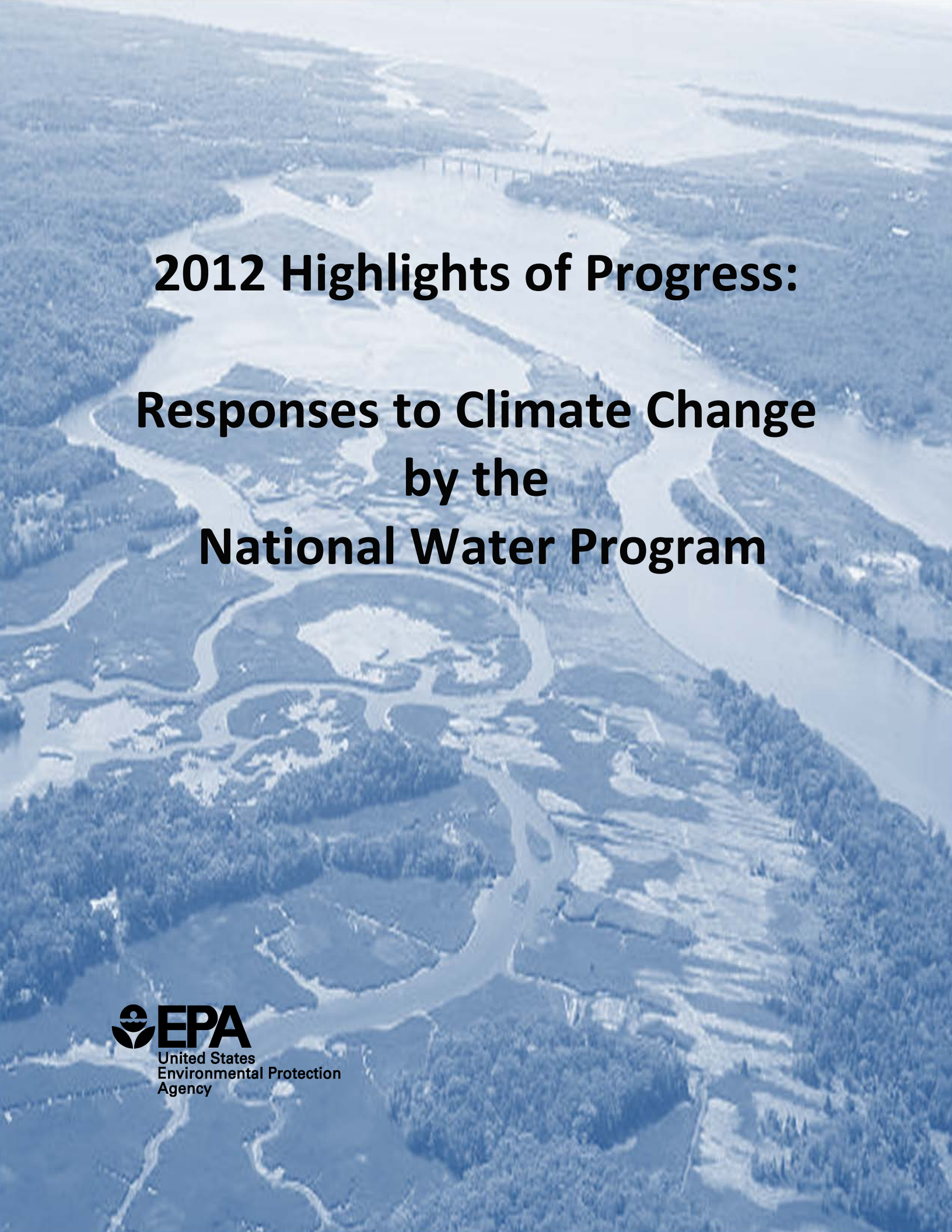

2012 Highlights of Progress:

Responses to Climate Change by the National Water Program

EPA
United States
Environmental Protection
Agency

Prepared by:
Office of Water
U.S. Environmental Protection Agency
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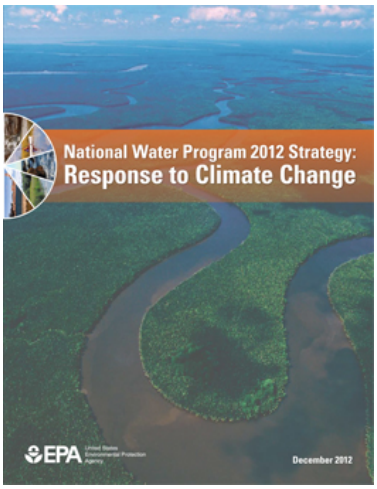
TABLE OF CONTENTS



Introduction

The National Water Program at the U.S. Environmental Protection Agency released the *National Water Program 2012 Strategy: Response to Climate Change* (2012 *Strategy*) in December 2012 as an update to an initial climate change and water strategy released in 2008. The 2012 *Strategy* describes long-term goals for the management of sustainable water resources for future generations in light of climate change and is intended to be a roadmap to guide future programmatic planning and inform decision makers during the Agency's annual planning process. The new *Strategy* is available at http://water.epa.gov/scitech/climatechange/2012-National-Water-Program-Strategy.cfm.

The final completion and publication of the updated *Strategy* was the principal climate change accomplishment of the National Water Program in 2012. Also during 2012, EPA's national water programs and regional water programs continued work to implement a range of climate change response actions called for in the 2008 *Strategy* and updated in the new 2012 *Strategy.* This *2012 Highlights of Progress* report provides a summary of the major accomplishments of the EPA national water programs and regional water programs in 2012. This is the fourth climate change progress report for the National Water Program and the first progress report organized around the five long-term programmatic vision areas described in the new 2012 *Strategy:*

1. Water infrastructure;
2. Watersheds and wetlands;
3. Coastal and ocean waters;
4. Water quality; and
5. Working with Tribes.

Twenty highlights of projects and products implemented by the National Water Program in each of these five areas and related to cross-cutting program support are described in Part I of this report.

The 2012 *Strategy* describes water related climate change adaptation programs and projects at EPA regional offices. Part II of this report includes descriptions of a key 2012 accomplishment related to this work in each of the 10 climate change regions identified in the 2012 *Strategy* and for the large aquatic ecosystem programs implemented by EPA around the country (e.g. Chesapeake Bay, Great Lakes, and Gulf of Mexico). These national and regional highlights are presented in summary form in Appendix A.

It is important to note that, in addition to the accomplishments highlighted in each of these vision areas and climate regions, other important projects are in development and a range of supporting activities are being implemented. A detailed compendium of activities related to climate change and water programs is provided in Appendix B. Appendix C of this report includes summary descriptions of the major accomplishment of the EPA Office of Research and Development during 2012.

In addition to reporting on highlights of progress for 2012, the National Water Program is beginning a new process to track progress based on the stage or phase of development of climate response programs. Recognizing the long-term nature of addressing climate change, this approach tracks progress through seven developmental phases:

1. Initiation;
2. Assessment;
3. Response development;
4. Initial implementation;
5. Robust implementation;
6. Mainstreaming; and
7. Monitor outcomes and adaptive management.

Each of these phases is described in greater detail in Part III of this report. In addition, Part III includes an initial identification of the status of each climate change and water goal with respect to the developmental phases. This is the first assessment of the developmental status of climate change adaptation programs and projects across the National Water Program and will form a baseline for future assessments.

PART I
Vision Area 1: Water Infrastructure

Vision: *In the face of a changing climate, resilient and adaptable drinking water, wastewater and stormwater utilities (water sector) ensure clean and safe water to protect the nation's public health and environment by making smart investment decisions to improve the sustainability of their infrastructure and operations and the communities they serve, while reducing greenhouse gas emissions through greater energy efficiency.*

1. **Issued Water Utility Climate Tool: Version 2.0**
   The Climate Resilience Evaluation and Awareness Tool (CREAT) assists users in conducting climate change risk assessments and promotes a general understanding of climate change impacts for utility owners and operators. A new 2.0 version of CREAT was released in January 2013. The new CREAT 2.0 features more robust scenario-based planning, extreme events data, and energy management capabilities. The new version also includes embedded basic and advanced video training modules and allows utilities to conduct analysis comparison scenarios for multiple time periods. During 2012, pilots were conducted in Oakland, California and Wilmington, Delaware for the updated software.

2. **Published *Adaptation Strategies Guide***
   In January 2012, EPA published an *Adaptation Strategies Guide* that serves as an introduction to climate change adaptation planning for drinking water, wastewater, and stormwater utilities. Users can navigate this interactive Adobe PDF document in a manner similar to clicking through pages of a website. A series of briefs organized by region and climate-related impacts provide a better understanding of what challenges utilities can expect to face along with adaptation strategies that can be used to prepare their systems for those impacts. An updated version of the *Guide* will be released in the spring of 2013. The new *Guide* will include two new sections on Green Infrastructure and Energy Management, which contribute to a more comprehensive adaptation planning process.

3. **Published *Planning for Extreme Weather Events: Workshop Planner for the Water Sector***
   The *Extreme Events Workshop Planner* includes the tools and resources a utility needs to plan, customize, and conduct a workshop focused on planning for more frequent and more intense extreme events. Five extreme event scenarios are included in the *Workshop Planner*:
   - Flooding;
   - Drought;
   - Sea level rise;
   - Wildfire; and
   - Reduced snowpack.

Each scenario walks users through a long-term planning exercise in which workshop participants gain a better understanding of how projected changes in the frequency and intensity of extreme events can impact their utility and community, and how they can begin to adapt to prepare for these changes. By the end of a workshop, each participant will have identified actionable next steps they can take today to increase the resilience of their utility and community to extreme events. Three communities piloted the *Workshop Planner*: Manchester, New Hampshire; Erie, Pennsylvania; and Bisbee, Arizona.

4. **Published Extreme Events Case Study Series**
   The Office of Water, in collaboration with the National Oceanic and Atmospheric Administration (NOAA), the Water Environment Research Foundation (WERF), Water Research Foundation (WaterRF), and others, has developed case studies on six communities' experiences with extreme events and how they are planning for the future. The case studies are based on six workshops, focused on the Russian River Basin, California; the Apalachicola-Chattahoochee-Flint Basin, Georgia; Tidewater, Virginia; the Washington, D.C. Region; the Lower Missouri River Basin in Kansas; and the Lower Colorado River Basin in Central Texas. For more information, see: http://www.cpo.noaa.gov/ClimatePrograms/ClimateSocietalInteractionsCSI/SARPProgram/ExtremeEventsCaseStudies.aspx.

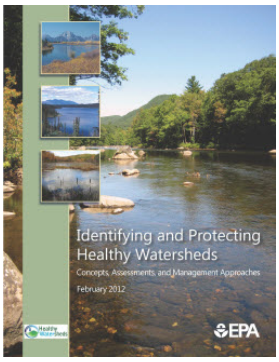
5. **Expanded WaterSense to New Multi-Family Housing and Irrigation**
   Efficient use of water is a key strategy for managing water resources as supplies become more unpredictable as a result of climate change. In August 2012, EPA released a revised specification for WaterSense labeled new homes which expanded the label to include multi-family housing. The WaterSense program also developed a fact sheet which was provided to EPA Regions to provide messaging on how consumers could take water-efficient actions during a drought. In late 2011, EPA released a WaterSense specification to label weather-based irrigation controllers. Use of labeled controllers can help to reduce water waste associated with outdoor landscape watering.

6. **Published *Planning for Sustainability Handbook for Water and Wastewater Utilities***
   EPA published the *Planning for Sustainability Handbook for Water and Wastewater Utilities* (EPA-832-R-12-001) in 2012 and conducted webinars for utilities on the use of the document. The handbook describes a number of steps utilities can undertake to enhance their existing planning processes to ensure that water infrastructure investments are cost-effective over their life cycle, resource efficient, and support other relevant community goals. The handbook includes a section that talks about how to incorporate sustainability principles into financial management strategies. For more information, see: http://water.epa.gov/infrastructure/sustain/upload/EPA-s-Planning-for-Sustainability-Handbook.pdf.

Vision Area 2: Watersheds and Wetlands

Vision: *Watersheds are protected, maintained, and restored to ensure climate resilience and to preserve the social and economic benefits they provide; and the nation's wetlands are maintained and improved using integrated approaches that recognize their inherent value as well as their role in reducing the impacts of climate change.*

7. **Published *Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches***



In February of 2012, the Office of Water released a technical guide *Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches* http://water.epa.gov/healthywatersheds. This document serves as a technical resource for states and other resource managers interested in identifying healthy watersheds and implementing holistic, healthy watersheds protection programs. EPA is also working with the State of California to identify healthy watersheds through an integrated assessment which includes a climate change vulnerability component to be completed in May 2013. Partners include the California Water Resource Control Board, California Department of Fish and Game, and EPA Region 9.

8. **Hosted Webcast: *Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration***

EPA hosted a National Webcast: *Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration* in the spring of 2012 which provided an overview of the newly released study linking ecologically important coastal habitat restoration with adaptation and mitigation strategies as a way to reduce the impacts of ongoing global climate change.

9. **Integrated Climate Change in Wetland Program Development Grants**

EPA integrated considerations of climate change (mitigation and adaptation) into its 2012 Headquarters Wetland Program Development Grants Request for Proposals (RFP) announcement and used the RFP to guide funding decisions for building state and tribal capacity. Appropriate partners are being identified for establishing restoration objectives within the context of climate change. After new grant recipients are announced in Fiscal Year (FY) 2013, EPA will consider other potential partnerships.

10. Addressed Climate Change in Recovery Potential Screening Methodology

Climate change relevance to restoration planning has been incorporated into the Recovery Potential Screening methodology that assists states in assessing prospects of restoration success and linking this to driving factors. The Recovery Potential Screening website (www.epa.gov/recoverypotential) now includes a "biotic and climatic risks" subcategory under the stressor indicators (see http://owpubauthor.epa.gov/lawsregs/lawsguidance/cwa/tmdl/recovery/indicatorsstressor.cfm#bioclimrisks), and several other parameters sensitive to climate change risks to restoration success have been built into the ecological and stressor indicators that are also available on the website. Examples include flow alteration and temperature stress. The Recovery Potential screening website was comprehensively peer-reviewed by members of the EPA Office of Research and Development (ORD) Global Climate Change Research team to enable a good two-way exchange of indicator concepts and data sources.

Vision Area 3: Coastal and Ocean Waters

Vision: *Adverse effects of climate change and unintended adverse consequences of responses to climate change have been successfully prevented or reduced in the ocean and coastal environment. Federal, tribal, state, and local agencies, organizations, and institutions are working cooperatively; and information necessary to integrate climate change considerations into ocean and coastal management is produced, readily available, and used.*

11. Expanded Climate Ready Estuaries Program

Climate Ready Estuaries grants were provided to four new National Estuary partners in 2012:

- San Juan Bay Estuary Program, Puerto Rico;
- Buzzards Bay National Estuary Program, Massachusetts;
- Peconic Estuary Program, New York; and
- Mobile Bay National Estuary Program, Alabama.

Climate ready projects have now been initiated with 23 National Estuary Programs (NEPs). In addition, in 2012, the program initiated 6 new climate adaptation projects (with five NEPs, including the 4 new partners listed above), bringing the total projects to 37. Additional information about the program can be found at http://www.epa.gov/cre.

12. Hosted Workshop on Coastal Climate Change Vulnerability Assessments

In March 2012, the Climate Ready Estuaries program worked with NOAA to host a joint meeting on climate change vulnerability assessments. About 50–60 members attended from the program's stakeholder communities, in addition to about 20–25 more staff members from federal agencies.

13. Implemented Pilot Projects on Climate Adaptation: Estuary and Utility Cooperation

In 2012, EPA conducted pilots to increase the coordination between Climate Ready Water Utilities (CRWU) and Climate Ready Estuaries initiatives. The North Hudson Sewerage Authority and the New York/New Jersey Harbor National Estuary Program project was completed in 2011 and the report is now available on EPA's website. The 2012 pilots were conducted by the Albemarle-Pamlico National Estuary Program in North Carolina and the Morro Bay National Estuary Program in California. For all three pilot projects, CREAT was used to conduct a joint risk assessment with watershed partners to identify current and future climate threats and adaptation options.

Vision Area 4: Water Quality

Vision: *The Nation's surface water, drinking water, and ground water quality are protected, and the risks of climate change to human health and the environment are diminished, through a variety of adaptation and mitigation strategies.*

14. Developed Climate Assessment Tool (CAT) for Stormwater

In 2012, EPA developed the Climate Assessment Tool (CAT) as a module for the Stormwater Calculator based on the Stormwater Management Model (SWMM). The Stormwater CAT, which will be released in final form in 2013, allows users to assess the efficacy of stormwater control measures including "green infrastructure" measures, in a range of potential climate change-influenced precipitation and temperature conditions. The Stormwater CAT will aid municipalities in implementing stormwater management programs. Outputs from the stormwater calculator and SWMM may be integrated into watershed models which would allow for comprehensive management of stormwater controls.

15. Revised *NPDES Permit Writers' Manual* to Address Climate Change

The 2012 version of the *NPDES Permit Writers' Manual* includes new text providing for consideration of climate change in two sections:

- **Section 5.2.2.7: Apply Additional Regulatory Considerations in Calculating Thermal Discharge Limits – Clean Water Act Section 316(a) Variance**: Permitting authorities should be aware that the effects of global climate change could alter the thermal profile of some receiving waters making the historical record of thermal conditions less representative of future conditions.
- **Section 6.2.4.2: Receiving Water Critical Conditions Receiving Water Upstream Flow:** Modelers should be aware that the effects of climate change could alter historical flow patterns in rivers and streams, making these historical flow records less accurate in predicting current and future critical flows.

16. Established *Principals for an Energy-Water Future*

The Office of Water developed and published *Principles for an Energy-Water Future*, which outlines six principles to address the energy-water nexus including:

- Efficiency in the use of energy and water should form the foundation of how we develop, distribute, recover, and use energy and water;
- The exploration, production, transmission and use of energy should have as small an impact on water resources as possible, in terms of water quality and water quantity;

- The pumping, treating, distribution, use, collection, reuse and ultimate disposal of water should have as small an impact on energy resources as possible;
- Wastewater treatment facilities, which treat human and animal waste, should be viewed as renewable resource recovery facilities that produce clean water, recover energy, and generate nutrients;
- The water and energy sectors – governments, utilities, manufacturers, and consumers – should move toward integrated energy and water management from source, production, and generation to end user; and
- Maximize comprehensive, societal benefits.

For more information on the principles, see:
http://water.epa.gov/action/upload/EnergyWater-Principles4_17_12.pdf.

Vision Area 5: Working with Tribes

Vision: *Tribes are able to preserve, adapt, and maintain the viability of their culture, traditions, natural resources, and economies in the face of a changing climate.*

17. **Initiated *Tribal-Focused Environmental Risk Sustainability Tool* (Tribal-FERST)**
    The Office of Water is participating in a project with the EPA Office of Research and Development to develop the *Tribal-Focused Environmental Risk and Sustainability Tool* (Tribal- FERST). Tribal-FERST is a web-based geospatial decision support tool that provides Tribes with access to the best available human health and ecological science. In Tribal-FERST, users will be able to follow step-by-step guidance for identifying priority issues (e.g. climate change), compiling data, ranking and addressing risks, and assessing impacts of actions taken. At each step, relevant information will be provided, such as:
    - Fact sheets and reports about environmental issues of concern;
    - A tribal environmental data table providing quantitative information to support risk prioritization;
    - Decision-making guides integrating traditional ecological knowledge and western science;
    - A geospatial mapping component;
    - Access to best practices and guidance for addressing risks; and
    - Links to other tools relevant to tribal environmental decision-making.

Vision Area 6:
Cross-cutting Program Support

18. Co-Chair of the Climate Change Adaptation and Water Stakeholder Group

Since 2012, the Office of Water has served as co-chair of a newly established Climate Change Workgroup of the Advisory Committee on Water Information (ACWI). The workgroup includes 40 representatives of federal agencies and stakeholder organizations that have come together to provide advice and comment to Federal agencies on a range of climate change and water resources issues, including the progress in implementing the *National Action Plan: Priorities for Managing Freshwater Resources in a Changing Climate.*

19. Supported Development of Climate Technical Training

The Office of Water participated in developing a technical training curriculum that instructs water resources professionals on how to incorporate climate science and its associated uncertainties into hydrologic assessment studies. The project was conducted in partnership with the EPA's ORD, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, Western Water Assessment, and the University Consortium of Atmospheric Research to build the curriculum.

20. Participated in EPA and Interagency Climate Change Adaptation Efforts

National Water Program staff participated in a range of workgroups within EPA and with other federal agencies working to adapt to a changing climate including the:

- EPA Climate Change Adaptation Workgroup;
- Interagency Climate Change Adaptation Task Force;
    - *Fish, Wildlife, and Plants Climate Adaptation Strategy* workgroup;
    - *National Ocean Policy* workgroup on climate change;
    - Freshwater Resources Workgroup;
- Interagency Ocean Acidification Working Group; and
- Coral Reef Task Force.

The Office of Water also has an interagency agreement with NOAA where climate adaptation is a joint focus.

PART II
HIGHLIGHTS FROM CLIMATE CHANGE REGIONS

Climate change poses different challenges in different regions of the country. Highlights of the efforts to adapt water programs to a changing climate in the climate change regions identified in the *2012 Strategy*, and for the large aquatic ecosystem programs implemented by EPA around the country (e.g. Chesapeake Bay, Great Lakes, and Gulf of Mexico) are presented below.

Northeast Climate Region

1. **Initiated Water Champions Program**
   The Water Champions Program is a service-learning partnership program implemented by EPA Region 2. It is designed to encourage development of sustainable, stakeholder driven projects that lead to long-term behavioral changes in local communities, including water conservation that leads to reduced energy use and reduction in greenhouse gas emissions. Through collaboration with local and regional agencies and/or organizations (such as universities, state agencies, schools, etc.) the Water Champions Program identifies a Stewardship Facilitator and works with this person to develop a Water Champions Project in a local community. High school students, at the direction of the Stewardship Facilitator, develop and implement projects aimed at achieving measurable reductions in local and regional water consumption. There are four core objectives to the "Water Champions" Program:

   - Build capacity for organizations to inform the community about the importance of water conservation and the existence of cost saving/water reducing technologies, along with the WaterSense Program;
   - Recruit regional and/or local retailers of water consuming technologies to participate in EPA's WaterSense program;
   - Gather data on the purchase of water efficient technologies and calculate the reduced volume of water used and cost savings associated with these purchases; and,
   - Share project outcomes and look to recruit additional organizations in the area to participate in this service-learning project.

   More information can be found at:
   http://www.epa.gov/region02/p2/other_p2_prog_init_actv.html#other_programs.

Southeast Climate Region

2. **Implemented Cooperative Energy Management Initiative for Wastewater Utilities**
   EPA Region 4 developed and implemented an Energy Management Initiative (EMI) in collaboration with the Tennessee Department of Environment and Conservation to work with water and wastewater public utilities in Tennessee to save energy and reduce their carbon footprint. A group of seven Tennessee water utilities participated in the EMI, which included several site visits and participation in a series of four energy management workshops. The site visits were completed in November 2011 and included energy benchmarking at each utility using Portfolio Manager and a preliminary energy assessment of the utility's facilities. Reports from those visits were presented to the utilities in January-February 2012. The project resulted in:
   - 7,300,000 kWh savings on annual basis;
   - $620,000 energy cost savings annual basis;
   - 7,100 tons carbon dioxide (CO_2) emissions reduction on an annual basis; and
   - Overall energy savings: 16.9%.

   A public recognition event for participating utilities was held in Nashville, Tennessee in October 2012.

Midwest Climate Region

3. **Developed Innovative Aquifer Storage**
   EPA Region 5 issued an operational permit for the Joint Powers Water Board (JPWB) in Minnesota. The Board's Aquifer Storage and Recovery (ASR) program is the first of its kind in Region 5 and is expected to serve as a model for others. The ASR program is currently in the storage phase, recharging the aquifer with potable water during winter and fall months when consumer demand is low. ASR is expected to help the Board realize significant capital savings by modulating daily treatment needs. JPWB captured/stored more than 50,427,000 gallons of treated water in 2012.

Great Plains Climate Region

4. **Organized Forum on Sustainable Materials for Climate Adaptation**
   EPA Region 6 worked to incubate a Sustainable Materials and Pollution Prevention Forum in the Dallas Fort Worth (DFW) area of Texas. The forum continues to serve as a venue for regular meetings of more than 16 cities in the DFW area to share project ideas and results in a variety of sustainability areas that intersect with climate change adaptation. The Forum has been formed and membership continues to grow.

Southwest Climate Region

5. **Improved Water Utility Energy Management**
   EPA Region 9's Sustainable Infrastructure Program completed a comprehensive one-year pilot program of monthly energy management webinars with eight water/wastewater utilities resulting in ten projects that reduced nearly 3,244 megawatt hour (MWh)/year of electricity, greenhouse gas emissions of nearly 2,300 Metric Ton Carbon Dioxide Equivalent (MT CO_2 e)/year, plus nearly $600,000 in reduced operating costs by implementing projects using the Environmental Management Systems approach. Region 9 also partnered with the San Francisco State University and San Diego State University's Industrial Assessment Centers (IACs) to audit 9 wastewater treatment facilities in California, Hawaii and Arizona. The IACs recommended 25 unique energy conservation opportunities which could save a total of $5.5M/year and 27M kilowatt hour (kwh)/year.

Pacific Northwest Climate Region

6. **Incorporated Climate Change into Total Maximum Daily Loads (TMDLs)**
   EPA Region 10 hosted a workshop to kick off work on a Total Maximum Daily Load (TMDL) pilot project investigating how to incorporate climate change into a nonpoint source TMDL. Participants included climate and watershed scientists, staff from the Nooksack Tribe and Lummi Nation, Washington Department of Ecology, EPA ORD-Corvallis Lab, and EPA Region 10.

Montane Climate Region

7. **Added Climate Change to Water Supply Environmental Impact Statements**
   EPA Region 8's National Environmental Policy Act (NEPA) and Section 404 programs have been working with other federal agencies to include climate change analyses in water supply Environmental Impact Statements (EISs). In 2012, EPA advocated for a more quantitative climate change water resources analysis to be utilized in the documents for new water supply projects. These efforts mainly resulted in qualitative analyses of climate change effects. Although EPA has not yet developed generalized watershed information in the region for use in climate change analyses, comments and requests for such analysis from other federal agencies may be influential. A water supply EIS submitted in 2012 and reviewed by EPA Region 10 included a quantitative climate analysis of impacts in the context of climate change. Key partners include the U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, States, and local water providers.

Alaska Climate Region

8. **Conducted Climate Change Webinars for Tribes in Alaska**
   The EPA Anchorage Operations Office, in partnership with the Institute for Tribal Environmental Professionals, hosted quarterly webinars with Tribes in Alaska on climate change impacts, including impacts on water resources. One of these webinars was hosted by the Chickaloon on salmon restoration in light of climate change. Another webinar introduced the State of Alaska's project to assess coastal and riverine erosion and its impacts to landfills and contaminated areas.

Caribbean Islands Climate Region

9. **Used Coastal Zone Management Strategies to Address Coastal Climate Change Issues**
   EPA Region 2 and the Puerto Rico Coastal Adaptation Project (part of the Puerto Rico Coastal Management Program led by NOAA) have been collaborating to:

   - Identify the communities and ecosystems most at-risk from coastal hazards and climate changes using the best available scientific knowledge;
   - Identify, assess, and prioritize effective adaptation strategies and policies that could be implemented in Puerto Rico;
   - Serve as a clearinghouse of climate information for Puerto Rico researchers, planners, government officials, businesses, NGOs, and concerned citizens; and
   - Provide opportunities and space for multi-stakeholder communication on the topic of coastal vulnerability and adaptation.

U.S. Pacific Islands Climate Region

10. **Initiated Coral Reef Protection Strategy**
    EPA Region 9 is working with other federal agencies to develop a Coral Reef Strategy for Hawaii and the U.S. Pacific Territories of Guam, Commonwealth of the Northern Marianas Islands, and American Samoa. Corals in these regions are threatened by climate changes including warming air and water, increased storm intensity, and rising sea levels. Acidification of ocean waters as a result of increases in CO_2 levels in the atmosphere also pose risks to corals, as do water pollution and overfishing. NOAA evaluated 83 species of coral for risk of extinction from climate change-related stressors and has proposed listing 59 coral species in the Pacific Ocean as threatened or endangered under the Endangered Species Act. Region 9 seeks to better focus authorities, technical assistance, and funds for protection of coral reefs in the Pacific Islands, and to provide leadership on the links between coral reef protection and climate change. The Strategy will identify actions needed to protect coral reefs include reducing sources of land based pollution and increasing the resilience of coral reefs to climate change stressors.

Large Aquatic Ecosystems

11. Implemented Climate Change Adaptation Projects for Large Aquatic Ecosystems

Key projects concerning climate change were completed in several U.S. coastal areas:

- The **San Francisco Bay** Large Aquatic Ecosystem program collaborated with the Bay Conservation and Development Commission (BCDC) to identify habitats and infrastructure that are vulnerable to climate change and sea level rise, and to formulate new policies for BCDC's Bay Plan to address these vulnerabilities. For additional information, see http://www.sfestuary.org/projects/detail2.php?projectID=4.

- The new **Puget Sound** Study action plan will include several climate pieces focusing on a potential monitoring program.

- The **Chesapeake Bay** Program reviewed the current understanding of climate change impacts on the tidal Chesapeake Bay and identified critical knowledge gaps and research priorities.

- The **Gulf of Mexico** Program has developed a resilience index for coastal communities and has installed equipment to monitor changes to land and water elevation.

- The Long Island Sound Study used Climate Ready Estuaries funding to develop a **Connecticut Adaptation Resources Toolkit (CART)** that in turn was based on its experience from another Climate Ready Estuary project that involved working with the town of Groton and other federal and state partners to develop a climate change adaptation plan.

- EPA Region 1 and ORD are developing quantitative methods for projecting the likely pollutant (phosphorus, nitrogen, and total dissolved solids) loading consequences of climate change on **Lake Champlain.** This project will provide an example of how climate change can be incorporated into the TMDL process.

Great Lakes and Climate Change

12. Implemented Climate Change Adaptation Projects for the Great Lakes

In 2012, the Office of Water supported several projects in the Great Lakes region related to climate change:

- **Great Lakes Restoration Initiative (GLRI) 2012 Request for Proposals**: Awarded two grants to work with local Great Lakes communities to help them assess their climate vulnerabilities and implement adaptation planning and provided extra credit to any GLRI application that incorporated a sensitivity to climate change implications into their proposed work.

- **GLRI 2012 Interagency Agreements:** Approved climate change information activities under several interagency agreements with federal partners in implementing the GLRI and encouraged all federal partners to incorporate sensitivity to climate change impacts into their GLRI interagency agreements.

- **GLRI Capacity Grants to States and Tribes:** Included climate change planning and adaptation work in some GLRI capacity grants to Great Lakes States and Tribes.

- **U.S. – Canada Great Lakes Water Quality Agreement (GLWQA):** Succeeded in adding a climate change impacts annex to the newly negotiated amendments to the GLWQA with Canada.

PART III
Assessment of Progress:
2012 Baseline

The National Water Program is beginning a new process in 2012 to track progress in implementing climate change response programs based on assessing the stage or phase of development of efforts to implement each of the 19 specific "Goals" identified in the 2012 *Strategy*.

Seven developmental phases for climate change related work are:

1. **Initiation** - conduct a screening assessment of potential implications of climate change to mission, programs, and operations;

2. **Assessment** - conduct a broader review to understand how climate change affects the resources in question;

3. **Response Development** - identify changes necessary to continue to reach program mission and goals and develop initial action plan;

4. **Initial Implementation** - initiate actions in selected priority programs or projects

5. **Robust Implementation** - programs are underway and lessons learned are being applied to additional programs and projects;

6. **Mainstreaming** - climate is an embedded, component of the program; and

7. **Monitor Outcomes and Adaptive Management** - continue to monitor and integrate performance, new information, and lessons learned into programs and plans.

More detailed description of each of these phases of assessment is included in Table I.

Recognizing the long-term nature of work to address climate change, the National Water Program has identified the current (i.e. December 2012) status of work on each of the Supporting Actions in Table II of this report. The 2012 baseline assessment has a total numeric value of 42 out of a total possible score of 133 (i.e., 19 Goals with the potential to achieve a score of 7 for each action equates to a total score of 133). This combined score indicates that many actions to implement goals are in the early stages of implementation.

Future annual progress reports will identify the cumulative progress toward full implementation of the *Strategy* in both narrative and numeric terms.

TABLE I
DESCRIPTION OF PHASES

National Water Program Phases	Explanation	Examples of Evidence of Achievement
1. Initiation	Conduct a screening assessment of potential implications of climate change to mission, programs, and operations	• Preliminary information is developed to evaluate relevance of climate change to the mission or program; a decision is made as to whether to prepare a response to climate change; further exploration of climate change implications has been authorized • Responsibilities are assigned at appropriate levels within the organization and resources are available to develop a more in-depth assessment
2. Assessment	Conduct a broader review to understand how climate change affects the resources in question Work with stakeholders to develop an understanding of the implications of climate change to the mission, programs, and operations	• Review science literature and assessments to understand how climate change affects the resources being protected (threat to mission); Engage internal staff and external stakeholders in evaluation • Identify climate change issues and concerns and communicate with internal and external stakeholders and partners. • Identify which specific programs are threatened and what specific information or tools need to be developed • Communicate findings to partners and stakeholders and engage them in dialogue on building adaptive capacity
3. Response development	Identify changes necessary to continue to reach program mission and goals Develop initial action plan Identify and seek the research, information and tools needed to support actions Begin to build the body of tools, information and partnerships needed to build capacity internally and externally	• Develop initial program vision and goals for responding to climate change. • Identify needed response actions or changes that will allow the organization to begin to address climate impacts on its mission • Initiate strategies and actions in a few key areas to begin to build organizational ability to use climate information in decision processes • Identify program partners' needs for building adaptive capacity • Begin working with an external 'community of practice' to engage in tool and program development • Rudimentary methods are put in place to track progress and options for more formal measures are identified and evaluated • Develop a strategy and partnerships to obtain additional needed research

4. Initial Implementation	Initiate actions in selected priority programs or projects	• Make it clear within the organization that incorporating climate change into programs is critical • Initiate actions and plans identified in Step 3 • Initiate projects with partners • Develop needed information and tools • Initial implementation of measures capable of documenting the extent of implementation of needed actions by partners/stakeholders • Some program partners have begun to implement response actions
5. Robust Implementation	Programs are underway and lessons learned are being applied to additional programs and projects	• Lessons learned are evaluated and strategies are refined • Efforts are initiated to consider climate change in additional program elements • Continue to institute institutional changes to include climate change in core programs, including refinement of measures • External communities of practice are in place to support ongoing capacity development
6. Mainstreaming	Climate is an embedded, component of the program	• The organization's culture and policies are aligned with responding to climate change • All staff have a basic understanding of climate change causes and impacts • All relevant programs, activities, and decisions processes intrinsically incorporate climate change • Measures for documenting progress among partners/stakeholders are well established and supporting program evaluation
7. Monitor Outcomes and Adaptive Management	Continue to monitor and integrate performance, new information, and lessons learned into programs and plans	• Progress is evaluated and needed changes are implemented • As impacts of climate change unfold, climate change impacts and organizational responses are reassessed

TABLE II
SUPPORTING ACTIONS AND 2012 BASELINE ASSESSMENTS/SCORES

Visions and Goals	*Strategic Actions*	*2012 Development Phase / Score*
<u>Infrastructure:</u> In the face of a changing climate, resilient and adaptable drinking water, wastewater and stormwater utilities (water sector) ensure clean and safe water to protect the nation's public health and environment by making smart investment decisions to improve the sustainability of their infrastructure and operations and the communities they serve, while reducing greenhouse gas emissions through greater energy efficiency.		
Goal 1: Build the body of information and tools needed to incorporate climate change into planning and decision making.	SA1: Improve access to vetted climate and hydrological science, modeling, and assessment tools through the Climate Ready Water Utilities program.	Phase: Response Development Score: 3
	SA2: Assist wastewater and water utilities to reduce greenhouse gas emissions and increase long-term sustainability with a combination of energy efficiency, co-generation, and increased use of renewable energy resources.	
	SA3: Work with the States and public water systems, particularly small water systems, to identify and plan for climate change challenges to drinking water safety and to assist in meeting health based drinking water standards.	
	SA4: Promote sustainable design approaches to provide for the long-term sustainability of infrastructure and operations.	
Goal 2: Support Integrated Water Resource Management (IWRM) to sustainably manage water resources.	SA5: Understand and promote through technical assistance the use of water supply management strategies.	Phase: Assessment Score: 2
	SA6: Evaluate and provide technical assistance on the use of water demand management strategies.	
	SA7: Increase cross-sector knowledge of water supply climate challenges and develop watershed specific information to inform decision making.	

Visions and Goals	*Strategic Actions*	*2012 Development Phase / Score*
<u>Watersheds & Wetlands</u>: Watersheds are protected, maintained and restored to ensure climate resilience and to preserve the social and economic benefits they provide; and the nation's wetlands are maintained and improved using integrated approaches that recognize their inherent value as well as their role in reducing the impacts of climate change.		
Goal 3: Identify, protect, and maintain a network of healthy watersheds and supportive habitat corridor networks.	SA8: Develop a national framework and support efforts to protect remaining healthy watersheds and aquatic ecosystems.	Phase: Response Development Score: 3
	SA9: Collaborate with partners on terrestrial ecosystems and hydrology so that effects on water quality and aquatic ecosystems are considered.	
	SA10: Integrate protection of healthy watersheds throughout the National Water Program core programs.	
	SA11: Increase public awareness of the role and importance of healthy watersheds in reducing the impacts of climate change.	
Goal 4: Incorporate climate resilience into watershed restoration and floodplain management.	SA12: Consider a means of accounting for climate change in EPA funded and other watershed restoration projects.	Phase: Response Development Score: 3
	SA13: Work with federal, state, interstate, tribal, and local partners to protect and restore the natural resources and functions of riverine and coastal floodplains as a means of building resiliency and protecting water quality.	
Goal 5: Watershed protection practices incorporate Source Water Protection to protect drinking water supplies.	SA14: Encourage States to update their source water delineations, assessments or protection plans to address anticipated climate change impacts.	Phase: Assessment Score: 2
	SA15: Continue to support collaborative efforts to increase state and local awareness of source water protection needs and opportunities, and encourage inclusion of source water protection areas in local climate change adaptation initiatives.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
Watersheds & Wetlands (continued)		
Goal 6: Incorporate climate change considerations into the Clean Water Act 404 regulatory program as they relate to permit reviews and compensatory mitigation.	SA16: Consider the effects of climate change, as appropriate, when making significant degradation determinations in the Clean Water Act Section 404 wetlands permitting and enforcement program	Phase: Initiation Score: 1
	SA17: Evaluate, in conjunction with the U.S. Army Corps of Engineers, how wetland and stream compensation projects could be selected, designed, and sited to aid in reducing the effects of climate change.	
Goal 7: Improve baseline information on wetland extent, condition and performance to inform effective adaptation to climate change.	SA18: Expand wetland mapping by supporting wetland mapping coalitions and training on use of the new federal Wetland Mapping Standard.	Phase: Initiation Score: 1
	SA19: Produce a statistically valid, ecological condition assessment of the nation's wetlands.	
	SA20: Work with partners and stakeholders to develop information and tools to support long term planning and priority setting for wetland restoration projects.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
<u>Coastal and Ocean Waters</u>: Adverse effects of climate change and unintended adverse consequences of responses to climate change have been successfully prevented or reduced in the ocean and coastal environment. Federal, tribal, state, and local agencies, organizations, and institutions are working cooperatively; and information necessary to integrate climate change considerations into ocean and coastal management is produced, readily available, and used.		
Goal 8: Collaborate to ensure information and methodologies for ocean and coastal areas are collected, produced, analyzed, and easily available.	SA21: Collaborate to ensure that synergy occurs, lessons learned are transferred, federal efforts effectively help local communities, and efforts are not duplicative or at cross-purposes.	Phase: Response Development Score: 3
	SA22: Work within EPA and with the U.S. Global Change Research Program and other federal, tribal, and state agencies to collect, produce, analyze, and format knowledge and information needed to protect ocean and coastal areas and make it easily available.	
Goal 9: EPA geographically targeted programs support and build networks of local, tribal, state, regional and federal collaborators to take effective adaptation measures for coastal and ocean environments.	SA23: Work with the National Water Program's larger geographic programs to incorporate climate change considerations, focusing on both the natural and built environments.	Phase: Assessment Score: 2
	SA24: Address climate change adaptation and build stakeholder capacity when implementing NEP Comprehensive Conservation and Management Plans and through the Climate Ready Estuaries Program.	
	SA25: Conduct outreach and education, and provide technical assistance to state and local watershed organizations and communities to build adaptive capacity in coastal areas outside the NEP and Large Aquatic Ecosystem programs.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
Coastal and Ocean Waters (continued)		
Goal 10: Address climate driven environmental changes in coastal areas and ensure that mitigation and adaptation are conducted in an environmentally responsible manner.	SA26: Support coastal wastewater, stormwater, and drinking water infrastructure owners and operators in reducing climate risks and encourage adaptation in coastal areas.	Phase: Assessment Score: 2
	SA27: Support climate readiness of coastal communities, including hazard mitigation, pre-disaster planning, preparedness, and recovery efforts.	
	SA28: Support preparation and response planning for diverse impacts to coastal aquatic environments.	
Goal 11: Ocean environments are protected by EPA programs that incorporate shifting environmental conditions, and other emerging threats.	SA29: Consider climate change impacts on marine water quality in NWP ocean management authorities, policies, and programs.	Phase: Assessment Score: 2
	SA30: Use available authorities and work with the Regional Ocean Organizations and other federal and state agencies through regional ocean groups and other networks so that offshore renewable energy production does not adversely affect the marine environment.	
	SA31: Support the evaluation of sub-seabed sequestration of CO_2 and any proposals for ocean fertilization.	
	SA32: Participate in interagency development and implementation of federal strategies through the National Ocean Council and the National Ocean Council Strategic Action Plans.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
<u>Water Quality</u>: Our Nation's surface water, drinking water, and ground water quality are protected, and the risks of climate change to human health and the environment are diminished, through a variety of adaptation and mitigation strategies.		
Goal 12: Protect waters of the United States and promote management of sustainable surface water resources.	SA33: Encourage States and communities to incorporate climate change considerations into their water quality planning.	Phase: Assessment Score: 2
	SA34: Encourage green infrastructure and low-impact development to protect water quality and make watersheds more resilient.	
	SA35: Promote consideration of climate change impacts by NPDES permitting authorities.	
	SA36: Encourage water quality authorities to consider climate change impacts when developing wasteload and load allocations in TMDLs where appropriate.	
	SA37: Identify and protect designated uses that are at risk from climate change impacts.	
	SA38: Clarify how to re-evaluate aquatic life water quality criteria on more regular intervals; and develop information to assist States and Tribes who are developing criteria that incorporate climate change considerations for hydrologic condition.	
Goal 13: As the nation makes decisions to reduce its greenhouse gas emissions and develop alternative sources of energy and fuel, the National Water Program will work to protect water resources from unintended adverse consequences.	SA39: Continue to provide perspective on the water resource implications of new energy technologies.	Phase: Initiation Score: 1
	SA40: Provide assistance to States and permittees to assure that geologic sequestration of CO_2 is responsibly managed.	
	SA41: Continue to work with States to help them identify polluted waters, including those affected by biofuels production, and help them develop and implement TMDLs for those waters.	
	SA42: Provide informational materials for stakeholders to encourage the consideration of alternative sources of energy and fuels that are water efficient and maintain water quality.	
	SA43: As climate change affects the operation or placement of reservoirs, EPA will work with other federal agencies and EPA programs to understand the combined effects of climate change and hydropower on flows, water temperature, and water quality.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
<u>Water Quality (continued)</u>		
Goal 14: Collaborate to make hydrological and climate data and projections available.	SA44: Monitor climate change impacts to surface waters and ground water.	Phase: Response Development Score: 3
	SA45: Collaborate with other federal agencies to develop new methods for use of updated precipitation, storm frequency, and observational streamflow data, as well as methods for evaluating projected changes in low flow conditions.	
	SA46: Enhance flow estimation using National Hydrography Dataset Plus (NHDPlus).	
<u>Working With Tribes:</u> Tribes are able to preserve, adapt, and maintain the viability of their culture, traditions, natural resources, and economies in the face of a changing climate.		
Goal 15: Incorporate climate change considerations in the implementation of core programs, and collaborate with other EPA Offices and federal Agencies to work with Tribes on climate change issues on a multi-media basis.	SA47: Through formal consultation and other mechanisms, incorporate climate change as a key consideration in the revised NWP Tribal Strategy and subsequent implementation of Clean Water Act, Safe Drinking Water Act, and other core programs.	Phase: Assessment Score: 2
	SA48: Incorporate adaptation into tribal funding mechanisms, and collaborate with other EPA and federal funding programs to support sustainability and adaptation in tribal communities.	
Goal 16: Tribes have access to information on climate change for decision making.	SA49: Collaborate to explore and develop climate change science, information, and tools for Tribes, and incorporate local knowledge.	Phase: Assessment Score: 2
	SA50: Collaborate to develop communication materials relevant for tribal uses and tribal audiences.	

Visions and Goals	*Strategic Actions*	*2012 Baseline Assessment*
Cross-Cutting Program Support		
Goal 17: Communication, Collaboration, and Training	SA51: Continue building the communication, collaboration, and training mechanisms needed to effectively increase adaptive capacity at the federal, tribal, state, and local levels.	Phase: Response Development Score: 3
Goal 18: Tracking Progress And Measuring Outcomes	SA52: Adopt a phased approach to track programmatic progress towards Strategic Actions; achieve commitments reflected in the Agency Strategic Plan; work with the EPA Work Group to develop outcome measures.	Phase: Response Development Score: 3
Goal 19: Climate Change and Water Research Needs	SA53: Work with ORD, other water science agencies, and the water research community to further define needs and develop research opportunities to deliver the information needed to support implementation of this 2012 *Strategy*, including providing the decision support tools needed by water resource managers.	Phase: Assessment Score: 2
		Total Score: 42 of a possible 133

Appendix A:
Highlights Summary Table

Highlights: National Water Programs

Vision Area 1: Water Infrastructure

1) Issued Water Utility Climate Tool: Version 2.0
2) Published *Adaptation Strategies Guide*
3) Published *Planning for Extreme Weather Events: Workshop Planner for the Water Sector*
4) Published Extreme Events Case Study Series
5) Expanded WaterSense to New Multi-Family Housing and Irrigation
6) Published Planning for Sustainability Handbook for Water and Wastewater utilities

Vision Area 2: Watersheds and Wetlands

7) Published *Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches*
8) Hosted Webcast: *Restore-Adapt-Mitigate: Responding to Climate Change through Coastal Habitat Restoration*
9) Integrated Climate Change in Wetland Program Development Grants
10) Addressed Climate Change in Recovery Potential Screening Methodology

Vision Area 3: Coastal and Ocean Waters

11) Expanded Climate Ready Estuaries Program
12) Hosted Workshop on Coastal Climate Change Vulnerability Assessments
13) Implemented Pilot Projects on Climate Adaptation: Estuary and Utility Cooperation

Vision Area 4: Water Quality

14) Developed Climate Assessment Tool (CAT) for Stormwater
15) Revised *NPDES Permit Writers' Manual* to Address Climate Change
16) Established *Principals for an Energy-Water Future*

Vision Area 5: Working with Tribes

17) Initiated Tribal-Focused Environmental Risk Sustainability Tool (Tribal-FERST)

Vision Area 6: Cross-cutting Program Support

18) Co-Chair of the Climate Change Adaptation and Water Stakeholder Group
19) Supported Development of Climate Technical Training Organize Extreme Events Workshops
20) Participated in EPA and Interagency Climate Change Adaptation Efforts

Highlights: Climate Regions

Northeast Climate Region

1) Initiate Water Champions Program

Southeast Climate Region

2) Implement Cooperative Energy Management Initiative for Wastewater Utilities

Midwest Climate Region

3) Develop Innovative Aquifer Storage

Great Plains Climate Region

4) Organize Forum on Sustainable Materials for Climate Adaptation

Southwest Climate Region

5) Improve Water Utility Energy Management

Pacific Northwest Climate Region

6) Incorporate Climate Change into Total Maximum Daily Loads (TMDLs)

Montane Climate Region

7) Add Climate Change to Water Supply Environmental Impact Statements

Alaska Climate Region

8) Conduct Climate Change Webinars for Tribes in Alaska

Caribbean Islands Climate Region

9) Use Coastal Zone Management to Address Coastal Climate Change Issues

U.S. Pacific Islands Climate Region

10) Initiate Coral Reef Protection Strategy

Appendix B:
Compendium of Additional 2012 Accomplishments

In addition to the accomplishments highlighted for each of the vision areas and climate regions, other important projects are in development and a number of supporting activities are being implemented. A complete summary of activities related to climate change and water programs is provided below.

National Water Program Climate Change Adaptation Accomplishments

Office of Wetlands, Oceans and Watersheds

- In 2012, EPA developed a **Climate Change Risk Management Workbook** designed to assist water resources managers in the development of climate change vulnerability assessments and action plans on an estuary or waterbody basis. The workbook describes a step-by-step process that managers can follow to evaluate climate related risks and develop response actions that fit the conditions and needs of a specific water resource. The workbook is planned for release in late 2013.

- The U.S. Fish and Wildlife Service maintains the National Wetlands Inventory. In 2009, EPA co-led a stakeholder working group (Federal Geographic Data Committee (FGDC) Wetlands subcommittee) to **develop a new standard to support digital mapping of wetlands** for incorporation into the National Wetlands Inventory and the National Hydrography Dataset (NHD). Accurate mapping of wetlands is essential to understanding how climate change may result in changes in wetlands over time. EPA has supported the long-term objective of the FGDC Wetlands subcommittee to complete digital mapping for the country. Specifically, a number of **2012 RFP Wetland Program Development Grants have supported National Wetlands Inventory mapping,** including:

    - Vermont Agency of Natural Resources: Vermont Agency of Natural Resource's proposal aims to strengthen and develop the overall Vermont Wetland Program;
    - DuPage County Wetland Survey and Mapping Project in DuPage County Illinois;
    - Colorado State University FY 2012 Wetland Program Development Grants Stream Mitigation and Mapping project;
    - Developing Key Components of a Coordinated Wetlands Program for the Kenai Peninsula (Keep-Wet) Alaska;
    - Chilkoot Indian Association Wetland Program Planning Capacity Building Project – will include a wetland mapping pilot study; and
    - Washington Historical Mapping and Wetland Program Development.

- The Office of Water is planning a **national conference focused on the linkages between healthy forests and healthy waters**, which will include topics related to climate-induced impacts, sustainability, and economic-based incentives fostering protection and restoration of natural resources including those in floodplains which protect water quality and provide resilience in the face of climate change. The conference is being developed by the American Water Resources Association in partnership with EPA, U.S. Forest Service, The Nature Conservancy, and Pinchot Institute among others. Final topic areas have been agreed upon and a finalized "Call for Abstracts" has been approved by the conference steering committee. The target audience consists of foresters, water resource managers, aquatic ecologists/biologists, land use planners, economists, engineers, water supply purveyors, companies who are major water users, and land managers from the governmental, private, environmental and academic communities.

- EPA and its state, tribal, and federal partners are implementing the first-ever **National Wetland Condition Assessment (NWCA),** a statistical survey of the quality of our Nation's wetlands. This assessment data will help provide a baseline of wetland condition that will help understand changes in wetland condition over time as a result of climate change and other factors. Field crews collected data at 1,179 sites from Florida to Alaska in the summer of 2011. In 2012, EPA processed field and laboratory data from these sites and initiated data validation and quality assurance reviews. During 2013, EPA will continue to validate and perform quality assurance checks on the field and laboratory data, and begin analysis of the data with key federal, state, and academic collaborators. A report detailing the results of the survey will be drafted for public release and comment in 2013.

- EPA serves on the U.S. government delegation to meetings of the London Convention and London Protocol, international ocean dumping treaties, and supported development of several actions related to climate change:

    - On November 2, 2012, Contracting Parties to the London Convention and London Protocol issued a statement of concern regarding an **ocean fertilization** activity reported to have been carried out in July 2012 in ocean waters off the Canadian west coast. See http://www.imo.org/MediaCentre/PressBriefings/Pages/47-ocean-fertilisation.aspx for the International Maritime Organization press release;

    - In November 2012, Contracting Parties to the London Convention and London Protocol adopted revised **international guidance for the Assessment of Carbon Dioxide Streams for Disposal into Sub-Seabed Geological Formations** (2012 CO_2 Sequestration Guidance).

Office of Ground Water and Drinking Water

- The **Climate Ready Water Utilities Toolbox** (a searchable web-based toolkit that contains approximately 600 climate-related resources for water utilities) was updated in February 2012 enabling faster and easier access to the newest and most relevant climate information. The resources available include reports and publications, funding resources, activities, upcoming events, and models and tools for technical information.

- EPA and its partners have published the web-based **Adaptive Response Framework** reference document built on the 2011 National Drinking Water Advisory Council's Climate Ready Water Utilities report. It explains that using an adaptive management approach is important when planning for climate change and highlights aspects to consider throughout the process of becoming "climate ready" including awareness, adaptation, mitigation, policies, community, and partnerships.

Office of Science and Technology

- Work continues in partnership with the U.S. Geological Society (USGS) to develop **estimates of the plausible future hydrologic response of our nation's rivers and streams to climate change**. Presentations describing this work were given by USGS colleagues at the November 2012 Annual Meeting of the American Water Resources Association in Jacksonville, Florida. Work currently focuses on calibrating the Water Balance Model and adapting the USGS gridded Water Balance Model to the NHDPlus waterbody network. Interim products are expected to be ready for peer review in 2013, pending budgetary decisions.

- Completed a hydrologic flow assessment with the state of Virginia in July 2012, described in the technical document, ***Virginia Ecological Limits of Hydrologic Alteration (ELOHA): Development of Metrics of Hydrologic Alteration***. This document ties landscape alteration and flow alteration together and examines the effects on aquatic life. (Partnership with Virginia Department of Environmental Quality).

- The Office of Water is developing a draft **Hydrologic Flow white paper**, in collaboration with EPA Regions, EPA Office of Research and Development, and USGS scientists, which provides technical content and non-prescriptive approaches for considering hydrologic flow. Completion of the white paper is expected in 2013.

Office of Wastewater Management

- In 2012, EPA released the ***2012 Guidelines for Water Reuse***. The 2012 reuse guidelines update and build on the Agency's previous reuse guidelines issued in 2004, incorporating information on water reuse that has been developed since the 2004 document was issued. In addition to summarizing U.S. existing regulations, the

document includes water reuse practices outside of the U.S., case studies, information on planning for future water reuse systems, and information on direct potable reuse and industrial reuse. Disinfection and treatment technologies, emerging contaminants, and public involvement and acceptance also are discussed.

- EPA helped fund a National Research Council study entitled ***Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater.*** The study, which was finalized in 2012, concluded that "environmental buffers do not provide water quality services that cannot also be provided by the use of engineered practices, such as advanced treatment and constructed storage facilities. Although environmental buffers remain useful elements of water treatment systems that should be considered alongside other options, they are not essential elements to reach water quality goals."

- The Office of Water posted the **Green Infrastructure Permitting and Enforcement fact sheets** on the green infrastructure website, discussing how municipalities can incorporate green infrastructure into sanitary sewer overflow (SSO), combined sewer overflow (CSO), and MS4 permitting and enforcement. The facts sheets are available at: http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries.

- EPA worked with the White House Council on Environmental Quality (CEQ) to hold a **green infrastructure conference** in September 2012 in which approximately 90 green infrastructure experts from across the country gathered to discuss opportunities for and barriers against green infrastructure.

- In July 2012, the Office of Water began a series of **technical assistance projects with 17 communities** in 16 states. The projects include code reviews to eliminate barriers to green infrastructure in local codes and ordinances, design guidance for particular sites/ contexts, and cost - benefit analyses of the multiple benefits of green infrastructure. These projects are ongoing and will be completed by December 2013

- In September 2012, the Office of Water launched the ***Campus RainWorks Challenge*** for college and university students - a design competition to engage students in green infrastructure design. 370 teams are participating from 46 states. The competition closed at the end of the fall semester and winners will be announced in April 2013.

- The Office of Water completed an **Energy Management Progress Report** documenting national and Regional efforts to assist utilities in developing energy management plans based on EPA *Energy Management Guidebook*. Three webinars on energy management for utilities were conducted.

Climate Change Adaptation Accomplishments Related to Water in EPA Regions

Region 10

- With seed money from EPA Region 10 and additional support from other sponsors, Washington State University Extension Energy Program led a planning team to design a **workshop series focusing on energy efficiency for water and wastewater utilities** in western Washington. Two workshops were conducted in 2012 with ten utilities participating. Partners include Bonneville Power Administration, Puget Sound Energy, Zero Waste Alliance and the EPA. The utilities participating in this series will learn approaches and techniques leading to reduced energy consumption.

- EPA Region 10 is working with the Washington Department of Ecology, the Lummi Nation, and the Nooksack Tribe to identify the best way to **integrate available climate change data into Ecology's TMDL for temperature stress on salmon** in the South Fork Nooksack River, Washington. This will provide a case study of both process and climate change science as a basis to support future decisions. Examining the way temperature can be improved in the Nooksack watershed in order to support salmon restoration is a high priority for the Nooksack and Lummi Tribes. The climate change pilot will identify available science for the watershed, and document technical issues in a parallel effort to the ongoing TMDL.

- Consistent with the **Puget Sound Action** Agenda, EPA Region 10:

    - conducted an erosion survey to evaluate **sea level rise** threat in San Juan County;
    - mapped habitat and infrastructure vulnerability in Puget Sound and restoration potential for reducing climate change vulnerability; and
    - worked with several Tribes and counties to incorporate climate change in their plans and/or analyses.

Region 9

- Region 9 focused on the development and **beneficial use of biogas at wastewater treatment facilities**. Primary areas of emphasis in 2012 included working to expand the Region 9 Biogas Mapping Tool, researching biogas characteristics, and working with California agencies and other interested entities to remove technical and regulatory barriers that currently discourage the use of biogas.

- With American Recovery and Reinvestment Act of 2009 (ARRA) funds, EPA Region 9 and the Hawaii Department of Health held targeted workshops on each of the main Hawaiian Islands for **field energy audits at four major wastewater treatment plants in Kauai, Honolulu, Maui, and Hawaii counties**. In 2012, Honolulu County received a

Clean Water State Revolving Fund loan from the Hawaii Department of Health to support implementation of audit recommendations at the Kailua Wastewater Treatment Plant. This **cogeneration and energy conservation project will construct a facility to convert methane to electricity at the wastewater treatment plant**.

Region 8

- Through the Sustainable Water Infrastructure Program, Region 8 promoted **utility energy efficiency through outreach, training, workshops, and incentives.** This activity stresses the adoption and use of cost-effective technologies and management strategies to enhance energy efficiency at water and wastewater utilities. The Region worked with 13 utilities to benchmark energy use, complete process audits, and develop energy management plans. The utilities worked with EPA and its partners on follow-up activities to facilitate implementation of their plans. Eleven of 13 utilities are actively implementing some or all of the efficiency opportunities identified. Average savings, excluding Denver Metro Wastewater, equal $57,166/year and 750,235 kWh/year, equivalent to 517 $MTCO_2e$. Denver Metro identified almost $800,000/year and 1,752,917 kWh/year in annual energy cost savings, equivalent to 1,209 $MTCO_2e$.

- The first **WaterSense labeled affordable home** in the nation was recognized in Region 8. The home, in Colorado, was built by Habitat for Humanity of Metro Denver to the specifications of EPA's three labeled home programs - ENERGY STAR, Indoor airPLUS and WaterSense. Representatives of WaterSense have been involved in numerous speaking engagements to promote the WaterSense label for new homes, and to educate consumers about the Program. A webinar was given by ENERGY STAR, Indoor airPLUS and WaterSense for various state chapters of the U.S. Green Building Council that showcased how these programs are a component of LEED.

- In EPA Region 8, Colorado Springs Utilities was selected as **WaterSense Promotional Partner of the Year**. Not only have they promoted WaterSense, but they have also offered rebates for water-saving products, and have a new home in their jurisdiction built to WaterSense specifications.

Region 7

- During 2012, EPA Region 7 worked with the Wichita State Environmental Finance Center to conduct four workshops on **energy management for a group of five pilot communities** in the Wichita area. During workshops, participants from municipal water utilities learned how to assess energy use and develop plans for improving energy efficiency. Climate change was discussed as one of the reasons to improve utility performance and reduce greenhouse gas emissions produced by the coal-fired power industry. The five cities are currently implementing projects that each have committed to undertake along with monitoring and measuring to record achievements. Partners in this effort included the Environmental Finance Center at Wichita State University,

Kansas Department of Health & Environment, Pollution Prevention Institute at Kansas State University, Kansas Municipal Utilities, Kansas Energy Office, Westar Energy, and Schneider Electric.

- **Water Sense Program** in Region 7 gained four new partners in 2012. The new partners include two irrigations partners, one promotional partner and one building partner.

- EPA Region 7 supported Kansas Department of Health and the Environment implementation of an **asset/energy management training on small systems** conducted with Wichita-Environmental Finance Center and Kansas Municipal Utilities focused. The Department hosted workshops in each field office with follow-up on a case-by-case basis if requested.

- EPA Region 7 worked with the States and public water systems, particularly small water systems, to **identify and plan for climate change challenges to drinking water safety** and to assist in meeting health based drinking water standards. The Region also worked with State Water and Wastewater Agency Response Network (WARN) networks to host trainings for improved planning and encourage inclusion of source water protection areas in local climate change adaptation initiatives, especially in drought impacted areas.

Region 6

- EPA Region 6 worked with **communities along the Mexico Border to improve energy efficiency at water facilities.** The Region developed a Pumping System Assessment Tool and provided training to water and wastewater utility operators of systems along the border. Operators learned how to assess the energy efficiency of pumps and motors and to consider operational changes or capital improvement upgrades to more efficient pumps/motors. The Region also conducted a workshop with utility managers from four communities along the border to increase awareness of developing and implementing an energy management plan. Two energy management webinars that highlighted energy management practices at water and wastewater utilities as well as ways to reduce energy consumption were also conducted.

- EPA Region 6 continues to work with the Louisiana Department of Natural Resources on the development of its primacy delegation **application for Class VI CO_2 geosequestration injection wells**. To date, no other Region 6 state program has indicated that they are actively pursuing Class VI delegation.

- In Dallas, EPA Region 6 partnered with Delta Faucet Company, along with local Green Plumbers, Innerline Plumbing and Andress Plumbing, to **complete replacements with WaterSense-labeled showerheads, faucet aerators and toilet flappers** at 12 non-profit organizations that run facilities to help the homeless find shelter and temporary

housing. These organizations did not have the budget to pay for these much needed plumbing repairs and replacements. Delta Faucet, along with BrassCraft and Neoperl, donated the water efficient products. Andress Plumbing and Innerline Plumbing donated the labor and installation materials.

- To make it easier for businesses to sign up for these programs, EPA Region 6 created a **Green Bundling Program**. This program provides a single point of contact at EPA and consolidates the applications into a single form. This saves environmentally conscious businesses time, money, and bureaucratic delays that can stall innovative projects. This creates a "win-win" situation for EPA and the business community.

- Region 6 continues to provide **technical assistance to incorporate relative sea level rise (land loss) projections and other adaptive measures into the post-Katrina and post-Deepwater Horizon oil spill coastal planning efforts for Louisiana**. The objective of this participation is to increase coastal community sustainability and decrease coastal habitat vulnerability as part of the feasibility planning, design, and construction of some of the largest flood damage risk reduction features in the nation.

Region 5

- Region 5 teamed up with WaterSense Partner Delta Faucet Company to fix water leaks in Chicago housing developments during the 2012 EPA-sponsored **Fix-a-Leak Week**. The Chicago effort led to an estimated leak removal of 1 million gallons per year. The Region participated in the Minnesota state fair, helping Minnesota celebrate the very first statewide WaterSense Day. Region 5 added 50 new WaterSense Partners in 2012.

- Watershed planning and implementation work in Region 5 under both ARRA and 319 programs has enabled additional cross-programmatic considerations, including **green infrastructure that improves watershed resilience and improves adaptation to a changing climate.** Water utility needs and outputs have been, and increasingly are, considerations for comprehensive watershed plans. Most watershed plans now include green infrastructure best management practices as a way to address nonpoint source pollution, but the practices also have the effect of assisting flow and water quality related to treatment plant operations.

- Region 5 concluded the **Indiana Energy Management Pilot** in 2012. For the 10 utilities who participated, annual natural gas use decreased by 34% on average and electricity use decreased by 15%, translating to $234,000 saved annually for the group. Published outputs from the pilot are posted at: http://www.epa.gov/r5water/energymanagement/index.html, including fact sheets for each participant, a summary report with recommended action, and supplemental documents.

Region 4

- EPA Region 4 worked with National Estuary Programs across the Region **to implement a range of projects related to climate change focusing on sea level rise.** Some of these projects were:

    - Albemarle Pemlico NEP partnered with the North Carolina Division of Public Health and East Carolina University to map coastal assets at risk from sea level rise;
    - Indian River Lagoon NEP funded the Balmoral Institute for a project titled "Prioritizing TMDLs Using Seagrass Habitat Vulnerability to Sea Level Rise";
    - Sarasota Bay NEP collaborated with Sarasota County and Florida Sea Grant Program to integrate sea level rise and climate change into the 'Post-Disaster Redevelopment Plan' process; and
    - Tampa Bay NEP participates in an information and technology exchange with scientists and water managers in The Netherlands through the "Resilient Tampa Bay" program sponsored by the University of South Florida.

- Region 4 submitted comments on a **Class V CO_2 experimental permit application and draft Underground Injection Control permit** which was eventually issued by the Alabama Department of Environmental Management to Denbury Onshore. Additionally, prior to the Class V CO_2 experimental permit application being withdrawn by the permit applicant, Tampa Electric Company, Region 4 submitted comments to the Florida Department of Environmental Protection on a Class V CO_2 experimental permit application for a proposed CO_2 sequestration project near Tampa, Florida. In 2012, Region 4 received and reviewed post injection monitoring reports from permittees for two Class V CO_2 experimental wells in Kentucky (Direct Implementation state).

- EPA Region 4 is working with EPA Region 1 to develop **tools that can be used by the Federal Emergency Management Agency (FEMA) during Presidential Declared Disasters** so opportunities for energy efficiency and energy improvements can be identified and implemented as part of the emergency repair and replacement assistance from FEMA. EPA Regions 4 and 1 are participating with EPA Headquarters in development of a joint workgroup with FEMA to discuss and explore this issue.

- In 2010, FEMA and EPA Region 4 signed a Memorandum of Agreement that is designed to enhance the agencies' collaboration on the **use of smart growth approaches in communities that have been impacted by disasters, and to provide information to communities that are planning to minimize weather-related impacts.** In 2011, the state of North Carolina also expressed support for sustainable communities and establishment of a sustainability workgroup at the state level. As these actions raised the potential interest of communities in piloting climate adaptation projects, EPA and FEMA announced an opportunity for technical assistance. In 2012, two communities—New Bern and Wilmington—were selected as pilot locations. The technical assistance

consisted of two-day workshops held onsite to evaluate and propose **approaches to deal with local sea level rise issues that will increase with climate change.** The New Bern project focused on challenges related to storm surge from the Neuse River that occurs during hurricanes and other significant storms, in particular in a low-wealth downtown neighborhood. The Wilmington project was designed to address the threat of storm surge to grey infrastructure that will increase due to sea level rise predicted to occur more frequently in the future.

Region 3

- EPA Region 3 and Pennsylvania Department of the Environment developed **"Weathering Change"** in which the agencies work with the community to foster understanding of the weather-related changes that are beginning to happen in the community. They maintain extensive information on their website, targeted to communities, on how to prepare for climate change, covering issues such as flooding, stormwater and coastal erosion. The agencies hosted a Climate Change Roundtable over the course of a year and a half and hosted an "Out of Harm's Way" day-long forum on managing climate change impacts in the communities around the Delaware Estuary.

- The Region 3 Energy Team is working with state and local partners to develop and present **courses in energy audits** in 2013. The Region is also planning on working with local journals and newsletters from various organizations related to water and wastewater to do more articles on energy audits.

- A comprehensive landscape condition assessment for non-tidal wetlands in Region 3 was completed under a collaborative agreement between Penn State University and the Virginia Institute of Marine Science. The assessment characterizes the capacity of every mapped wetland (i.e., in the National Wetland Inventory database) in Region 3 to provide water quality and habitat services using remotely sensed data. The project will also diagnose the dominant stressors affecting wetland condition in each state and ecoregion in the Mid-Atlantic. The data will be valuable to the Region for establishing **baseline wetland condition and will increase the ability to track changes that may occur as a result of climate change**. Additionally, the data can be used to move toward more targeted watershed initiatives.

Region 2

- EPA Region 2 worked with New York State to include a strategic goal in the annual workplan to address and document the basis (including the use of mixing zones) for Clean Water Act 316(a) thermal variance determinations. The New York Department of Environmental Conservation is currently working with EPA to determine how to best evaluate, document, and consider the **thermal and biological impacts of Clean Water Act 316(a) determination in permits in the context of climate change.**

- EPA Region 2 participated with the EPA's Global Change Impacts and Adaptation Group and Tetra Tech, Region 1, and scientists from State bioassessment and biomonitoring programs on an analytic foundation for a **pilot climate change monitoring network for freshwater medium-high gradient streams in New England and New York.** The steering group also assisted with the development of decision points, including regional reference criteria, stream classification and vulnerability assessment priorities. The vulnerability assessment focused on three categories: (1) low flow events and warming temperatures, (2) shift in the timing of winter/spring runoff, and (3) peak flow events. The final products include maps of catchments and sampling sites classified by different types of vulnerabilities to climate change effects. Recommendations include the selection of 30 sites across the region, common sampling methodologies, and a list of parameters to collect.

- Region 2 began a dialog with the tribal nations regarding climate change adaptation and **Total Ecological Knowledge (TEK)**. EPA Region 2 provided a climate change grant to the Nations in September 2011, which has been extended through September 2013. Under this grant activities are underway by the nations who are meeting, gathering and sharing data, discussing the hired consultant's report of vulnerability assessment of nation lands, and also planning climate adaptation strategies. Three nation climate adaptation strategies will be prepared and submitted to Region 2 as an output of the grant - one for a consortium of four nations; one for the Seneca Nation and one for the ocean coastal Shinnecock Nation).

- Region 2 sought and received Regional Applied Research Effort (RARE) funding to quantify the role of ribbed mussel populations in promoting salt marsh accretion and nutrient removal. Partners included EPA ORD at Naragansett and the Partnership for the Delaware Estuary (PDE).

- Region 2 conducted "energy roundtable meetings" in New Jersey attended by environmental engineers and wastewater operators that and spread awareness on energy efficiency by:
    - Providing energy efficiency and sustainability training
    - Benchmarking and EPA software tools
    - Promoting New Jersey Board of Public Utilities programs
    - Exchanging technical information of technologies and management practices
    - Exchanging real world experience

Region 1

- In EPA Region 1, over 100 municipal water/wastewater facilities participated in roundtable discussions and have been **trained on energy management plans.** Two wastewater facilities are near Zero Net Energy and at least four others are working on plans to reach Zero Net Energy. Nearly $139M in ARRA, State Revolving Funds (SRFs),

and State and Tribal Grant Program (STAG) funds has been invested in energy projects in water/wastewater facilities since FY 2008.

- EPA Region 1 supported development of a **sustainability model for Narragansett Bay** that evaluates nitrogen reduction options and their impact on energy/climate issues, water quality improvements and social and economic goals. This model will be tested to evaluate whether it should be adapted for other watersheds.

- Casco Bay Estuary Partnership and the Piscataqua Region Estuaries Partnership are working with the New England Environmental Finance Center, based at University of Southern Maine, to use its **COAST model in evaluating the economic vulnerability of communities in their watersheds to sea-level rise and coastal flooding**, focusing on Portland, Maine and Hampton/Seabrook, New Hampshire. The project has included multiple stakeholder meetings for each area and the development of adaptation recommendations.

- Piscataqua Region Estuary Partnership replaced the first high-priority undersized culvert identified in its 2010 Climate Ready Estuaries-funded **Oyster River Culvert Assessment Report** (during dry summer 2012 conditions) and will work to incorporate findings into hazard mitigation plans to possibly become eligible for FEMA funding to replace additional culverts. In addition, Casco Bay Estuary Partnership applied the culvert assessment and prioritization approach from the Piscataqua Region Estuaries Partnership project throughout the entire Casco Bay watershed, a great example of tech transfer.

- EPA hosted a successful regional **Climate Ready Estuaries "lessons learned" workshop** attended by over 80 individuals from NEPs, Federal agencies, States, local governments, and NGOs. In partnership with Headquarters, EPA Region 1 will produce a "lessons learned" brochure based on the workshop to disseminate widely across the region.

- EPA Region 1 is an active member of the **New England Federal Partners, which recently established a climate change workgroup** to coordinate and share information about cross-agency climate change concerns and actions. EPA and NOAA co-chair this committee.

- Light Detection and Ranging (LiDAR) data has been acquired for the Northeast coastal zone through a state-federal partnership with EPA support. LIDAR data provide highly accurate topographic data and is a key tool in development of state and local plans for **adapting to risks posed by sea level rise and storm surges**. EPA Region 1 is working to disseminate LiDAR products as they are released, and develop a prioritized list of areas for new LiDAR data collection in order to strategically obtain LiDAR for all of New England.

- EPA Region 1 worked with New Hampshire Department of Environmental Services to finalize a report and GIS (geographic information systems) maps that **identified drinking water infrastructure at risk of flooding** and status of generator coverage at drinking water utilities in 2011 and 2012. A community-based water emergency exercise was conducted in a vulnerable community based on a flood/climate change scenario.

- In partnership with New England Water Works Association, two New England Water Emergency Response Conferences were held (one in New Hampshire, one in Connecticut) with a **spotlight on mapping climate change messaging for the water sector**.

Appendix C:
Summary of 2012 Research Highlights

Major accomplishments of the EPA Office of Research and Development in 2012 related to climate change and water resources are summarized below.

1) Eco-regional Analysis of Nearshore Sea-Surface Temperature (SST) in the North Pacific

This work assembled a 29-year nearshore time series of mean monthly sea surface temperature (SST) along the North Pacific coastline using remotely-sensed satellite data. The data were used to describe nearshore (<20 km offshore) SST patterns of 16 North Pacific ecoregions delineated by the Marine Ecoregions of the World (MEOW) hierarchical schema, as well as SSTs in the U.S. Arctic ecoregions. The quantification of sea surface temperature SST is extremely important because it influences the distribution, migration, and invasion of coastal species. Near-shore and estuarine environments provide critical habitat to most fisheries resources and are likely to be impacted by climate change. The present analysis and processed data enable climate modelers and ecologists to assess future changes in SST and can be used in predictions of potential impacts of near-shore temperature increases using current patterns of species' distributions and temperature regimes.

2) Decision-making Framework to Evaluate the Full Costs and Benefits of Different Mitigation and Adaptation Actions

This research is developing approaches to evaluate costs and benefits of adaptation efforts for water utilities. The work describes the cost-carbon footprint calculation and Pareto optimization techniques to support decision making in water infrastructure expansion, and also includes development of a process engineering procedure with examples to calculate water consumption and wastewater generation in alternative fuel production systems and conventional coal-fired power plants. Research in this project also included development of a GIS-based model and program for calculation of water conservation achieved using alternative adaptive urban planning scenarios.

3) Regional Coordination and Implementation of Climate Change Mitigation and Adaption; Region 10 Pilot

This research and its results are designed to inform Region 10 and the Office of Water about how to consider climate change in water quality temperature impairments for TMDLs. The initial efforts of this work resulted in a negotiated work plan with Region 10. Input was solicited from key stakeholders to identify the scope, approach, methods and study design, and was incorporated into a formal research plan. The plan's development included substantial Tribal involvement by the Nooksack Indian Tribe and Lummi Nation and is supportive of the Tribal Science Priorities for Climate Change and Traditional Ecological Knowledge (TEK).

The applied research plan outlines a parallel study strategy that is being used to concurrently accomplish both a Research Objective (Start-To-Finish Climate Change TMDL Pilot) and a Regulatory Objective (South Fork Nooksack River, Washington Temperature TMDL). This research was developed in response to Region 10's stated preference for a Climate Change Pilot to implement a "learn by doing" approach for climate change adaptation. Phase 2 (Research Analysis and Risk/Vulnerability Assessment) is proceeding on schedule and will be followed by an EPA report scheduled to be completed in 2014.

4) Water Demands of Future Energy Portfolios under a Changing Climate

This analysis compares different scenarios of future energy portfolios to assess regional differences in water needs as well as aggregate water demand for transportation energy, and how those trade off against greenhouse gas emissions reductions. The research relied upon a nine-region model of the integrated U.S. energy system represented in the MARKAL (MARKet ALlocation) energy systems model to map the changes in water withdrawal and consumption during a transition to a low carbon-emitting U.S. transportation fleet. The study evaluated alternative scenarios both with and without carbon constraints, while varying the pace of vehicle electrification. Results indicate that the regional water demand and interregional transfers of embodied water could be significant as the light-duty vehicle (LDV) fleet moves away from petroleum-based fuels toward a more heterogeneous LDV fleet and fuel mix, with exports of embodied water on the order of hundreds of billion gallons of water per year for ethanol coming from the Midwest. Interregional transfers of water embodied in electricity may also reach tens of billion gallons of water per year. However, these water requirements will vary substantially based on the light-duty vehicle mix, carbon policy, electric power generation mix, biofuel production levels, and feedstock characteristics. Water consumption associated with energy could increase from less than 3,000 Bgal/yr in 2005 to over 6,000 Bgal/yr by 2035.

5) The Role of Nitrogen in Climate Change and the Impacts of Nitrogen-Climate Interactions on Terrestrial and Aquatic Ecosystems, Agriculture and Human Health in the United States

This report reflects discussions and perspectives of participants at a recent workshop on climate change and the nitrogen cycle. Key findings specifically related to climate and water were identified. One point is that the effect of climate change on nitrogen processing in fresh and coastal waters will be felt most strongly through changes to the hydrologic cycle, and that alterations in the amount, timing, frequency, and intensity of precipitation and hydrologic manipulation by human infrastructure and climate change will affect input and removal rates of reactive nitrogen. Further, without mitigation, the concurrent impositions of climate change and the increasing load of nitrogen to freshwater and estuarine ecosystems will most likely have unprecedented additive or synergistic effects on water quality, aquatic biodiversity, human health, and fisheries. Another important finding related to nutrients and water quality is with regards to the application of nitrogen as a fertilizer. Crop demand for nutrients is highly dependent upon climate and climatic variability, so improved nutrient use management will be increasingly challenging under climate change scenarios of more variable climatic patterns.

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