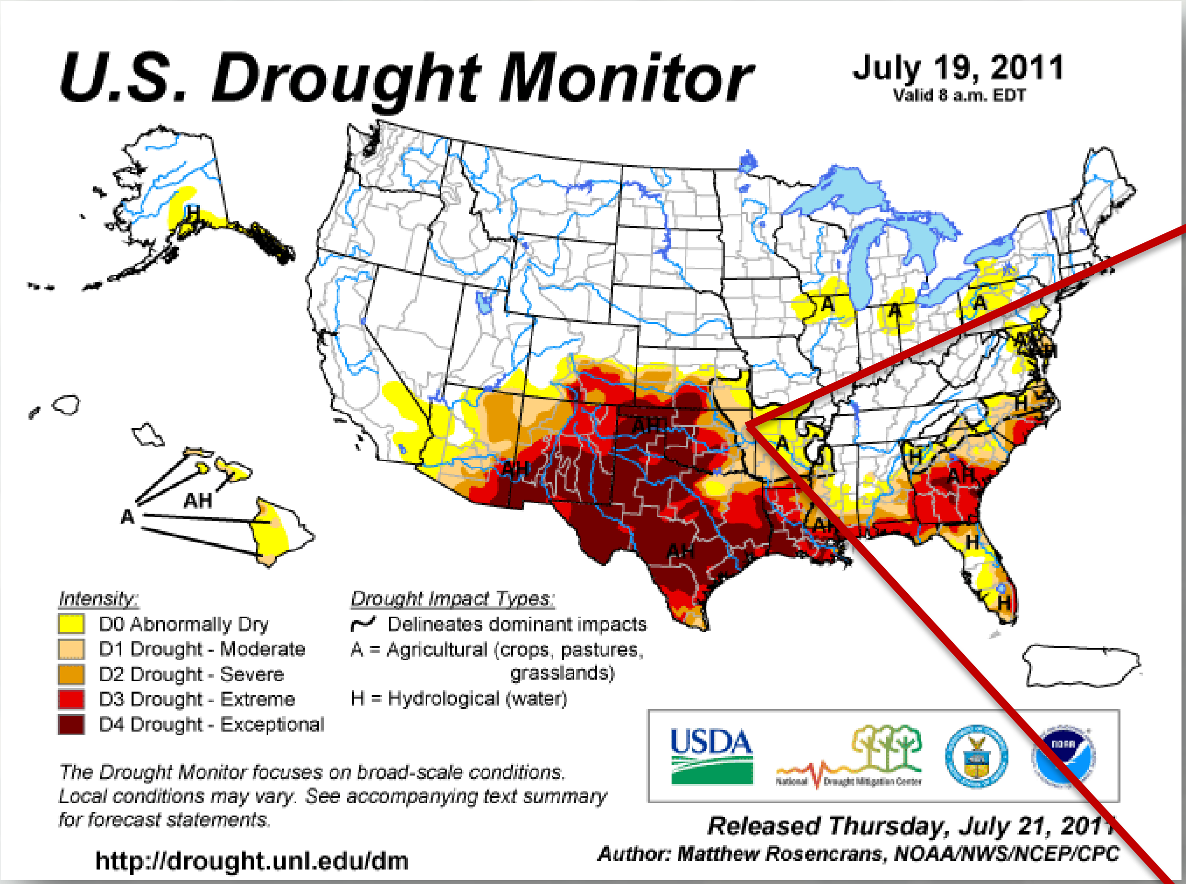
We have a reasonable science base for changes occurring in western snow-dominated watersheds

We have some science around snow-dominated watersheds in the Northern Plains

RRN 2009 flood



Drought doesn't protect us from floods ……



BUILDING STRONG®

POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks.

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage works, and land-cover and land-use change. Two other (sometimes indistinguishable) challenges to stationarity have been externally forced, natural climate changes and low-frequency, internal variability (e.g., the Atlantic multidecadal oscillation) enhanced by the slow dynamics of the oceans and ice sheets (*2*, *3*). Planners have tools to adjust their analyses for known human disturbances within river basins, and justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design.

[1]U.S. Geological Survey (USGS), c/o National Oceanic and Atmospheric Administration (NOAA) Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA. [2]USGS, Tucson, AZ 85745, USA. [3]Stockholm International Water Institute, SE 11151 Stockholm, Sweden. [4]USGS, Reston, VA 20192, USA. [5]Research Centre for Agriculture and Forest Environment, Polish Academy of Sciences, Poznań, Poland, and Potsdam Institute for Climate Impact Research, Potsdam, Germany. [6]University of Washington, Seattle, WA 98195, USA. [7]NOAA Geophysical Fluid Dynamics Laboratory, Princeton, NJ 08540, USA.

*Author for correspondence. E-mail: cmilly@usgs.gov.

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate.

How did stationarity die? Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (*4*, *5*) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and possibly flood risk, where prevailing atmospheric water-vapor fluxes converge (*6*). Rising sea level induces gradually heightened risk of contamination of coastal freshwater supplies. Glacial meltwater temporarily enhances water availability, but glacier and snow-pack losses diminish natural seasonal and interannual storage (*7*).

Anthropogenic climate warming appears to be driving a poleward expansion of the subtropical dry zone (*8*), thereby reducing runoff in some regions. Together, circulatory and thermodynamic responses largely explain the picture of regional gainers and losers of sustainable freshwater availability that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (*15*). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (*16*), although attempts to detect a recent change in global flood frequency have been equivocal (*17*, *18*). Projected changes in runoff during the multidecade lifetime of major water infrastructure projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (*19*). Some regions have little infrastructure to buffer the impacts of change.

Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system (*4*, *20*).

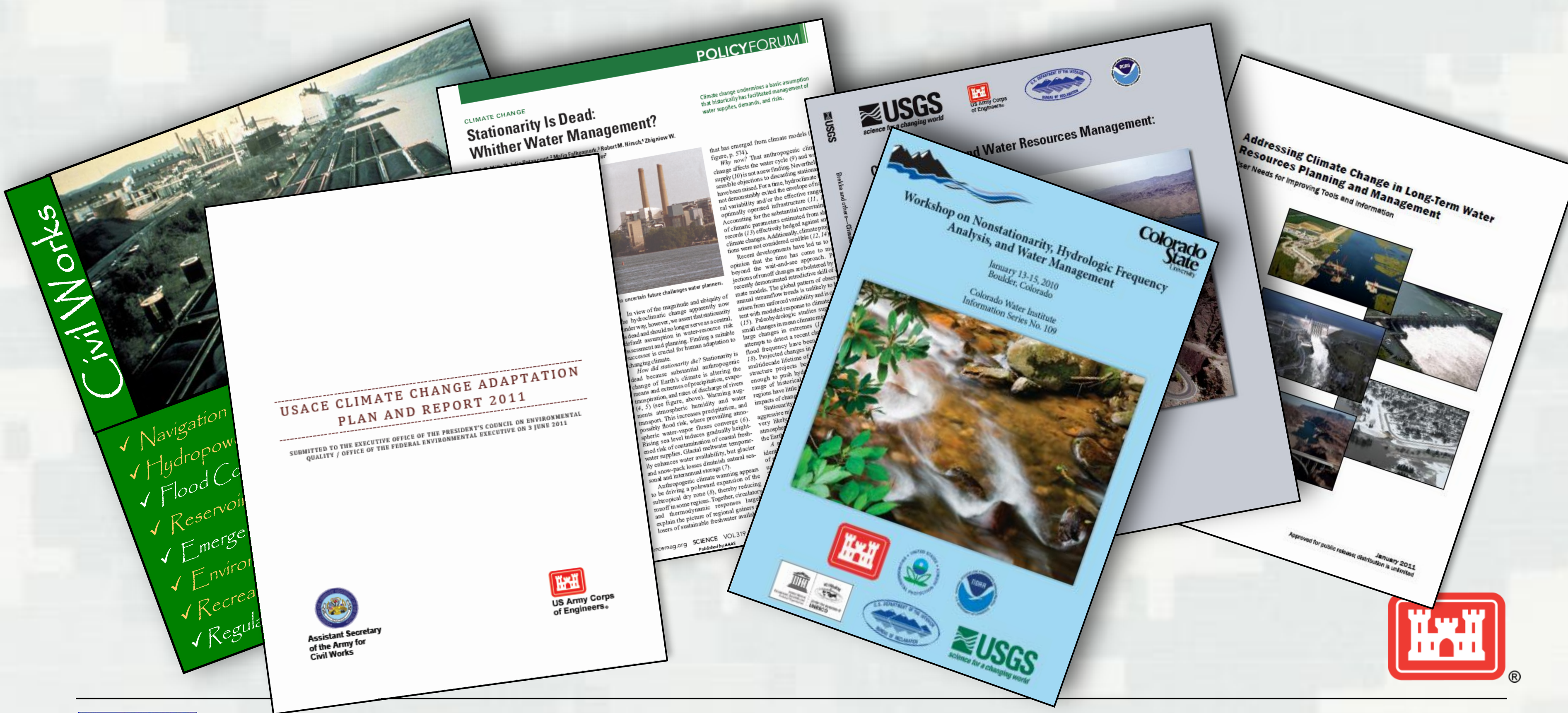
A successor. We need to find ways to identify nonstationary probabilistic models of relevant environmental variables and to use those models to optimize water systems. The challenge is daunting. Patterns of change are complex; uncertainties are large; and the knowledge base changes rapidly.

Under the rational planning framework advanced by the Harvard Water Program (*21*, *22*), the assumption of stationarity was

"Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, and risks".

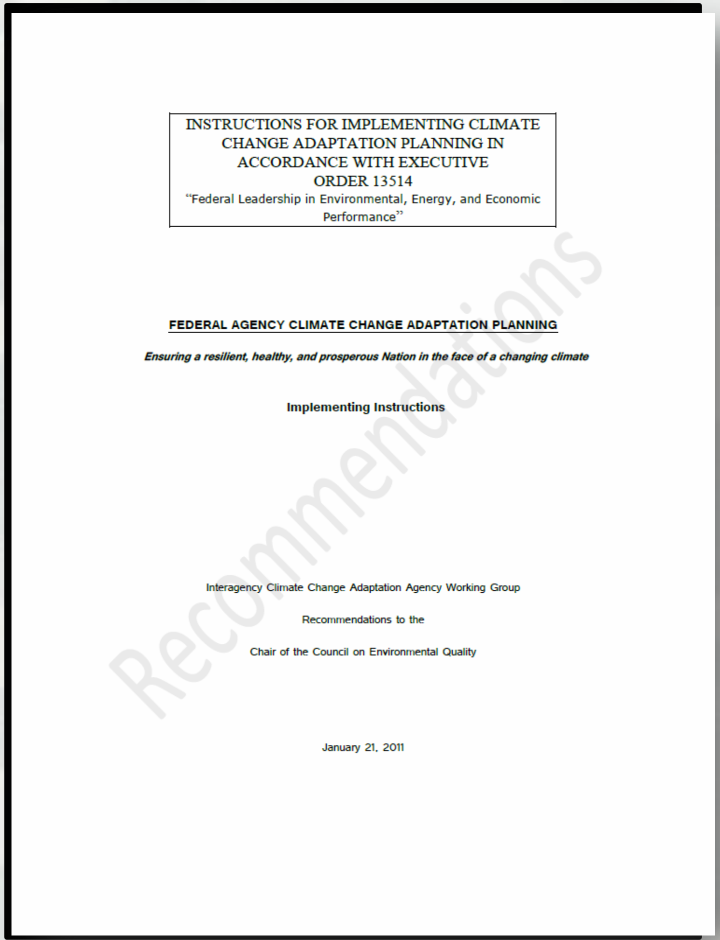
Stationarity assumes that the statistical properties of hydrologic variables in future time periods will be similar to past time periods

How's USACE Addressing the Problems?
&
Where does Federal Water-Resource Adaptation Fit?



Agency Climate Change Adaptation Process

- CEQ issued instructions for implementing climate change adaptation in accord w/EO 13514 – included requirements to:
  - Identify a senior official responsible for carrying out adaptation actions
  - Establish an agency climate change adaptation policy
  - Complete a high-level analysis of agency vulnerability to climate change



INSTRUCTIONS FOR IMPLEMENTING CLIMATE CHANGE ADAPTATION PLANNING IN ACCORDANCE WITH EXECUTIVE ORDER 13514
"Federal Leadership in Environmental, Energy, and Economic Performance"

FEDERAL AGENCY CLIMATE CHANGE ADAPTATION PLANNING

Ensuring a resilient, healthy, and prosperous Nation in the face of a changing climate

Implementing Instructions

Recommendations

Interagency Climate Change Adaptation Agency Working Group

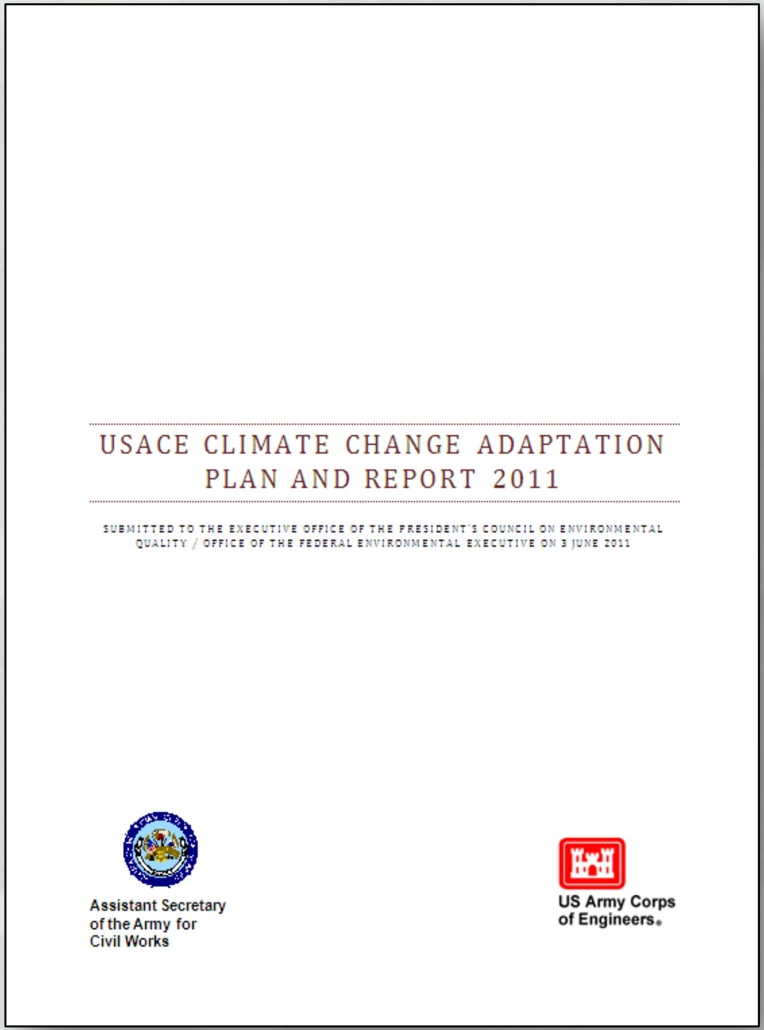
Recommendations to the

Chair of the Council on Environmental Quality

January 21, 2011

USACE Adaptation Plan and Report

- Contains policy statement
- Answers the guiding questions posed by the White House Council on Environmental Quality in its Implementing Instructions
- Provides information on USACE progress, programmatic efforts, and adaptation planning priorities


USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011

SUBMITTED TO THE EXECUTIVE OFFICE OF THE PRESIDENT'S COUNCIL ON ENVIRONMENTAL QUALITY / OFFICE OF THE FEDERAL ENVIRONMENTAL EXECUTIVE ON 3 JUNE 2011

Assistant Secretary of the Army for Civil Works

US Army Corps of Engineers®

USACE Climate Change Adaptation Policy

June 2011

USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011

SUBMITTED TO THE EXECUTIVE OFFICE OF THE PRESIDENT'S COUNCIL ON ENVIRONMENTAL QUALITY / OFFICE OF THE FEDERAL ENVIRONMENTAL EXECUTIVE ON 3 JUNE 2011

USACE CLIMATE CHANGE ADAPTATION POLICY STATEMENT

As the Nation's largest and oldest manager of water resources, the US Army Corps of Engineers (USACE) has long been successfully adapting its policies, programs, projects, planning, and operations to impacts from important drivers of global change and variability. Climate change and variability, both observed and as projected for the future, are among those important drivers of global change having significant impacts to the management of US national water resources and infrastructure.[1] The Nation's water-resource infrastructure managed by USACE both protects public health and human life and annually provides billions of dollars of economic, social, and environmental benefits crucial to the continued progress of the Nation.

It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects. USACE shall continue undertaking its climate change adaptation planning, in consultation with internal and external experts and with our Districts, Divisions, and Centers, and shall implement the results of that planning using the best available – and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change information into the actionable basis for adapting its Civil Works and Military Programs missions to climate change impacts. Furthermore, USACE shall consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

These actions which USACE is now conducting and has outlined for the future are fully compatible with the guiding principles and framework of the US Federal Interagency Climate Change Adaptation Task Force and the Implementing Instructions for Federal Agency Climate Change Adaptation issued on 4 March 2011 jointly 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 and Budget.[2]

Together with CEQ, USACE recognizes the very significant differences between climate change adaptation and climate change mitigation in terms of physical complexity, fiscal and material resources, level of knowledge and technical readiness, and temporal and geographic scale. Because of these differences, understanding and implementing climate adaptation policies and measures requires very different knowledge, skills, and abilities than implementing mitigation measures. Relatedly, USACE understands and is acting to integrate climate adaptation (managing the unavoidable impacts) with mitigation (avoiding the unmanageable impacts). It is the policy of USACE that mitigation and adaptation investments and responses to climate change shall be considered together to avoid situations where near-term mitigation measures might be implemented that would be overcome by longer-term climate impacts requiring adaptation, or where a short-term mitigation action would preclude a longer-term adaptation action.

The successful implementation of this USACE adaptation policy will help enhance the resilience of the built and natural water-resource infrastructure USACE manages and reduce its potential vulnerabilities to the effects of climate change and variability. This success will allow USACE to continue fulfilling its missions using Integrated Water Resource Management to safeguard the Nation's tremendous investment in the built and natural water-resource infrastructure by mainstreaming climate change adaptation in all USACE activities.

[1] USGS Circular 1331 "Climate Change and Water Resources Management: A Federal Perspective", available at http://pubs.usgs.gov/circ/1331/, a joint document by the USACE, Bureau of Reclamation, US Geological Survey, and National Oceanic and Atmospheric Administration.

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

v

"It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects".

"… using the best available – and actionable – climate science and climate change information…"

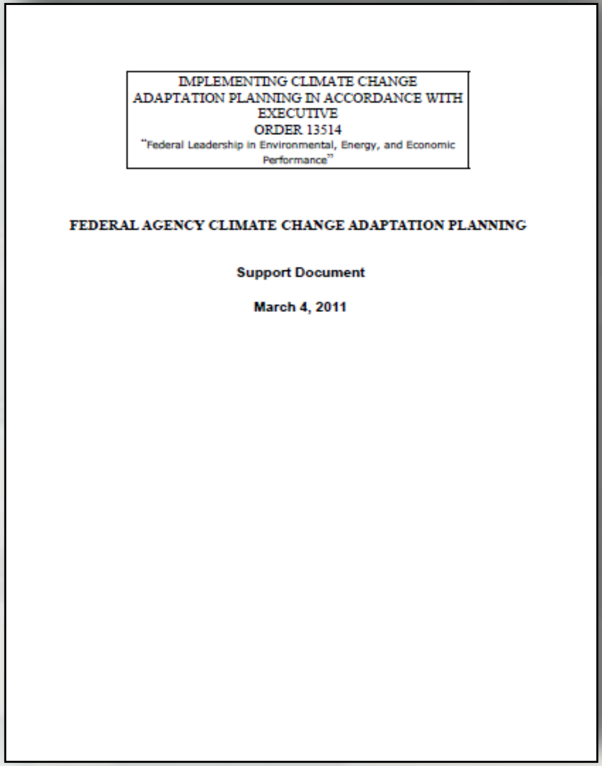
"… it shall be considered at every step in the project life cycle for all USACE projects, both existing and planned, … to *reduce vulnerabilities and enhance the resilience of our water-resource infrastructure*".

http://corpsclimate.us

®

Motivation: Guiding Questions

- **Action:** By 3 June 2011, submit to CEQ your agency responses to the Guiding Questions in the CEQ Implementing Instructions Support Document Appendix E
- Questions are designed to help agencies:
  - Begin assessing how climate change will affect missions, programs, and operations
  - Undertake a high-level analysis of vulnerability to climate change effects
  - Draft high-level assessment due in September 2011, final in March 2012



IMPLEMENTING CLIMATE CHANGE ADAPTATION PLANNING IN ACCORDANCE WITH EXECUTIVE ORDER 13514
"Federal Leadership in Environmental, Energy, and Economic Performance"

FEDERAL AGENCY CLIMATE CHANGE ADAPTATION PLANNING

Support Document

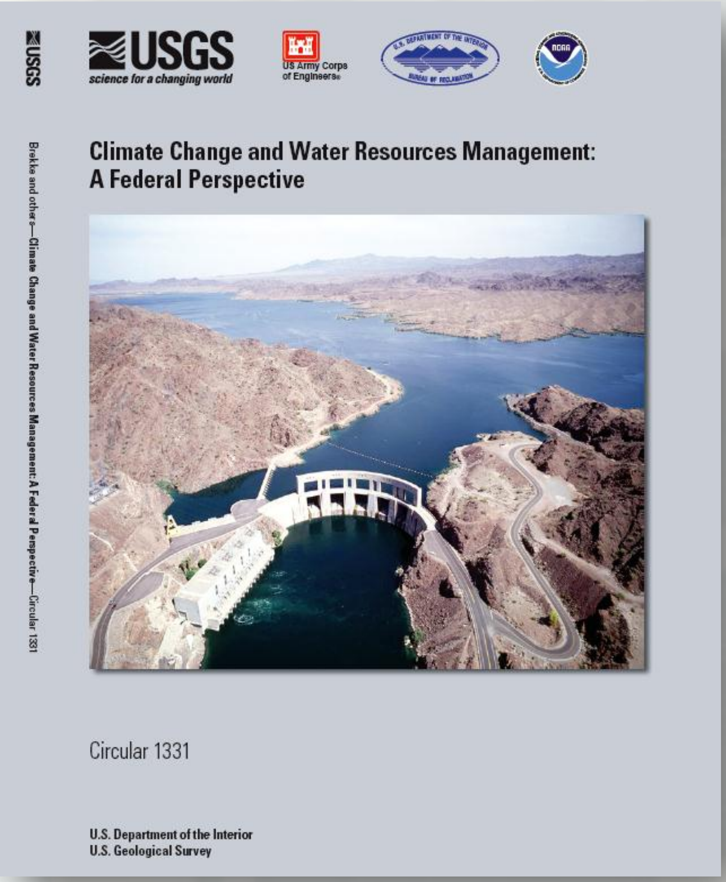
March 4, 2011

CEQ Question 1: Impacts and Adaptation

Q1: How is climate change likely to affect the ability of your agency to achieve its mission and strategic goals?

How we responded:

1. Identify missions and operations and how they are impacted by climate change
2. Evaluate how to incorporate climate change considerations into activities related to the Nation's water resources
3. Provide a firm foundation for future policies, methods, research, and applications of climate data for water resources management



http://pubs.usgs.gov/circ/1331

Climate Change – Illustrative Impacts Aligned with Potentially Affected CW Business Areas

Climate Change	Impact	Business Area
Increasing average air temperature	Change in form of precipitation (snow vs. rain)	N, F, E, H, W, EM
	Changes in water temperatures → water quality, lake stratification	E
	Effects on crops and growing season → changing water demand	H, W
	Changes in ecosystem structure and function	E
	Changes in invasive species or pest distribution	N, F, E, H, W
	Changes in river ice regimes	N, F, E, H, EM
	Changes to glacial processes	N, F, E
	Changes to ocean ice regimes	N, F, E
	Changes to permafrost	E
	Changes in energy demand	N, E, H, W
	Altered ocean circulation → changing tide & surge regimes	N, F, E, EM
	Increased frequency &/or location of extreme events → droughts, floods, tornados, heat waves, cold waves, ice storms, blizzards, dust storms	N, F, E, H, W, EM
	Changing persistence of large-scale atmospheric features	N, F, E, H, W, EM
	Changes in evapotranspiration, rainfall-runoff relationships	N, E, H, W, EM

N=Navigation, F=Flood and Coastal Storm Damage Reduction, E=Environment, H=Hydropower, W=Water Supply, EM=Emergency Management

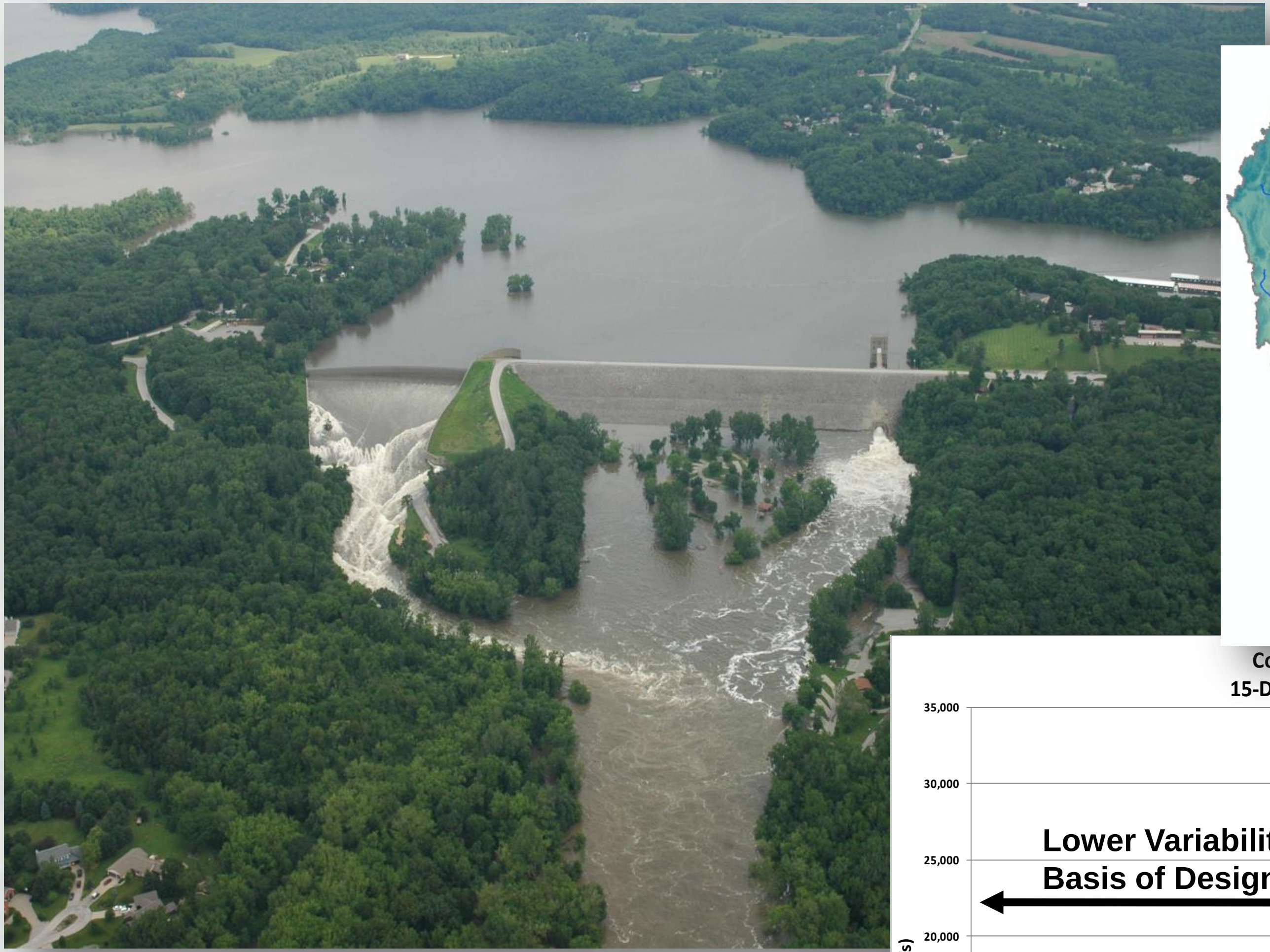
Table 2: Priority Questions

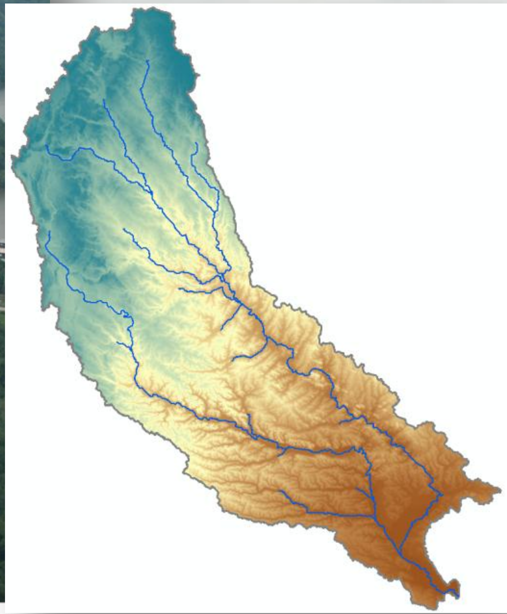
Priority Questions Driving USACE Approach	Business Area Impacted	How These Questions Relate to Business Areas.
How do we respond to increasing variability of precipitation with climate change?	N, F, E, H, W	Increasing variability impacts our capacity to: • Provide navigation services • Manage reservoirs as authorized to provide flood risk reduction, and prepare, respond and recover from floods and coastal storms • Effectively plan, design, and manage ecosystem restoration project • Provide reliable hydropower • Manage reservoirs for authorized water supply
How to account for nonstationarity in hydrologic analyses?	N, F, E, H, W	Nonstationarity undermines a fundamental assumption of hydrologic and coastal design, requiring new methods, processes, and technologies supporting updated planning, design, and operations of our projects and programs supporting navigation, flood and coastal storm risk reduction, environment, hydropower, and water supply..
How to perform flood-related and other hydrologic analyses?	N, F, E, H, W	Climate change and variability have revealed: • The need to consider multiple plausible futures • That there are many approaches to obtain climate information – which approaches are suitable for which decision? • Gaps in knowledge and lack of established methods of performing hydrologic analyses required to adequately plan, design, and operate our projects and programs supporting navigation, flood and coastal storm risk reduction, environment, hydropower, and water supply.

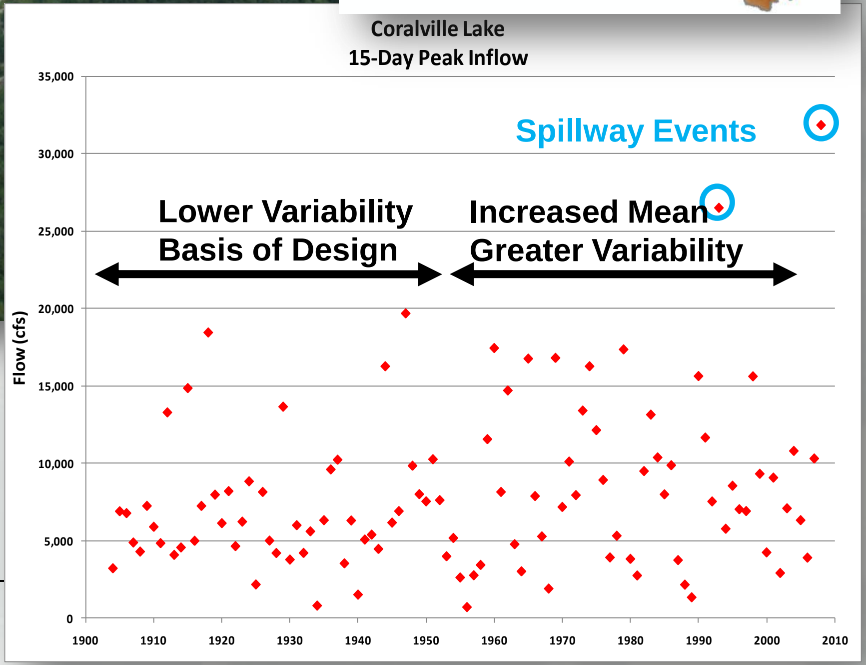
N=Navigation, F=Flood and Coastal Storm Damage Reduction, E=Environment, H=Hydropower, W=Water Supply, EM=Emergency Management

Table 3: Collaboration

Agency	How Climate Change Management Challenges are Similar
Department of Commerce, National Oceanic and Atmospheric Administration	Similar needs to monitor and track changes to water resources impacted by climate change Provides water resources science support to USACE
Department of Commerce, US Coast Guard	Similar impacts to navigation and disaster response
Department of Defense	Similar impacts to land and water resources management & national security
Department of Homeland Security, Federal Emergency Management Agency	Similar impacts to disaster preparedness, response, recovery and flood risk reduction
Department of the Interior, Bureau of Reclamation	Water resources management operation agency Similar impacts to land and water resources management
Department of the Interior, National Park Service	Similar impacts to land and water resources management
Department of the Interior, US Geological Survey	Similar needs to monitor and track changes to water resources impacted by climate change Provides water resources science support to USACE
Department of Transportation, Federal Highway Administration	Similar impacts to infrastructure
Environmental Protection Agency	Similar impacts to water quality
National Aeronautics and Space Administration	Similar needs to monitor and track changes to water resources impacted by climate change Provides water resources science support to USACE







Coralville, IA Pilot Study: Multipurpose reservoir

Central Questions

- How do we allow for shoreline retreat to preserve critical tidal and near-shore ecosystems?
- How will changing climate affect reservoir sedimentation?
- How do we incorporate climate change considerations into reservoir operating policies that will be adaptable to potential climate changes?
- What information is needed for monitoring and assessing drought for water management decision making?
- How should this information be communicated to stakeholders?
- At what point will back bay flooding decrease benefits to the point that beach renourishment is unjustified in those locations?

Example (Potential & Theoretical) Adaptation Measures at Coralville

Modification of storage allocation within the reservoir

- Seasonal or permanent

Modification of reservoir release schedule

- May require downstream modifications to river corridor to allow for higher growing-season releases

Expanded use of forecast tools in reservoir regulation

- Current regulation plans are rigid and were not designed to employ modern forecast products
- Operation flexibility would enable the system to adapt to changing & unexpected conditions

Integrating reservoir operations with systemic flood risk management for the basin under climate change conditions entails
integration of structural & non-structural methods,
Federal & local flood risk management systems,
& risk communication

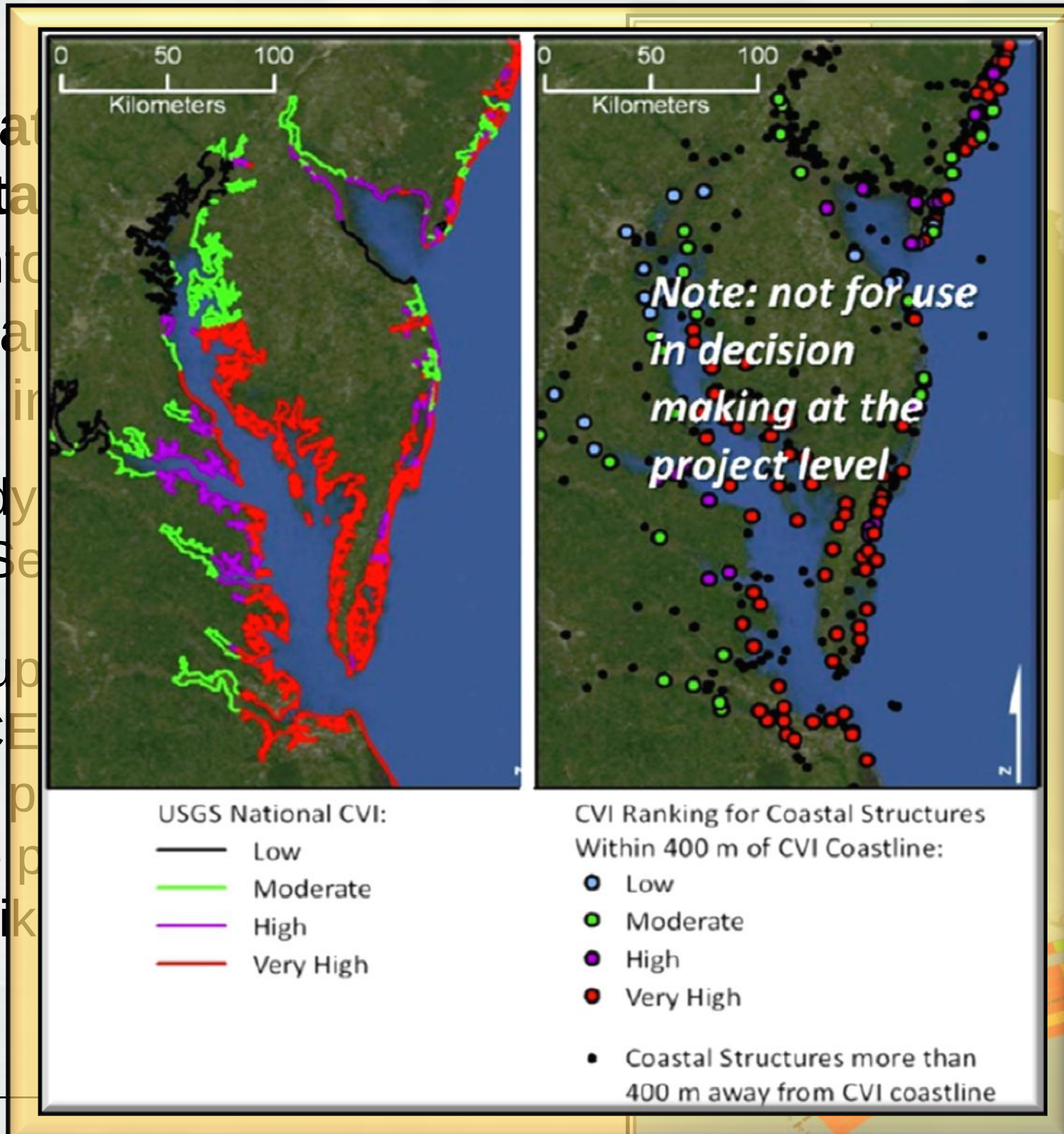
adapted from K. Landwehr & G. Karlovits, USACE

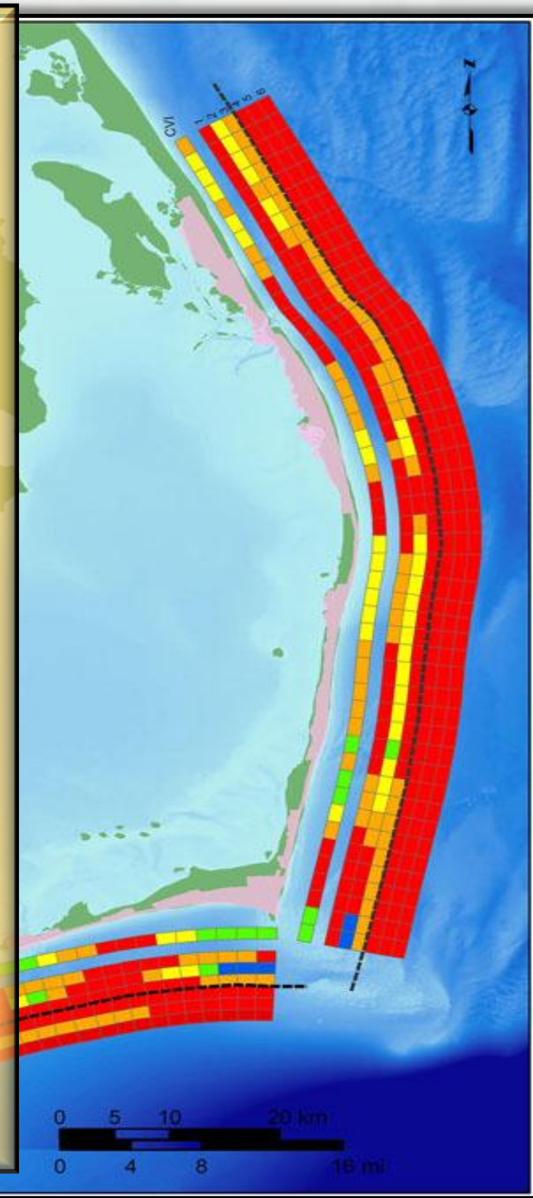
Vulnerability Assessments & Coastal Change

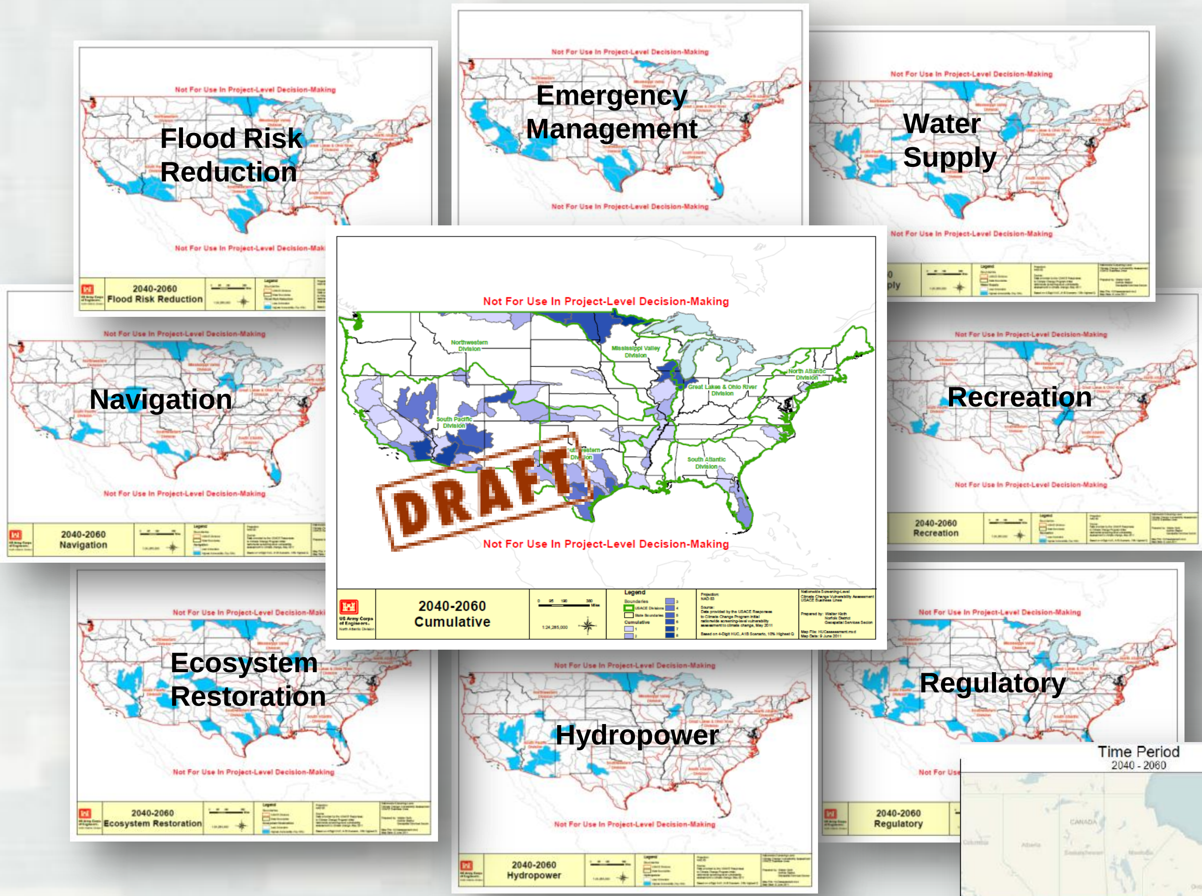
USGS **Na**
of Coast
insight int
for coastal
changes i

- Already
  Park Se

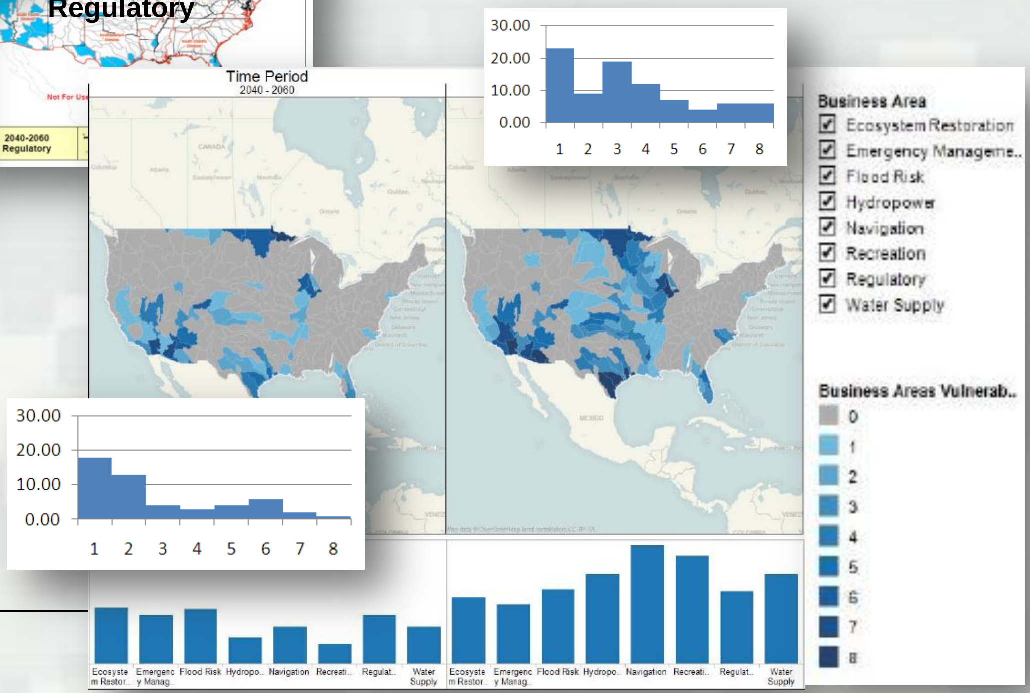
- Joint u
  USACE
  Navy: p
  where p
  most lik







Each business line has a set of indicators related to performance and vulnerability. The top ten percent most vulnerable HUCs *for the given condition* for each BL are summed to build the DRAFT cumulative map in the center



We are in the midst of analyzing and interpreting the results of this screening-level assessment, and will be working with BL and MSCs to refine the process over the next year for use in the WIDT

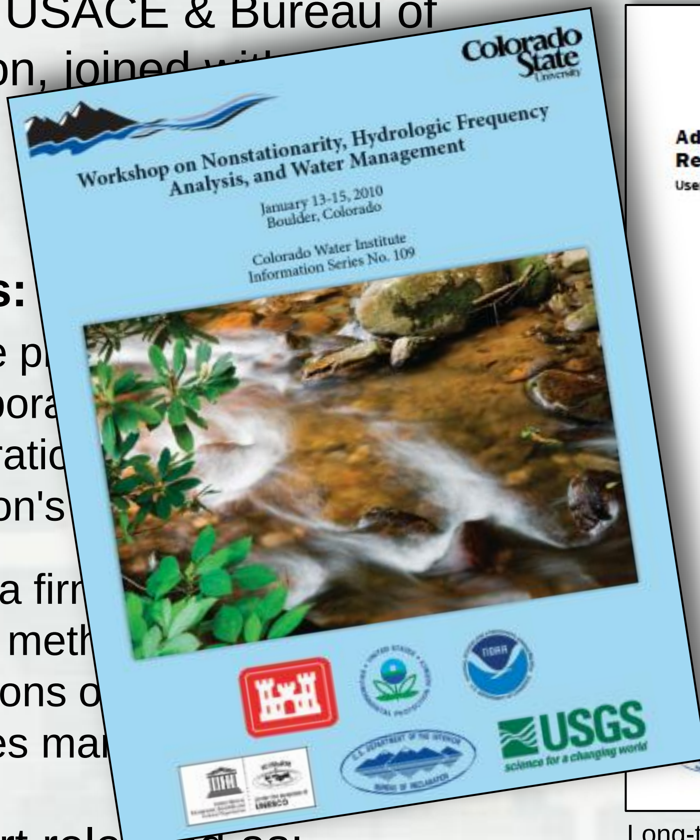
Climate Change & Water Working Group
(CCAWWG)

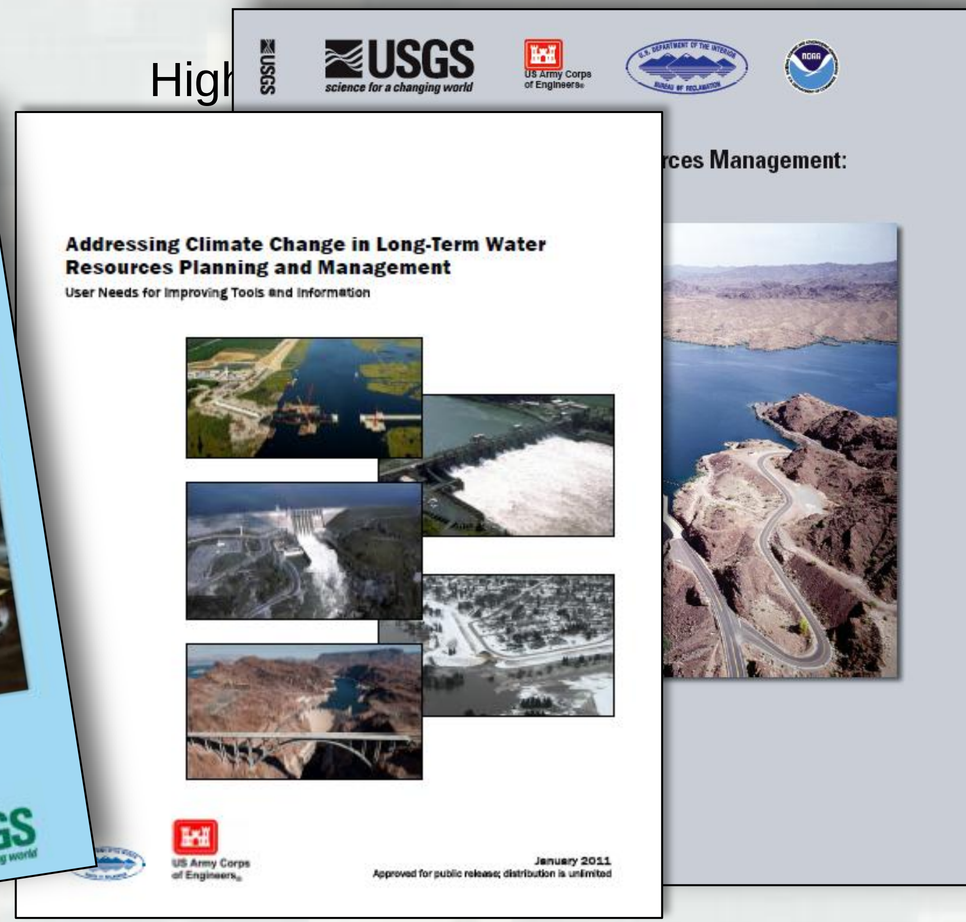
The two chief US water management agencies - USACE & Bureau of Reclamation, joined wi[...] chief water [...] & NOAA

High[...]

Objectives:

- Evaluate p[...] to incorpora[...] consideratio[...] the Nation's [...]
- Provide a fir[...] policies, meth[...] applications o[...] resources ma[...]





Joint Report released as:

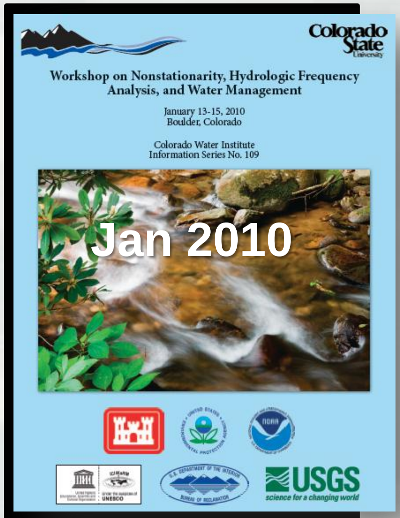
USGS Circular 1331, February 2009

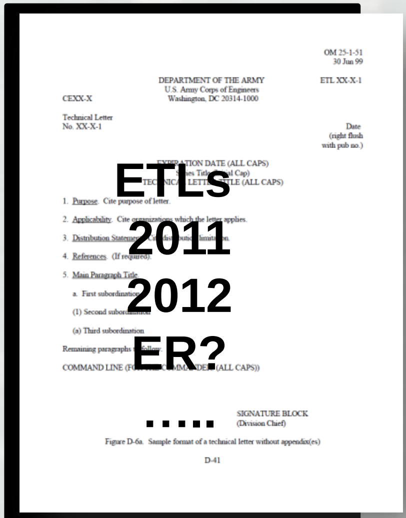
Long-term user needs produced in 2010;
short-term analog report coming in Spring 2012

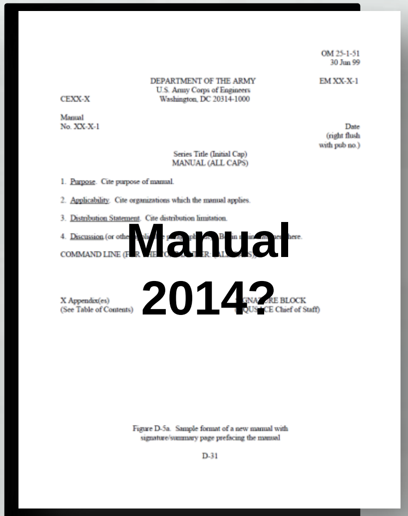
http://corpsclimate.us

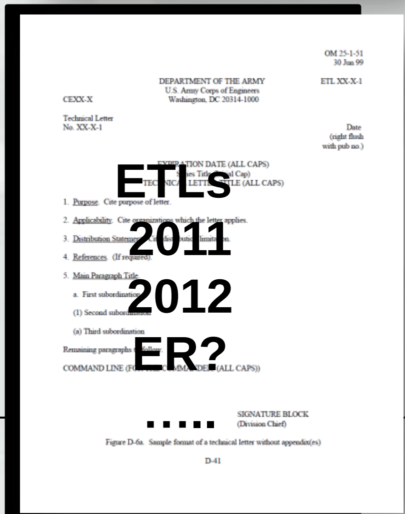
Path Forward for Hydrology…..

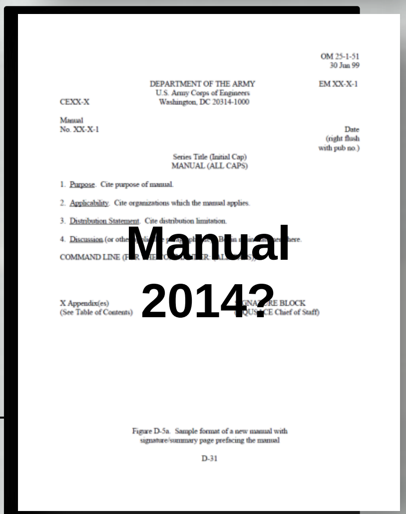
Workshop : Expert Opinions | **Peer-Reviewed Publication: Legally Justifiable** | **Broad Guidance** | **Refined Guidance**











Programmatic Efforts

Progress since 2006 with plans for action

IPET/HPDC Lessons Learned Implementation (FY06 - 12)

Responses to Climate Change (FY10 - 14)

Global Change Sustainability (FY11 - 20)

- Nationwide Datum Standard
- Sea-Level Change Guidance
- USGS Circular 1331
- Nonstationarity Workshop
- Sea-Level Adaptation Guidance
- Portfolio of Approaches Workshop
- Long Term User Needs
- Climate Change Vulnerability Pilots
- Future Guidance and Policies
- Big S Sustainability Actions

- Update Drought Contingency Plans
- Comprehensive Evaluation w.r.t. Sea-Level Change
- Update Reservoir Sedimentation
- Integrate Adaptation & Mitigation…….

Accomplishments

- Nationwide datum and subsidence standard (2006 – present)
- Sea-level change guidance (2007 – present)
- Water resources management (2007 – present)
- Adaptation Pilots (2009 – present)
- Nationwide screening level vulnerability assessment (2010 – present)
- Integrating adaptation and mitigation (2009 – present)

Summary

- USACE progress to date is significant
  - Products include a foundational report, *Climate change and water resources management: A federal perspective*, workshops directed at priority issues of climate change adaptation for water resources managers, guidance development, and a report on user needs for long-term water resources planning.
- USACE has coordinated and collaborated extensively to address the climate challenges facing us
- Our vulnerability assessment is on track (ahead of schedule)

QUESTIONS?

www.hec.usace.army.mil

US Army Corps of Engineers
BUILDING STRONG®

IWR INSTITUTE FOR WATER RESOURCES