III. National Water Program: Climate Change Response Actions

Climate change will result in significant impacts on water resources. Water program managers need to define goals for responding to climate change and identify key response actions to be implemented to accomplish these goals over the coming years.

Five major goals for the ***National Water Program Strategy: Response to Climate Change*** are:

Goal 1: Water Program Mitigation of Greenhouse Gases: use water programs to contribute to greenhouse gas mitigation;
Goal 2: Water Program Adaptation to Climate Change: adapt implementation of core water programs to maintain and improve program effectiveness in the context of a changing climate;
Goal 3: Climate Change Research Related to Water: strengthen the link between EPA water programs and climate change research;
Goal 4: Water Program Education on Climate Change: educate water program professionals and stakeholders on climate change impacts on water resources and programs; and
Goal 5: Water Program Management of Climate Change: establish the management capability within the National Water Program to engage climate change challenges on a sustained basis.

These five major goals are supported by more specific objectives and Key Actions to be implemented by the National Water Program. The Key Actions are highlighted throughout this section. Some Key Actions would expand existing efforts to better address climate change while others are new actions specifically focused on climate change issues. All the actions in this ***Strategy*** are to be initiated within the next two years (i.e., FY 2008 or 2009). Appendix 2 includes a summary of Key Actions and supporting information, including the water program office responsible for implementing the action.

The Key Actions described throughout this document were selected with several general principles in mind.

1. **Define Areas of Uncertainty:** Key Actions included in this document draw on the best available science. Every effort has been made to understand uncertainty related to the action and to defer actions not supported by sound science. Given the uncertainty associated with some climate change impacts on water resources, it will be important for water programs to be able to clearly measure water-related climate impacts, to adapt program management based on new information, and to conduct research needed to address issues.

2. **Evaluate Proactive and Reactive Actions:** Some actions seek to proactively avoid the consequences of climate change (e.g., protecting wetlands) while others react to these consequences (e.g., protecting infrastructure facilities against flooding). Given uncertainty, proactive policies can result in needless costs while reactive policies can be much more expensive than avoiding the problem in the first place. Careful balancing of these concerns is needed.

3. **Guard Against Unintended Consequences:** Actions to address climate change can have unintended consequences that need to be understood (e.g., hardening of sea defenses around a water infrastructure facility can shift rising sea levels to inundate wetlands or other infrastructure) and should be weighed in implementation plans.

1. Greenhouse Gas Mitigation Related to Water

The largest sources of emissions and of potential reductions of greenhouse gases are from the electricity generation, transportation and industry sectors. However, reductions of greenhouse gases associated with water programs can play a role in America's efforts to reduce greenhouse gases, and such reductions would contribute to meeting the President's goal of an 18 percent reduction in greenhouse gas intensity by 2012.

Goal 1:
Water Program Mitigation of Greenhouse Gases: use water programs to contribute to greenhouse gas mitigation.

Many of the actions that can help reduce greenhouse gas releases also help conserve scarce water supplies and help improve water quality. Water conservation is a "win-win-win" situation—in many cases a single program investment will have greenhouse gas, water supply, and water quality benefits, and will lead to economic savings and greater sustainability of water infrastructure.

A range of Key Actions related to water programs that lead to mitigation of greenhouse gases are described in the following sections:

- water-related energy conservation/production;
- water conservation;
- "green building" design and "smart growth;" and
- direct greenhouse gas emissions mitigation from agriculture.

In addition, EPA recognizes that water pollution control processes can be energy intensive and, where authorized by statute, will consider the energy and potential climate change implications of clean water and drinking water regulations.

If creation of greenhouse gases cannot be avoided, these gases can be sequestered so that they are not released to the atmosphere. Carbon dioxide sequestration refers to the process of capturing carbon dioxide to prevent release to the atmosphere. Sequestration activities related to water programs include:

- geologic sequestration of carbon through underground injection; and
- "biological" carbon sequestration through forestry and agricultural practices, many of which benefit water resources.

A. Water-Related Energy Conservation/Production

OBJECTIVE:
Promote water-related energy conservation.

Drinking water and wastewater facilities, both public and private, spend billions of dollars a year on energy to collect, treat, and deliver clean water—with much of this cost borne by ratepayers. Pumping water, including pumping and conveyance of wastewater to treatment plants, and distribution of treated water to customers, are generally the most energy intensive components of water and wastewater systems. Energy

is also required to treat wastewater and to treat water to drinking water standards, and for collection and distribution. Nationwide, drinking water and wastewater utilities use 75 billion kilowatt hours (Reardon 1994)—resulting in the emissions of approximately 116 billion pounds of CO_2—per year.

Energy use by drinking water and wastewater facilities accounts for approximately three percent of the United States' energy consumption (Reardon 1994). Drinking water and wastewater treatment facilities have the potential to achieve 15–30 percent energy savings (CEE 2007, p.1) by implementing energy conservation measures alone, and even more with on-site energy generation. Drinking water and wastewater treatment facilities have the capacity to generate and use energy from low-head hydroelectric, solar and/or wind power, while wastewater treatment facilities also have the capacity to generate energy from capture and use of methane.

Pumping is typically the major use of energy in the treatment stage, although the amount of energy used by drinking water facilities is also affected by the quality of the source water. Most energy consumed by wastewater facilities is for aeration, pumping, and solids processing. Energy requirements for biosolids processing vary according to the method used. Pump and blower motors can account for more than 80 percent of a wastewater utility's energy use (EPA 2006). Although lagoons use little energy, trickling filters used in attached growth processes and aeration in activated sludge systems require large amounts of energy. Advanced treatment also requires a great deal of energy, particularly denitrification and membrane filtration processes. The energy required for the handling, transport, and beneficial use of treated residuals increases as the distance from the treatment site to the disposal/application sites increases.

Energy consumption by drinking water and wastewater treatment facilities is likely to continue increasing. New or revised drinking water treatment requirements could also heighten energy consumption. Further, reduced supplies and increased demand will require pumping water greater distances. Climate change will lead to higher temperatures that will likely result in buildings and unit processes needing more cooling. Changes in rain patterns in some areas may increase combined sewer overflow (CSO) and sanitary sewer overflow (SSO) events while in other areas declining in-stream flows will cause reduced assimilative capacity for wastewater effluent, both of which may require greater treatment for sediments, pathogens, and nutrients.

To improve water and wastewater energy efficiency, EPA's ENERGY STAR program has developed a "Focus" in the water and wastewater industries. An ENERGY STAR Focus is a targeted effort to improve the energy efficiency within a specific industry or combination of industries. A Focus creates momentum for continuous improvement in energy performance, provides the industry's managers with the tools they need to achieve greater success in their energy management programs, and creates a supportive environment where energy efficiency ideas and opportunities are shared. The National Water Program will continue working with the ENERGY STAR program to promote energy efficiency in this sector.

Several provisions of the Clean Water Act speak directly or indirectly to the question of energy efficiency in wastewater treatment. For example:

- section 313(b) of the Act encourages demonstration of innovative processes and techniques for more efficient use of energy at Federal wastewater treatment facilities;
- section 304(d)(3) of the Act encourages development of innovative processes and techniques for publicly owned (wastewater) treatment works (POTWs), including those processes described under section 201(g)(5), that take into account the more efficient use of energy (e.g., variable frequency drive motors reduce energy use of pumps by up to 50 percent); and
- under sections 304(b)(1)(B), 306, and 307 of the Clean Water Act, the National Water Program develops effluent limitations guidelines (ELGs) for industrial (non-POTW) facilities and the use of energy in these processes is one consideration in the development of the guidelines.

Significant progress is being made in the development of new tools for benchmarking energy performance among public water and wastewater utilities. For example, the ENERGY STAR program is expanding the capability of its Energy Performance Rating System (EPRS) to enable drinking water and wastewater utilities to assess their energy use over time and compare it to other utilities—normalized for weather and facility characteristics. As of October 2007, wastewater treatment plant energy performance can be rated using the ENERGY STAR program's on-line tool, Portfolio Manager. Portfolio Manager can be used to establish baseline energy use, prioritize investments, set goals, and track energy use and carbon emissions reductions over time. The ability to rate the energy performance of drinking water treatment and distribution facilities is still under development.

A related effort is the development of audit and tracking systems. For example, a Supervisory Control and Data Acquisition (SCADA) system monitors the operation of water-system control points such as pumps, reservoirs, and metering stations, while keeping track of energy usage. Other types of databases, such as the Washington D.C. Blue Plains wastewater treatment facility's Energy Information System, keep track of energy use and cost, broken down by the facility's processes.

In addition to saving energy, public and private drinking water and wastewater facilities can produce energy to offset what they would otherwise need to buy from local power utilities. The National Water Program could also work with the Office of Air and Radiation to promote these practices. Many facilities have already installed alternative energy power production facilities, including solar, wind, and hydro, for heating and electricity generation. For example, Calera Creek Water Recycling Plant in Pacifica, CA is using solar panels that provide 10–15 percent of its energy needs, resulting in an estimated $100,000 savings annually in energy costs (EPA 2006).

Wastewater facilities can also generate energy from the capture and use of methane. Combined Heat and Power (CHP) systems can recover biogas (a mixture of methane, carbon dioxide, water vapor, and other gases) from anaerobic digesters to heat buildings or to generate electricity. For example, San Francisco's East Bay Municipal Utility District (EBMUD) captures and uses biogas to generate enough energy to cover 90 percent of energy needed at its main wastewater facility. If all 544 large sewage treatment plants in the U.S. operating anaerobic digesters were to install combined heat and power, about 340 megawatts of clean energy could be generated, offsetting 2.3 million metric tons of carbon dioxide emissions annually (i.e., equivalent to planting about 640,000 acres of forest, or the emissions of about 430,000 cars) (EPA 2007n).

This power is also marketable as "green power" to power utilities that are now required by State laws to have alternative or "green" power as a part of their overall production. Additional energy savings can be achieved by installing adequate insulation in buildings and replacing conventional lighting with energy-efficient options.

KEY ACTION #1:

Improve Energy Efficiency at Water and Wastewater Utilities.

The National Water Program will continue to work with the Office of Air and Radiation to promote energy performance benchmarking programs, use of energy audits and energy tracking systems, use of alternative energy sources within plants (e.g., solar, wind, hydro), installation of Combined Heat and Power systems for heat and energy generation in facilities that use anaerobic digesters, and will provide State and local governments information on available and emerging treatment technology.

B. Water Conservation

OBJECTIVE:
Promote water conservation to reduce energy use.

Water quantity and water quality are inextricably linked. Impacts on water resources due to climate change will make this connection more visible. For example, discharge of treated effluent assumes adequate flow for dilution and low flows require higher treatment to avoid impairments; shortages of precipitation and reduced snow melt result in increased competition between human uses and aquatic uses of in-stream flows; and shortages of surface water drive increases in groundwater pumping, which in turn affect recharge.

Water conservation through water use efficiency will be important not just to extend water supply, but also to reduce greenhouse gases. Reduced water consumption saves energy because less water needs to be pumped and treated. On the other side of the water/energy equation, when energy use is reduced, water is saved because less is needed to operate power plants. About half of the water gathered in the United States from surface and groundwater sources is used for power plant cooling (although most is returned) compared to 34 percent for irrigation and 11 percent for residential and commercial purposes (USGS 2004, pp. 6-7). On average, each kilowatt generated consumes approximately 0.2 to 0.3 gallons of water (EPA 2007o), which is based on cooling water consumption and annual electricity generation estimates from the Electric Power Research Institute (EPRI 2002, p. 6-3) and the Energy Information Administration (EIA 2004), respectively.

There are many opportunities for energy savings on the supply side, realized through better planning, maintenance, and operation of water delivery systems, as well as through the development of new technologies and processes. What is often overlooked is how demand-side management or conservation programs can effectively increase water and energy savings. For example, California's State Water Plan (California Department of Water Resources 2005) concluded in 2005 that the largest single new water supply available to meet their expected growth over the next 25 years will be water-use efficiency—made more critical in light of projected water shortages due to climate-related decreases in snow pack.

Residential and business customers use more energy to heat, cool, and otherwise use water than utilities spend treating and distributing it. For example, running a hot water faucet for five minutes is equivalent to running a 60-watt light bulb for 14 hours (Grumbles 2007 and EPA 2007o). By conserving water, less energy is used for these purposes.

For residential consumers, the opportunity to save both water and energy comes primarily from using water-efficient fixtures and appliances, including toilets, showerheads, faucets, clothes washers, dishwashers, and irrigation equipment. For example, an estimated 60 billion gallons and $650 million in energy costs (Grumbles 2007 and EPA 2007o) could be saved if every household also installed high-efficiency faucets or faucet aerators.

To promote water-efficiency and protect the future of our Nation's water supply, EPA launched the WaterSense program in 2007. The WaterSense label will help consumers and businesses identify products that meet the program's water-efficiency and performance criteria. The WaterSense program sets specifications for the labeling of products that are at least 20 percent more efficient than the current standards while performing as well or better than their less-efficient counterparts. Once a manufacturer's product is certified to meet EPA's WaterSense specification by an independent third party, they can use the label on their product. The WaterSense product specifications do not currently address energy consumption directly. However, all water savings realized through the use of WaterSense labeled products and services have a corresponding reduction in energy consumption. Both commercial and residential products and services will be addressed by WaterSense labeling efforts.

KEY ACTION #2:

Implement the WaterSense Program.

EPA will continue its current efforts to implement the WaterSense program and will incorporate educational information about related reductions in energy use.

As noted above, water conservation offers climate change mitigation opportunities through energy savings and in addition may serve adaptive needs that arise as a result of changes in water availability and/or overall demand. Adaptation is supported particularly when water conservation is carried out in a broader context of water resources management, including strategies to ensure availability of public water supplies (e.g. consideration of alternative sources of water).

KEY ACTION #3:

Water Conservation and Management for Drinking Water Systems.

The National Water Program will explore opportunities with States and drinking water systems to better address expected impacts of climate change on water supply and water usage rates through water conservation and water resources management.

A major opportunity for water conservation is the repair of leaking distribution systems. Such leaks commonly result in the loss of ten percent of a city's water. Significant amounts of water can be saved by timely investments in leak correction and more active implementation of leak detection technologies. In addition, infiltration and inflow in wastewater collection systems can significantly increase the volume of wastewater required to be treated resulting in increased energy and chemical demand.

KEY ACTION #4:

Water Conveyance Leak Detection and Remediation.

The National Water Program will promote technologies to identify and address leakage from water pipes and other conveyances.

Industry is also a significant user of water and is becoming aware of the importance of measuring, managing, and controlling water use. In particular, energy-intensive industries are finding water scarcity to be a limit to growth. In general, there is an economic incentive for facilities to use as little water as possible in their industrial operations. Reducing water use will also reduce costs (and energy requirements) associated with water use. In addition to increasing its water efficiency, industry has substantially increased its application of water re-use in the past 15 years through the practice of potable substitution, where reclaimed industrial wastewater is used for non-potable applications. The cost savings of implementing water re-use and reduction technologies and pollution prevention practices can be significant. The monetary savings of implementing water conservation and efficiency measures can be significant with payback periods that may be as short as a few months or years.

KEY ACTION #5:

Industrial Water Conservation, Reuse, and Recycling Technology Transfer.

The National Water Program will identify industries and facilities that best maximize their water efficiency and develop a technical guide for control authorities and industry for promoting water minimization, re-use, and recycling.

In addition, technology to recycle and reuse municipal wastewater is being used by communities in water scarce areas. As in the case of industrial water use, reuse of municipal wastewater reduces energy use and costs and thus reduces greenhouse gases. It also can benefit aquatic ecosystems by recycling water to beneficial uses within a community and reducing demand for water from other locations. EPA published guidelines for water reuse in 2004 (see *Guidelines for Water Reuse*; EPA, 2004).

Finally, Executive Order 13423, Section 2 (c), requires that beginning in 2008, Federal agencies reduce water consumption intensity, relative to the baseline of the agency's water consumption in fiscal year 2007, through life-cycle cost-effective measures, by 2 percent annually through the end of fiscal year 2015, or 16 percent by the end of fiscal year 2015. The Office of Water is responsible for developing Water Efficiency Implementation Guidance for all agencies covering the three elements of compliance: baseline development, efficiency opportunity identification/ implementation, and reporting. Federal agencies are also encouraged to include WaterSense products and services in their implementation strategies.

KEY ACTION #6:

Federal Agency Water Conservation Guidance.

The National Water Program will develop Water Efficiency Implementation Guidance for all Federal agencies under Executive Order 13423.

C. Promote "Green Building" Design and "Smart Growth"

OBJECTIVE:
Promote "green buildings" and "smart growth" to reduce energy and water needs.

Increasing the water and energy efficiency of water utilities has value from a greenhouse gas mitigation point of view, but sustaining these efficiencies over the long-term will require extending the commitment to water and energy efficiency into the building stock and the design of communities. By applying "green building" principles and "smart growth" policies, energy and water efficiencies at utilities can be multiplied. The National Water Program plays a role in this process because it regulates the stormwater associated with buildings and municipalities.

Several organizations, such as the U.S. Green Building Council's Leadership for Energy and Environmental Design (LEED) program and the American National Standards Institute (ANSI), are working with State and local governments and the private sector in promoting the "green buildings" concept and rating systems. These rating

systems document the commitment made by a developer to "green" building practices, such as reduced use of energy and water, on-site (decentralized) energy generation (e.g., solar power, geothermal), and water retention (e.g., green roofs).

Recent developments are expanding this concept to integrate "smart growth," "low impact design," and green building practices. For example, the new LEED for Neighborhood Development (LEED-ND) pilot Rating System reaches beyond the building envelope to include site selection and design, infrastructure linkages (e.g., mass transit), and credits for onsite stormwater management practices such as green roofs, rain gardens, and vegetated swales. The National Water Program is working with other offices in EPA to promote low impact development and smart growth concepts.

The National Pollutant Discharge Elimination System (NPDES) permit program generally requires stormwater discharge permits for industrial facilities, construction sites, and municipalities. These permits are a key regulatory tool for managing stormwater. As "green building" standards and "green infrastructure" practices gain wider acceptance, there will be a growing demand for recognition of these standards and practices within stormwater permits. In some cases, this may require greater flexibility in permitting to allow the use of such standards and practices. Recognition of "green building" standards and "green infrastructure" practices as an allowable element of stormwater permits would encourage their adoption.

KEY ACTION #7:

Promote Energy Saving/Generating "Green Buildings" and "Green Infrastructure" Including Provisions Allowing Such Practices in Stormwater Permits.

The National Water Program will work with other EPA offices to support States, Tribes, and local governments and the private sector in promoting the "green buildings" rating systems, with a focus on saving water and energy and will work to integrate provisions allowing "green infrastructure" practices into stormwater permits.

D. Promote Water Quality/Climate-Friendly Agricultural Practices

OBJECTIVE:
Reduce greenhouse gas emissions from agricultural sources.

Climate change can potentially be mitigated not only by the energy and water conservation efforts described above that reduce carbon emissions from fossil-fuel based energy production, but also through reductions in direct greenhouse gas releases, such as methane and nitrous oxide releases associated with agriculture and wastewater treatment.

Agriculture accounts for more than 8 percent of total greenhouse gas emissions, more than 30 percent of methane releases, and 80 percent of nitrous oxide releases. Agricultural producers have the potential to reduce nitrous oxide releases by expanding use of manure, biosolids, or other organic residuals. The impacts of such practices with regard to climate change are of interest because soil management and fertilizer use are the source of 79 percent of releases of nitrous oxide, which is 300 times more heat trapping than CO_2. Agricultural animal producers have the potential to reduce methane releases from livestock and its manure by considering feed alternatives and utilizing methane capture for combined heat and power production (EPA 2007m).

The National Water Program supports the U.S. Department of Agriculture in promoting sound agricultural management practices and works with the EPA Office of Air and Radiation to promote agricultural practices that benefit air quality and reduce greenhouse gas emissions. In this supporting role, the National Water Program will:

- identify and promote, through nonpoint pollution control programs, agricultural management practices that have both water quality and greenhouse gas reducing benefits (e.g., no till agriculture);
- encourage the use of organic residuals in row-crop and animal agriculture operations; and
- support programs, such as the AgStar program, that encourage the development of animal waste management practices that both protect water quality and reduce releases of methane while generating electric power.

E. Carbon Sequestration through Underground Injection

OBJECTIVE:
Assure that commercial scale geologic sequestration of carbon safeguards drinking water and the ocean environment.

Geologic sequestration is one technology in a portfolio of options that could be effective in reducing CO_2 emissions to the atmosphere and stabilizing atmospheric concentrations of CO_2.

Available evidence suggests that geologic storage capacity in the United States could be as high as 3,500 gigatons (Gts or a billion metric tons) of CO_2 in some 230 candidate sites. The 1,715 largest sources of CO_2 in the United States release about 2.9 $GtCO_2$ per year (Dooley et al. 2006, and for more information see also DOE's 2007 *Carbon Sequestration Atlas of the United States and Canada* in the Further Reading section at the end of this document).

The Underground Injection Control (UIC) Program under the Safe Drinking Water Act regulates injection of fluids, including solids, semi-solids, liquids, and gases (such as CO_2) to protect underground sources of drinking water. UIC regulations address the siting, construction, operation, and closure of wells that inject a wide variety of fluids, including those that are considered commodities or wastes. Proper operation of injection wells for sequestration projects is required under the Safe Drinking Water Act to safeguard underground sources of drinking water and protect public health.

Injection of fluids, including CO_2, into the subsurface for enhanced oil recovery and enhanced gas recovery is a long-standing practice within the UIC program. However, there are some key differences anticipated for geologic sequestration. For example, the relative buoyancy of CO_2, its corrosivity in the presence of water, the potential presence of impurities in captured CO_2, its mobility within subsurface formations, and large injection volumes anticipated at full scale deployment warrant specific requirements tailored to this new practice.

The Department of Energy's (DOE) National Energy Technology Lab and DOE's Regional Carbon Sequestration Partnerships are conducting research on geological sequestration of CO_2 to provide information about the capabilities, impacts, and best practices related to geologic sequestration (GS). On October 9, 2007, DOE announced awards for three demonstration projects that will test large-scale geologic sequestration of CO_2 (**http://www.doe.gov/news/5597.htm**).

EPA's Office of Ground Water and Drinking Water and Office of Atmospheric Programs issued UIC Program guidance in March 2007 (*Using Class V Experimental Technology Well Classification for Pilot Geologic Sequestration Projects*

– *UIC Program Guidance* (UICPG # 83)) to assist States and EPA Regional UIC program managers in evaluating permit applications for GS pilot projects and setting appropriate permit conditions for these projects to protect underground sources of drinking water and public health. (See EPA 2007 in the Further Reading section at the end of this document.)

EPA is also preparing to assist States and Regions in addressing permitting of commercial scale GS projects, which are important in addressing climate change. EPA will use an adaptive management approach, which includes establishing minimum federal requirements for States to protect underground sources of drinking water, providing technical assistance to States, Tribes, and Regions, and coordinating with a range of other Federal agencies. Through workshops and other outreach, stakeholders and the public will have an opportunity to participate in this process. EPA proposed revisions to the UIC Program regulations authorized under the Safe Drinking Water Act in the summer of 2008 and will work with stakeholders to consider comments on these proposed rules.

KEY ACTION #8:

Develop Geologic Sequestration Regulations.

In 2008, EPA will work with stakeholders to consider comments on regulations proposed in July 2008 for siting and managing geologic sequestration projects to prevent endangerment of underground sources of drinking water.

EPA has held several technical workshops to better define research gaps and needs addressing topics including:

- potential impacts on ground water and underground sources of drinking water;
- potential impacts on human health and the environment;
- integrity of CO_2 injection wells and other wells in the area of review;
- fluid displacement and pressure impacts;
- potential for large-scale CO_2 releases;
- measurement, monitoring, and verification tools related to sequestration of CO_2;
- potential impacts of CO_2 injection on geologic media (reservoir and seals); and
- geochemical and geomechanical effects.

EPA has held public hearings on the proposed regulations to share information about protecting underground sources of drinking water during geologic sequestration activities. EPA strongly encourages gathering and sharing of data through the permitting process for pilot projects and other efforts.

KEY ACTION #9:

Continue Technical Sequestration Workshops.

The National Water Program will continue to coordinate with EPA's Office of Research and Development, the Department of Energy, and National Laboratories on geologic sequestration research and hold public meetings and workshops with experts and stakeholders.

Finally, carbon can be sequestered in geologic formations under the seabed as well as on land. The 1996 Protocol to the London Convention on ocean dumping ("London Protocol") regulates sub-seabed sequestration of carbon dioxide streams from carbon dioxide capture processes for sequestration. Parties to the London Convention and

London Protocol are developing guidance for sub-seabed carbon sequestration. The Office of Water and the Office of Air and Radiation are participating in this effort.

The United States is working toward ratification of the London Protocol, including the proposal of amendments to the Marine Protection, Research, and Sanctuaries Act (MPRSA), to implement the treaty. One proposed change to the Act would require a permit for sub-seabed carbon sequestration. In addition, under the Safe Drinking Water Act, sub-seabed sequestration beneath ocean waters within a State's territorial waters must comply with any applicable requirements under EPA's Underground Injection Control program regarding the design, operation, and closure of underground injection wells.

KEY ACTION #10:

Support Evaluation of Sub-seabed and Ocean Sequestration of CO_2.

EPA will work with other interested agencies and the international community to develop guidance on sub-seabed carbon sequestration and will address any requests for carbon sequestration in the sub-seabed or "fertilization" of the ocean, including any permitting under the Marine Protection, Research, and Sanctuaries Act or the Underground Injection Control program that may be required.

F. Water Related "Biological" Sequestration of Carbon

OBJECTIVE: support "biological sequestration" of carbon through agricultural and forestry practices.

Carbon can be sequestered in biological as well as geologic structures. Some of the practices that result in the "biological sequestration" of carbon, and estimated tons of carbon sequestered per year/per acre of each practice, are described in Figure 8. In addition, wetlands have the potential to sequester carbon.

Biological Sequestration Practices Related to Water	
Agriculture/Forest Practice	**Estimated Tonnes of CO_2 Sequestered/Acre/Year**
Reduce cropland tillage	0.6 – 1.1
Cropland conversion to grassland	0.9 – 1.9
Riparian buffers	0.4 – 1.0
Afforestation	2.2 – 9.5
Reforestation	1.1 – 7.7
Changes in forest management	2.1 – 3.1

Figure 8: Biological Sequestration Practices Related to Water

Source: *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture* (EPA 2005, p. 2-3).

As a result of the world-wide effort to reduce carbon, a market has developed for the sequestration of carbon, and there is a worldwide price per ton sequestered. Although the price per ton is now low, this price is expected to increase as the demand for carbon sequestration rises. EPA has estimated that the biological sequestration resulting from forest and agriculture practices in the United States could reach close to 100,000 Tg (teragrams or million tonnes[6]) by 2095 if prices were to rise to $50 per ton/per acre (EPA 2005).

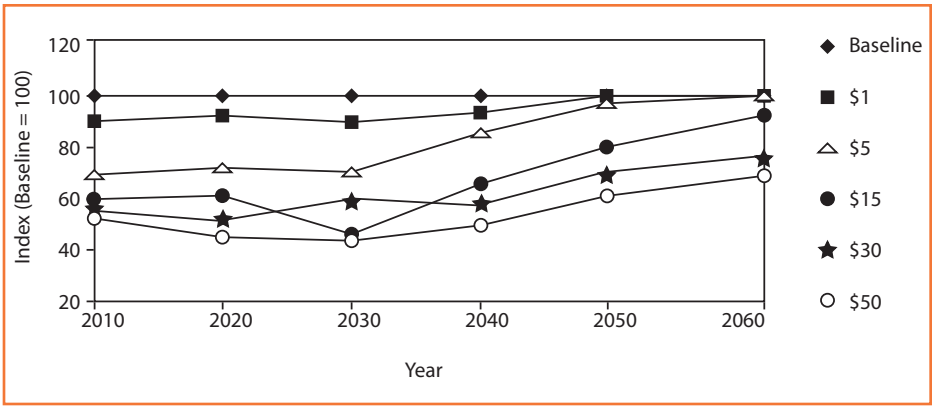

Figure 9: Phosphorus loading index over time by (constant) greenhouse gas price scenario (baseline = 100). This figure shows that estimated phosphorus loadings decline with the introduction of greenhouse gas prices ($ per tonne of CO_2 equivalent).

Source: EPA 2005.

The National Water Program is now promoting practices to protect water quality and wetlands and reduce nonpoint pollution including some of the practices that also sequester carbon. By continuing to promote these practices, water programs are contributing to carbon sequestration. Perhaps more important, as the price of a ton of carbon rises, land owners will change land uses in response to this price signal, adopting some additional practices with both carbon and water quality benefits.

EPA has estimated that the water quality benefits of carbon sequestration practices may be significant, depending on the price and the region of the country. Nationally, EPA estimates that, at a price of $6.80 per tonne of CO_2 equivalent, nitrogen loadings are reduced by 3.1 percent and phosphorous loadings reduced by 2 percent for a representative year (i.e., 2020). The overall impact on a 100-point water quality index is an improvement of about 2 percent. The biggest benefit would be in corn growing States. In 2020, at higher prices of $15 per tonne of CO_2 equivalent, phosphorous reductions may approach a 40 percent decrease from baseline conditions, and nitrogen reductions are slightly more than 10 percent below baseline conditions. These water quality benefits would be greater in twenty to thirty years (see Figure 9). These benefits would diminish or disappear in later years (e.g., 2060) as alternative sequestration practices are implemented (EPA 2005). In addition, more work is needed to understand how new incentives for agricultural production related to biofuels will impact these practices.

In recognition of the emerging market in biological methods of sequestering carbon, the National Water Program needs to learn how to identify which pollution control practices can also be marketed for their carbon sequestration value and to help realize this value. In addition, the program intends to support the efforts of the EPA Office of Air and Radiation and others to develop the documentation and data systems to effectively verify that the tons of carbon sequestered by these projects is accounted for and recognized as a contribution to mitigation of greenhouse gases.

KEY ACTION #11:

Pilot Marketing of Nonpoint Source Biological Sequestration.

The National Water Program will support cooperative pilot projects with selected State section 319 nonpoint pollution control programs to demonstrate the potential for marketing of nonpoint source biological sequestration to provide carbon sequestration benefits.

[6]A tonne is a metric ton, equal to 1 megagram (Mg); and 1 gigatonne (Gt) equals 1,000 Tg (therefore, 100,000 Tg = 100 Gt).

2. Adapting Water Programs to Climate Change

Goal 2:
Water Program Adaptation to Climate Change: adapt implementation of core water programs to maintain and improve program effectiveness in the context of a changing climate.

As the climate changes, the National Water Program has an obligation to continue to ensure that water is safe to drink and that the health of aquatic ecosystems is protected. To meet this challenge, Federal, State and Tribal managers of clean water and drinking water programs will need to adapt the implementation of the programs in light of the changing climate.

Adaptation of water programs to climate change will be a long and iterative process. The understanding of the impacts of climate change on water that is now emerging from scientific studies, however, provides a sufficient basis for defining an initial set of preliminary steps to adapt water programs to climate change.

Key actions that National Water Program managers will take in response to climate change are discussed in the following five sections representing core water programs:

- Drinking Water, Water Quality and Effluent Standards;
- Watershed Protection;
- NPDES Permits;
- Water Infrastructure; and
- Wetlands Protection.

The National Water Program is implemented through many individual programs established under the Clean Water Act, Safe Drinking Water Act, and other laws. Most of these programs fit within several core program areas (e.g., standards, watershed protection, NPDES permits, infrastructure protection, and wetlands protection). These core programs provide the organizing structure for most State and Federal water quality agencies and provide the organizing structure for the Key Actions in the ”adaptation” goal of this ***Strategy***.

The challenges posed by climate change, however, do not always fit neatly into existing programs and it is important to think about themes that define the critical elements of an effectively adapting core water program in response to climate change. Some of these climate change crosscutting themes are:

- **Develop Data to Adapt to Climate Change:** Water managers need baseline data and information to understand how climate change is altering the environment and inform long-term planning. Better information concerning the spatial location of waterbodies and wetlands is needed. In order to improve or maintain water quality and to protect public health, program managers need to understand the changes that might affect standards, permits, implementation strategies, etc. Further, in the event that a baseline ecological condition has permanently shifted, managers need to be able to identify that point and adapt program expectations and requirements.

- **Develop Analytic Tools:** In virtually every water program, the analytic and decision support tools that water managers rely on to process environmental data need to be expanded to address the more complex conditions that will arise from a changing climate.

- **Plan for Extreme Water Events:** Better data and analytic tools are of little value unless water managers recognize that climate change will change long-held assumptions about the norms of water events, including storms, an excess of water, and a lack of water. Recognition of the increased frequency of extreme water events is important to water program managers responsible for controlling nonpoint pollution, protecting wetlands, restoring impaired waters, and protecting the quality of drinking water. Perhaps most important, local water infrastructure mangers need to adapt emergency plans to reflect the most extreme water events.

- **Increase Watershed Sustainability and Resilience:** Individual water programs, such as standards, permits, and wetlands protection, need to adjust to the extremes of climate change. The demands of a changing climate, however, make it more important than ever that these programs be integrated and well coordinated on a watershed basis. From this more holistic perspective, managing stormwater, protecting wetlands, building water infrastructure, and sustaining drinking water supply all support an overarching goal of making an aquatic system more sustainable and resilient to the stresses of a changing climate.

- **Recognize Impacts on Children and the Disadvantaged:** The impacts of a changing climate can be more serious for children and the disadvantaged and these increased risks need to be considered when developing and implementing response actions. Children consume more water per pound of body weight than do adults, thus receiving relatively greater water-borne contaminants, and exposures through dermal uptake and inhalation of contaminants volatilizing from water are also greater. Response actions need to address water-borne infectious disease, asthma exacerbation (e.g. water damage from mold), displacement of populations, safety in weather related disasters, and interruptions of food supply.

- **Strengthen Partnerships and Collaboration:** A hallmark of water programs is that Federal, State, Tribal and local government share responsibility for program implementation. Although many of the Key Actions in this ***Strategy*** address steps that EPA will take, the success of the National Water Program response to climate change will depend on strengthening partnerships with State, Tribal, and local governments, the research community, and stakeholders representing agriculture, industry, and the environmental community.

A. Drinking Water, Water Quality, and Effluent Standards

OBJECTIVE:
Water standards continue to protect human health and the environment as the climate changes.

Under the Safe Drinking Water Act and the Clean Water Act, EPA establishes standards that define when water is safe to drink and when surface water is clean enough to support uses such as fishing and recreation. EPA also sets standards that must be met by all dischargers in an industry (e.g., paper mills) called "effluent guidelines." Each of these three types of standards may be affected by climate change.

Drinking Water Standards

The Safe Drinking Water Act provides for a comprehensive process to assess public drinking waters for contaminants and to develop drinking water standards for contaminants posing the greatest risk. The changes to water resources resulting from climate change, including warmer waters and higher levels of organic materials in water, suggest that drinking water contaminants may increase as the climate changes. EPA intends to assess these risks as part of its regular review of drinking water regulations, giving special attention to the risks of waterborne disease.

There are two key processes to identify and evaluate the potential impact of contaminants on public water systems. Under the Six Year Review process, the Agency reviews existing drinking water standards for more than 90 contaminants to determine whether it is appropriate to revise any of these regulations to maintain or provide for greater heath protection. Under the Contaminant Candidate List (CCL) process, EPA identifies new, unregulated contaminants that are known or likely to occur in public water systems and may need a national drinking water regulation. Because climate change could impact weather patterns and result in increased rain events, the runoff from these events could increase the occurrence of regulated and unregulated contaminants in public drinking water sources and supplies. Under both the Six Year Review and CCL processes, the Agency evaluates the occurrence of contaminants in drinking water to determine potential impacts on public health.

KEY ACTION #12:

Address Impacts of Climate Change on Potential Contamination of Drinking Water Sources.

The National Water Program will evaluate, as part of the contaminant occurrence analyses supporting the EPA Six Year Review of drinking water standards and the contaminant candidate list, the potential for projected climate change to increase the nature and extent of contaminants in drinking water supplies and systems.

In addition to recognizing the need to adapt standards established under the Safe Drinking Water Act to changing climatic conditions, the condition of surface water providing the supply for drinking water systems may also need attention. To better understand this potential problem, EPA will assess implications of climate change for biological contaminants and pathogens in surface waters and evaluate needed response actions, including revision of criteria recommendations under the Clean Water Act.

KEY ACTION #13:

Assess Need for New or Revised Clean Water Microbial Criteria.

The National Water Program will assess the potential for increases in waterborne disease and other water-related disease vectors as a result of climate change, including recommendations for appropriate responses (e.g., publish new or revised biological/pathogen criteria for surface waters).

Water Quality Standards

Climate change is likely to have significant effects on water quality standards for surface waters in several areas:

- higher/lower flows;
- water temperature;
- modified habitat; and
- salinity changes.

Changes in precipitation are expected to result in higher flows in some regions, lower flows in other regions, and more variability of flows. Higher flows could increase available dilution, but could also increase erosion and sedimentation (especially combined with greater peak velocity). Lower flows could substantially reduce available dilution, concentrate salts and other pollutants, and indirectly reduce dissolved oxygen (by increasing temperature and increasing metabolism). As a result, it may become more difficult to meet current water quality or drinking water standards.

Increases in water temperature can also make some contaminants, such as ammonia (EPA 1999) and pentachlorophenol (EPA 1986), more toxic for some species and foster the growth of microbial pathogens in sources of drinking water. Warmer temperatures often result in less water which in turn results in increased contaminant concentration levels. Perhaps most significantly, warmer waters hold lower levels of dissolved oxygen, the availability of which is critical to the health of aquatic species. Depending on the severity of such effects, States may need to consider them in their triennial review of water quality standards.

Changes in climate could change the range and distribution of aquatic species with, for example, warm water species expanding their habitat range and increasing in number and cold water species reducing their range and being eliminated in some waters. The timing and duration of various life stages could also become altered, which may produce subtle or possibly dramatic shifts in community structure. As a result, the appropriate target for some water quality standards (particularly numeric and narrative criteria based on biological assessment) may change. With a changing "natural reference", water quality standards for temperature and biological expectations may need to change to reflect these dynamic conditions.

Changes in sea level and fresh water flow could increase saltwater intrusions and affect the position of the salt front in estuaries and tidal rivers. As a result, there may be increased pressure to manage freshwater reservoirs to increase flows and attempt to maintain salinity regimes to protect estuarine productivity and drinking water supplies. Water quality standards in watersheds experiencing reservoir depletion may need to reflect these conditions. In the case of saltwater intrusions, biological expectations again may need to be adjusted.

In response to climate impacts to water quality, it may be necessary to consider the following actions with respect to water quality standards:

- expanded efforts to meet current standards;
- modifying criteria to protect uses; and
- modifying designated uses.

A designated use and associated criteria should only be removed or replaced when the first two actions, above, have been exhausted.

Dischargers and watershed activities may need to change to reflect the increased degree of difficulty in meeting current standards, where those standards remain the appropriate targets and where they remain attainable. In these cases, program efforts will concentrate on ways to better implement actions to meet standards in an altered or changing climate.

Some standards (i.e., pollutant-specific goals) may need to change to reflect more sensitive environmental conditions. In these cases, program efforts will concentrate on providing better recommendations that reflect necessary levels of protection in an altered or changing climate. For example, expected increases in sediment loads could be addressed with development of sediment criteria. Program efforts will also focus on ways to implement and meet these new recommendations.

Some designated uses and associated criteria may need to be removed and replaced with alternative uses and criteria where conditions have changed, or are anticipated to change, to the point that the current water quality

standards are not appropriate or are not attainable. In these cases, program efforts will concentrate on providing the means to discern these situations and providing options and approaches for developing revised standards in an altered or changing climate.

Some examples of altered conditions due to climate change that may require a water quality standards change or replacement may be: a persistent instream water temperature increase that prevents a cold water fishery from existing in a waterbody because the cold water species' temperature limits have been exceeded; or a freshwater coastal wetland, and its freshwater aquatic community, that has been turned into a saline waterbody due to salt water intrusion via sea level rise.

KEY ACTION #14:

Clean Water Criteria for Sedimentation/Velocity.

In anticipation of increased flow and velocity and sediment loadings in some streams, rivers, and estuaries, the National Water Program will review the potential for development of criteria for sediment and velocity in streams that are appropriate to these changing conditions.

In response to these problems, the following tools and procedures will need to be fully developed and implemented:

- measurement of biological condition and detection of changes;
- models to forecast hydrologic and water quality changes; and
- partnerships with land use managers.

The program will need the ability to measure and detect modifications in biological conditions as a result of climate change impacts. This may involve more extensive biological monitoring, development of indices and indicators that are sensitive to climate change impacts, and methods to link monitoring results with the effects of other stressors. This biological information base will be crucial to managing adaptation and deciding when compensation is appropriate (e.g., change activity in the watershed to maintain biology) and when revised goal setting is appropriate (i.e., to reflect reality). An example of this work is the development of guidance on coral reef bioassessments and biological criteria as part of EPA's participation in the U.S. Coral Reef Task Force.

KEY ACTION #15:

Develop Biological Indicators and Methods.

The National Water Program will improve the biological information base to better manage water resources in a changing climate, including developing guidance on coral reef bioassessments and biological criteria.

The program will need the ability to link ecological process models with landscape hydrology models to meet the forecasting need. This may involve predicting the effects of new temperature and precipitation patterns and discerning the effects of long-term climate change from the effects of normal short-term variability. As "natural conditions" become more dynamic, current empirical modeling approaches and characterization of current or past conditions may no longer be relevant or effective means of projecting to the future. Mechanistic modeling approaches and quantitative uncertainty analysis will become more important tools. The Office of Research and Development's Global Change Research Program will support this effort by developing national maps depicting

projected land use patterns, by decade, through 2040. ORD will also develop a downloadable and customizable ArcGIS tool that will enable local decision makers to develop their own land use scenarios.

KEY ACTION #16:
Link Ecological and Landscape Models.

The National Water Program will work with the Office of Research and Development, the Office of Air and Radiation, and Federal partners to invest in refinement of models of ecological process and landscape hydrology.

Development of Effluent Standards

Alternative energy sources may result in effluent sources that need to be controlled. For example, EPA intends to evaluate the processes being used to generate alternative energy sources such as biofuels and the wastewater generated from these processes. In addition, EPA intends to study whether new industries associated with climate change, will require permits as new sources and/or new dischargers.

In addition, potential changes in effluent composition, such as changes in pollutants or the amount of pollutants due to new or different air emissions control technologies or the addition of carbon sequestration technologies, may also require modifications to existing effluent guidelines or require changes in permit limitations for some categories.

KEY ACTION #17:
Evaluate New Industry Sectors.

The National Water Program will evaluate new industry sectors (including biofuels) and existing effluent guidelines for industrial categories to determine potential NPDES permitting needs and assess the need for new or revised technology-based performance standards.

B. A Watershed Approach

OBJECTIVE:
Use a watershed approach to adapt core water programs to climate change challenges.

For some time, EPA has supported management of water resources using a watershed approach, which is a coordinating framework that focuses community efforts on priority problems within a watershed. Using the watershed approach, utilities, agricultural producers, and other stakeholders look holistically at infrastructure planning, water pollution control, waterbody restoration, and soft path technologies, such as low impact development, thereby protecting, maintaining, or restoring the natural functions of the watershed. Many of the elements of a watershed approach lend themselves to adapting water programs to climate change including:

- water monitoring and data;
- watershed management tools;
- protecting estuaries;
- restoring impaired waters; and
- reducing pollution from nonpoint sources.

An important challenge the National Water Program will face in adapting these national programs to better address climate change needs will be managing the process of implementing the Key Actions described below and making the numerous small scale adaptations to core program management that are needed. In support of the prompt implementation of climate change adaptation actions related to watershed management, the Office of Wetlands, Oceans and Watersheds will develop a Climate Change Policy Memo that directs the incorporation of responses to climate change into these core programs.

KEY ACTION #18:

Watershed Climate Change Policy Memo.

The Office of Wetlands, Oceans, and Watersheds will develop a Climate Change Policy memo that promotes the incorporation of responses to climate change into core programs.

Water Monitoring and Data

The Nation's waters are monitored by State, Federal, Tribal, and local agencies, universities, dischargers, and volunteers. Water quality data are used to characterize waters, identify trends over time, identify emerging problems, determine whether pollution control programs are working, help direct pollution control efforts to where they are most needed, and respond to emergencies such as floods and spills. As the climate changes, monitoring the condition of water resources will be increasingly important and increasingly challenging. At the same time, identifying and measuring environmental changes that result from a changing climate is both difficult and uncertain. In addition, assigning effects to "climate" as opposed to other causes is frequently challenging.

The National Water Program will include assessment of climate change impacts in water resources assessments at the national level, such as the recent wade-able stream assessment and the Coastal Condition Report. These national overviews will provide useful information on climate-related changes to water resources but will also form a foundation for assessment of trends over time. To support this work, EPA will work with States, Tribes and other Federal agencies to include climate change–related measurements in monitoring programs, including reports from States under section 305(b) and ocean monitoring conducted by *The Bold*, EPA's Ocean Survey Vessel (OSV).

KEY ACTION #19:

Expand National Water Resource Surveys to Include Climate Change Indicators.

The National Water Program will expand the national water resources surveys, such as the recent assessment of wadeable streams and the Coastal Condition Report, to address climate change issues and information.

While understanding the impacts of climate change on the quality of water resources, it will also be increasingly important over time to understand changes in the spatial characteristics of fresh waters. The National Water Program will work with the U.S. Geological Survey to assess the potential for monitoring the change in the spatial characteristics of wetlands, freshwater lakes (including the Great Lakes), rivers, and streams as a result of changes in flow, velocity, increased evapotranspiration, and other factors associated with climate change and summarize any findings.

KEY ACTION #20:

Assess Waterbody Spatial Changes Due to Climate Change.

In cooperation with USGS, explore opportunities and needs to assess change in the spatial characteristics of fresh waters due to climate change and summarize any findings.

Watershed Management Tools

One of the most useful tools for understanding climate change impacts on water resources, especially impaired waters, is the Climate Assessment Tool (CAT) element of the BASINS water modeling program. (For more information about CAT, see Johnson et al. 2006 in the Further Reading section at the end of this document or visit http://www.epa.gov/waterscience/BASINS/.) EPA intends to promote the use of the model and provide training to EPA, State and Tribal program staffs on how to use the model to support assessment of climate-related water resources impacts and program decisions.

KEY ACTION #21:

BASINS Climate Assessment Tool.

The Office of Water will develop training sessions in Washington, DC, and selected Regions to assist EPA, State, Tribal, and other government staffs in using the CAT element of the BASINS decision support tool.

Protecting Coastal Estuaries

The National Estuary Program (NEP) promotes technical transfer of information, expertise, and best management practices within 28 estuaries designated as nationally significant watersheds. The accomplishments within these watersheds also assist other coastal watersheds facing similar water pollution and water quality impairments. This approach has proven to be a success over the past 15 years and the NEP is seen as a model for other comprehensive watershed and community-based programs.

The National Water Program will work with individual estuary programs to promote climate change as a priority for NEPs' Comprehensive Conservation and Management Plan revisions. In addition, the National Water Program will work with the Office of Air and Radiation to establish a "Climate Ready Estuaries Program" (similar to the existing "Climate Friendly Parks" with the National Park Service) that would provide climate change outreach to estuaries and recognize efforts of coastal watersheds to adapt to climate change.

KEY ACTION #22:

"Climate Ready Estuaries".

The National Water Program will establish a "Climate Ready Estuaries" Program in partnership with the Office of Air and Radiation's Climate Change Division.

In a related effort, the National Water Program will continue participation in the U.S. Coral Reef Task Force. In this effort, EPA is supporting local action strategies to address threats to reefs, developing guidance on coral reef bioassessments and biological criteria, and working to reduce stress on reefs from other sources (e.g., water pollution, vessel discharges).

KEY ACTION #23:

Continue Coral Reef Protections.

The National Water Program will continue participation in the U.S. Coral Reef Task Force and support related efforts to protect coral reefs.

Restoring Impaired Waters

The Clean Water Act provides for listing of waters not meeting State water quality standards and the development of plans, called "Total Maximum Daily Loads" (TMDLs) for reducing pollutant loadings as needed to meet water quality standards. The National Water Program is encouraging States and others to look for opportunities to develop TMDLs on a watershed basis and to implement restoration at the watershed scale. The National Water Program will consider the long range implications for waterbody impairment associated with climate change and will make needed revisions to TMDL guidance.

Nonpoint Pollution Control

Nonpoint source pollution continues to be the largest remaining source of water quality impairments in the Nation. State nonpoint source programs, developed under the Clean Water Act (CWA) Section 319 Program, are working to meet this challenge.

Congress enacted the 319 Program in 1987, establishing a national program to address nonpoint sources of water pollution. Under section 319(a), all States have developed nonpoint source assessment reports that identify nonpoint source pollution problems and the sources responsible for those water quality problems. Under section 319(b), all States have also adopted management programs to control nonpoint source pollution. Since 1990, Congress has annually appropriated grant funds to States under Section 319(h) to help them to implement those management programs.

In cooperation with NOAA, EPA has developed guidelines and methods under section 304(f)(1) and (2) of the Clean Water Act and under Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 section 6217 concerning estimates of the nature and extent of nonpoint sources of pollutants and methods to control pollution. EPA has further developed these guidelines into management measures for multiple stakeholder sectors. EPA will review the current guidelines in light of information related to climate change impacts on the type and extent of pollutants associated with nonpoint sources (e.g., greater storm intensity resulting in high rates of pollutant loads in runoff) and revise the guidelines as needed.

KEY ACTION #24:

Review/Revise Nonpoint Pollution Management Measures.

EPA will review the sector specific series "National Management Measures to Control Nonpoint Source Pollution" based on emerging information related to climate change impacts.

As research develops and nonpoint pollution control methods are better tailored to climate change, EPA will work with States to make climate change a priority for funding under section 319 and consider asking States and Tribes to amend nonpoint pollution management programs as needed to reflect new information relating to climate change, including information developed under section 304(f) relating to water movement and flow and the value of wetlands in mitigating impacts of climate change.

C. NPDES Permits

OBJECTIVE:
NPDES permits maintain protection of water quality as the climate changes.

The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point source discharges of pollutants into the waters of the United States. The NPDES permit program covers approximately 500,000 facilities and is administered by either EPA or authorized States.

At the national level, EPA establishes regulations and policies that set technology- and water quality–based standards and that provide a framework for implementing those standards in discharge permits. Permit authorities are required to reevaluate and renew NPDES permits every five years to ensure that permit requirements protect the quality of a waterbody.

Changes in the hydrologic cycle due to climate change will need to be taken into consideration throughout the permitting process in order to preserve water quality. The NPDES program will undertake the following actions to adapt program management in response to climate change impacts:

- coordinate with other parts of EPA's Surface Water Program and other agencies, such as USGS, to evaluate climate change impacts on water quality and to identify appropriate responses by EPA's water quality program;
- lay the groundwork to build EPA's ability to provide technical assistance to permit authorities and, in the long term, incorporate new information into permit writer training and stakeholder outreach; and
- build the capability of EPA's Wet Weather Permit Program to assist communities with adaptation to changes in hydrological cycles.

As discussed in the mitigation section of this ***Strategy***, the NPDES program will also promote technologies and practices that will help mitigate emissions of greenhouse gases.

Adapting the NPDES Permit Program

The five-year permitting cycle, as well as other mechanisms, provide permit writers with a significant amount of flexibility to adapt to changing conditions. However, an awareness on behalf of the permit writers and other stakeholders of the impacts of climate change will be crucial for ensuring that the program is protective of water quality within a changing climate regime. As an integral part of the National Water Program, conditions written into NPDES permits depend upon other program inputs, such as water quality standards, effluent guidelines, and Total Maximum Daily Loads (TMDLs). Cross-program workgroups (e.g., pesticides, ground water, and air programs) may be useful to identify changes each program will need to make. The NPDES program will be directly impacted by a variety of inter-office and intra-Agency decisions; therefore, continuous and effective inter-office dialogue will ensure that permit authorities are aware of, and properly able to incorporate, any new or revised permit requirements responsive to climate change.

Technical Assistance

Education, outreach, and technical assistance efforts will be targeted to permit writers as well as municipal, industrial, and agricultural stakeholders to help them understand and respond to the potential impacts of climate change in their areas. For example, the NPDES program intends to provide technical support to permitting authorities and permit writers on how to assess the need for revised water quality–based effluent limitations (WQBELs) and other permit conditions, as well as other aspects of program implementation. This may include assistance on issues such as:

- how to address changing values for low flow conditions due to climate change, used in calculating permit limits (i.e., 7Q10—the 7-day average low flow occurring once in 10 years);
- how to make reasonable potential determinations as other flow conditions change (i.e., 1Q10, 7Q10, and 30Q5);
- how to determine whether existing mixing zones continue to be protective of water quality;
- evaluating appropriate upset and bypass emergency conditions; and
- how climate change might affect anti-backsliding provisions.

EPA also intends to provide training and outreach to permit writers that will focus on ensuring the latest information and tools are available. The Permit Writers Course is one opportunity for providing basic information on a broad range of issues that permit writers should consider when developing permits. An introduction to climate change impacts can be incorporated into this training, but a more detailed forum for discussion will also be useful. Some of the climate change–related topics that may be suitable for more advanced training include:

- watershed–based permitting and the potential impacts that climate change can have on this process;
- use of best professional judgment (BPJ) to develop technology-based effluent limitations for pollutant discharges from new technologies that may be developed to adapt to climate change;
- ways to evaluate the need for new or revised permit conditions due to impacts caused by climate change.
- how existing data systems can be used as tools for collecting and querying information on facilities and water bodies; and
- trainings targeted to stakeholders on specific topics related to their areas of focus (e.g., CAFOs, POTWs, and wet weather)

KEY ACTION #25:

Review and Adapt NPDES Permit Program Tools.

Conduct an internal review of the flexibilities and tools in the NPDES program that can be used to respond to changing water quality/quantity conditions and new technologies; collaborate with programs within the Office of Water and across the Agency; modify and expand training to reflect climate change; and provide technical assistance to permit authorities and permit writers.

Wet Weather Permits

As discussed previously in this document, climate change is projected to cause increased intensity of wet weather events in some areas, while increasing intensity of drought in other areas, and in some cases both "wetter wet and drier dry" periods in the same region. This variability hits at the heart of one of the most challenging sources of water pollution—stormwater runoff and sewer overflows during "wet weather" events. Although overall precipitation may decline nationwide, precipitation is expected to fall in more intense downpours, challenging current wet weather controls.

Intensifying the Global Water Cycle:

"According to model predictions, the most significant manifestation of climate change for humans and the environment is an intensification of the global water cycle, leading to increased global precipitation, faster evaporation, and a general exacerbation of extreme hydrologic regimes, floods, and droughts" (Asrar et al. 2001, p. 1313). Further, the National Research Council stated that "Water is at the heart of both the causes and the effects of climate change" (NRC 1999).

The NPDES program is charged with controlling urban and industrial wet weather discharges. Urban discharges are those from a municipality's stormwater or wastewater conveyance infrastructure that are caused by precipitation events such as rainfall or heavy snowmelt. Wet weather discharges include stormwater runoff through municipal separate storm sewer systems (MS4s), combined storm and sanitary sewer system overflows (CSOs), and wet weather sanitary sewer overflows (SSOs). Stormwater runoff gathers pollutants such as sediment, oil and grease, chemicals, nutrients, metals, and bacteria as it travels across land and over surfaces. CSOs and wet weather SSOs contain a mixture of raw sewage, industrial wastewater and stormwater and have resulted in beach closings, shellfish bed closings, and aesthetic problems.

Installing infrastructure, such as pipes, wet weather storage and treatment systems, involves long-term planning and may take 15-20 years to fully implement; these systems have projected lifetimes of 50 years or more. Existing systems and current planning to reduce or eliminate CSOs and SSOs are based on historical rainfall records. EPA and States will need to help communities understand the climate scenarios that they are facing and will need to take climate change into account in their long-term planning. EPA will evaluate its programs to identify optimal response strategies and will work with the research community to develop tools for assessing rainfall patterns and design considerations.

Controlling stormwater discharges begins where water hits the ground. Traditional building techniques have created urban landscapes dominated by impervious cover, forcing rainfall to run off into waterways and stormwater systems. High volume and velocity scours waterways, increases erosion, floods human settlements, and overwhelms treatment systems. Shifting practices can significantly reduce both the volume and speed of runoff and, in fact, can aid the natural ecosystem by retaining water in the watershed and filtering out pollutants before they reach waterways. In the future, this will become even more important in the face of increasing temperatures and low flow periods that cause water shortages.

In support of this education effort, the National Water Program's Green Infrastructure Initiative is working to identify and demonstrate improved and new methods as well as techniques for preserving green space, increasing the perviousness of various types of land cover, retaining stormwater, and otherwise reducing the impacts of stormwater discharges. This work is expected to include assessment of the role of "green building" design specifications and approaches in developing CSO, SSO, and MS4 controls, as well as in guidance for non-point source stormwater controls.

KEY ACTION #26:

Evaluate Opportunities to Address Wet Weather/Climate Impacts at Municipal and Industrial Operations.

The National Water Program will evaluate the wet weather program to identify initiatives to effectively address increases in precipitation due to climate change. Actions will include identifying best practices for characterizing design storms that take climate change into account, incorporating climate change into outreach and training materials, and promoting Green Infrastructure and Sustainable Infrastructure.

Industrial activities are also subject to NPDES permit requirements for their stormwater discharges. The NPDES program will evaluate appropriate steps to take to address climate change impacts.

In addition, EPA intends to work with USDA and the agricultural community to better understand how climate change may impact major agricultural communities where animal feeding operations (AFOs) and concentrated animal feeding operations (CAFOs) are located, especially with regard to how manure storage and management systems might take into account climatological and hydrological changes.

KEY ACTION #27:

Assess Climate Impacts at Animal Feeding Operations.

The National Water Program will work with USDA to evaluate climate change impacts, such as increases in wet weather, on animal feeding operations.

D. Water Infrastructure

Impacts should be expected to vary regionally, but in general, climate change could result in increased demands on our infrastructure systems, both in terms of operations and maintenance costs and the need for capital expenditures. The suite of expected impacts can be grouped according to the type of change a system may face and fall roughly into the following categories:

- more water (through increased precipitation and storm intensity) and sea level rise;
- less water, with increased frequency and duration of drought;
- temperature change; and
- damage from more intense storms.

Changes will affect drinking water, wastewater, and stormwater systems and range in scope from physical damage, to changes in treatment costs and treatment infrastructure, to changes in drinking water supply. Some of the steps that the National Water Program can take to respond to the challenges that climate change poses for water infrastructure include:

- continue the Sustainable Infrastructure Initiative, a comprehensive strategy to change the way the nation views, values, and manages its water infrastructure—for more information, please visit **http://www.epa.gov/waterinfrastructure/**;
- support infrastructure planning tools;

- address issues related to use of the State Revolving Fund (SRF) loans; and
- improve emergency planning.

Sustainable Infrastructure Initiative

In attempts to move our systems and the sector as a whole towards greater sustainability, EPA initiated and is pursuing its Sustainable Water Infrastructure (SI) Initiative. The Initiative includes a suite of approaches that reduce the demands on our water and wastewater systems and, paired with innovations in financing, help to ensure that our infrastructure serves us for the long term. It is organized around four principles, or "pillars":

- Better management,
- Water efficiency,
- Full cost pricing, and
- Watershed approaches to infrastructure.

As all of the work under the Initiative seeks to reduce the demands on infrastructure and lessen the gap, it also encompasses the adaptations that help address any additional costs and demands resulting from climate change.

Decision Support Tools

A number of tools and outreach efforts can be adapted or created to foster the consideration of climate change in planning for infrastructure sustainability. For example:

- Advanced Asset Management (AAM) is an approach that plans for the replacement and repair of all a utility's infrastructure. Impacts from climate change will be included in EPA's AAM training and messaging; and

- Environmental Management Systems (EMSs) provide a means through which utilities examine their environmental footprints and constantly work towards improvements. This self evaluation process can be used as a vehicle for evaluating, adapting to, and mitigating climate change. A discussion of climate change will be included in EPA's outreach to promote EMSs.

KEY ACTION #28:

Implement the Sustainable Water Infrastructure Initiative and Adapt Decision Support Tools to Include Climate Change.

The National Water Program will continue the implementation of the Sustainable Infrastructure Initiative and incorporate climate change into its activities, including incorporating climate change considerations in a range of new and existing sustainable infrastructure tools and outreach efforts.

Adaptation requires that communities understand the potential consequences of climate change at the local level. While climate models are not scaled to project such local impacts, communities can use available science to understand the plausible range of changes to climate and resulting impacts on water resources they could face. This information can then be considered in local decision making processes. Given the long lifespan of water and wastewater infrastructure, it is prudent that planning for new and existing facilities include climate considerations. EPA can work with the professional water and wastewater community to develop and disseminate such decision support tools.

KEY ACTION #29:

Develop a Sustainability/Vulnerability Analysis Handbook for Climate Change Impacts.

The National Water Program will work to publish a document describing a process through which utilities can conduct a self analysis of sustainability, including a climate change–specific vulnerability analysis.

State Revolving Funds and Climate Change

The Clean Water Act and Safe Drinking Water Act both provide for State Revolving Funds (SRFs) through which States make low interest loans to finance water infrastructure projects. The National Water Program works with States to assure the effective management of these funds. The Drinking Water SRF provides about $1.6 billion in loans each year and the Clean Water SRF provides about $5 billion in loans each year. Taken together, the SRFs are a vital tool for financing needed water infrastructure.

It will be important to clarify the SRF eligibility of projects that provide for mitigation of greenhouse gases (through energy or water efficiency or energy generation) or for the adaptation of treatment and distribution/collection systems to accommodate climate change.

KEY ACTION #30:

Clarify Use of the Clean Water and Drinking Water SRFs to Support Adaptation to Climate Change.

The National Water Program will work with State partners to clarify what types of climate change–related infrastructure expenditures are eligible for SRF assistance.

Emergency Planning for Water Facilities

The impacts of climate change present ongoing challenges for the Agency's emergency response program. The possibility of more frequent, severe storms and flooding due to climate changes, along with the continued threat of terrorist attacks on our water and wastewater infrastructure, calls for a coordinated approach. To address this challenge, EPA has developed an agency-wide approach that identifies roles and responsibilities for Regions and Headquarters. The EPA approach incorporates an Incident Command System (ICS) that provides a set of core concepts, terminologies, and technologies common to all federal agencies.

Under the National Response Framework, EPA serves as an important support agency to the U.S. Army Corps of Engineers (the Corps) to enable the rapid restoration of critical water and wastewater services after a calamitous event. By Presidential Directive, EPA also is the federal lead for preparing water and wastewater systems to prevent, detect, respond to, and recover from terrorism and natural disasters.

In order to be prepared to respond to natural disasters such as hurricanes and floods, or possible terrorist attacks on our water and wastewater infrastructure, the National Water Program can take the following additional actions:

- **Provide Training:** Provide training (e.g., National Incident Management System and Incident Command System) and materials (e.g., best practices and table-top exercises) to improve the ability of drinking water and wastewater systems to prepare for and recover from all hazards, including natural disasters.

- **Develop Response Networks:** Coordinate with States, Tribes, and water sector associations to promote the adoption of mutual aid and assistance programs, known as Water and Wastewater Agency Response Networks (WARNs), so that utilities can exchange equipment and personnel to expedite the restoration of critical water services.

- **Participate in Emergency Response Exercises:** Integrate the water sector into national emergency response exercises such as Spill of National Significance (SONS) and TOPOFF ("TOP OFFicials") to enhance awareness of the importance of the sector and to measure the effectiveness of a simulated response. Implement a national effort to measure risk reduction efforts against all hazards in the water sector.

- **Coordinate Incident Control:** In coordination with the Federal Emergency Management Agency (FEMA) and the Corps, EPA will work within the National Response Framework to improve the marshalling of aid for utilities. This work includes identifying Department of Homeland Security and other databases as resources for critical infrastructure information that could prove useful in preparing for or responding to an event on the State or Federal level, and for establishing key definitions across the Federal government to facilitate emergency assistance (e.g., credentialing, resource typing).

- **Streamline Permitting:** In order to address emergency response and climate change, the NPDES program intends to develop processes to streamline and expedite permits concerning natural disasters. It will be important to provide flexible mechanisms for dealing with emergencies, such as permitting for emergency package treatment systems to quickly reinstate the ability to treat wastewater.

Following unfortunate events that damage communities and ecosystems, EPA and its Federal partners intend to ensure that rebuilding efforts take advantage of the opportunity to re-think planning and development. It is appropriate that Federal funding promote use of water and energy efficient technologies, use of sustainable re-development principles such as smart growth and green buildings/green infrastructure, and re-evaluate how to rebuild and preserve wetlands to mitigate future storm damage.

KEY ACTION #31:

Develop and Expand Emergency Response Planning.

The National Water Program will implement a range of actions (see above) to ensure existing emergency response planning considers impacts from climate change, and will work with federal partners to promote adoption of sustainable practices during recovery and rebuilding.

E. Wetlands Management

OBJECTIVE:
assure that development of wetlands protection guidelines and policies includes consideration of climate change.

Since 1989, the Federal government as a whole has embraced a policy goal of no net loss of wetlands under the Clean Water Act Section 404 regulatory program. In 2004, President Bush announced an additional national goal to protect, restore, and improve 3 million acres of wetlands by 2009. After achieving this goal a year early, the President recently announced a new challenge to protect, restore and improve an additional 4 million acres of wetlands nationwide. The Wetlands Program contributes to these goals by fostering effective wetlands management through strategic partnerships with States, Tribes, local governments, and other key partners.

The section 404 permit program regulates the discharge of dredged or fill material into all "waters of the United States" (as defined in the Clean Water Act), which includes wetlands, rivers, streams, and other aquatic resources. Wetlands are also the focus of the voluntary State/Tribal portion of the program. This portion builds the capacity of State, Tribal, and local governments to protect and manage wetlands through grants, by promoting wetlands monitoring and assessment, mapping, outreach, and through strategic partnerships.

The important functions and ecosystem services provided by the nation's wetlands, streams and other aquatic resources will continue to grow in importance as the climate changes. These resources provide crucial functions in four areas related to climate change:

- **Coastal Protection:** Facing the certainty of sea level rise and the potential for increasing hurricane intensities, the ability of coastal wetlands to reduce wave energy and protect coastal settlements may become more important.
- **Protecting Water Supplies:** With increasing aridity in some regions of the United States, the protection of remaining wetlands and streams that provide groundwater recharge and maintain minimum stream flows is important for maintaining water supplies.
- **Flood Mitigation:** With the projected increase in precipitation and storm frequency in other parts of the United States, the capacity of wetlands and headwater streams to reduce flood peaks, detain stormwater, and filter pollutants is important to the protection of life, property, and water quality.
- **Carbon Sequestration:** Lastly, the high primary productivity of many wetland types may make these systems attractive components of existing and future carbon sequestration efforts.

In light of the important contributions wetlands and other aquatic resources can make to adapting to climate change, the National Water Program will evaluate strategies for enhanced aquatic resource protection and develop a new standard for wetlands mapping. Key themes of this assessment process are to consider a watershed approach to aquatic resource protection and to emphasize integration with other water programs.

Regulatory Framework

Section 404 of the Clean Water Act establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires either a permit from the U.S. Army Corps of Engineers (the Corps) or an EPA-approved state program before dredged or fill material may be discharged into waters of the United States.

EPA developed the substantive environmental criteria used by the Corps to make its permitting decisions, known as the section 404(b)(1) Guidelines (the Guidelines). As articulated in the Guidelines, the basic premise of the permitting program is that no discharge of dredged or fill material may be permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. Permit applicants must demonstrate that:

- impacts to wetlands and other waters of the U.S. have been avoided to the "maximum extent practicable";
- unavoidable impacts have been minimized "to the extent appropriate and practicable"; and
- remaining impacts have been compensated for "to the extent appropriate and practicable."

Since protecting our Nation's existing aquatic resource base is critical to ensuring the country's ecological and economic resilience as climatic patterns shift, effective implementation of the section 404 regulatory program and meeting the no net loss and net gain goal is an important part of maintaining the ability to adapt to climate change. The section 404 Guidelines currently prohibit discharges that will cause or contribute to "significant degradation" of the waters of the United States. Significant degradation is broadly defined to include individual or cumulative impacts to human health and welfare; fish and wildlife; ecosystem diversity, productivity and stability; and recreational, aesthetic or economic values. In light of the growing concerns regarding the adverse effects of climate change and the recognition that protecting the Nation's wetlands and other aquatic resources can help to mitigate these effects, EPA will explore how consideration of the effects of climate change should inform significant degradation determinations and publish additional guidance where appropriate.

The section 404 permit review process also includes determining where there would be an "unacceptable adverse impact" resulting from the proposed activity, as described under section 404(c), as well as "substantial and unacceptable" impacts to Aquatic Resources of National Importance, pertaining to section 404(q), often called permit elevations. Criteria used for these determinations should take into account the chemical, physical and biological importance of an aquatic resource in light of climate change. The program will consider developing guidance describing any impacts determined to be "unacceptable" in consideration of the potential effects of climate change (e.g., where discharges would result in harm to wetlands critical to storm surge reduction).

General permits under section 404 authorize categories of activities that are expected to have minor impacts, without the need for completion of an individual permit application, as long as specified procedures and conditions for minimizing impacts are followed. Since almost 90 percent of section 404 permits each year are general permits, effective implementation of the general permit program is an important component of the broader regulatory program role in addressing the potential impacts of climate change. For example, conditions in general permits may identify key resource types (e.g., playa lakes) or specific locations (e.g., coastal Louisiana) that are protected on a regional or State basis.

In order to offset permitted impacts, the Corps typically requires between 40,000–50,000 acres of compensatory mitigation annually. This compensation takes the form of restored, created, enhanced and/or preserved complexes of wetlands and streams. EPA, in conjunction with the Corps, will evaluate how these wetland and stream compensation projects could be selected, designed and sited to also aid in mitigating the effects of climate change. For example, certain types of restoration projects might be encouraged because of their relative carbon sequestration benefits or because they would facilitate more effective wetland migration as sea level rises.

KEY ACTION #32:

Evaluate Opportunities to Refine the 404 Regulatory Framework to Address Climate Change.

The National Water Program will work with the Army Corps of Engineers to ensure effective implementation of the regulatory framework under section 404 of the Clean Water Act in a way that considers the effects of climate change and will explore the need for additional guidance on avoiding or minimizing impacts, defining "significant degradation" and "unacceptable adverse impact", and/or implementing compensatory mitigation.

National Wetlands Mapping Standard

Baseline information on the location and condition of wetlands and aquatic resources is necessary to manage the wetlands program and develop the models and plans needed to adapt to climate change. The existing National Wetland Inventory (NWI) mapping, managed by the Fish and Wildlife Service, is used extensively for those efforts and is already used to address the effects of climate change (e.g., modeling sea level rise).

The NWI maps were innovative when first produced, but additional work is now needed to better satisfy the demands for sophisticated analysis that supports effective environmental planning. Hardcopy maps are available for 81 percent of the Nation, and 53 percent of the NWI is available online for use in GIS applications. However, a significant portion of the arid West has not yet been mapped.

Stakeholder agencies and organizations have started an initiative to develop and implement a modernized Wetland Mapping Standard to update and improve the quality of the data. The goal of this effort is twofold: to accelerate the rate at which the national wetlands mapping is completed and to enable real-time updates of the national wetlands data layer in the future. Using the new Standard, other groups, such as States, local governments, and non-governmental organizations, will be able to collect and upload digitally mapped data to the NWI. EPA and other Federal agencies will be supporting a range of organizations to complete the national map. The Standard was published for public comment in August 2007.

KEY ACTION #33:

Finalize National Wetlands Mapping Standard.

Work with other Federal agencies to finalize the National Wetlands Mapping Standard and work with Federal partners to fund updates of arid west maps.

3. Climate Change Research Related to Water

Goal 3: Climate Change Research Related to Water: strengthen the link between EPA water programs and climate change research.

Research on climate change issues related to water is occurring both internationally and in the United States. Much of this research is being managed by Federal agencies, including EPA. The National Water Program will benefit from much of the research now underway and this Response to Climate Change document will be revised periodically to reflect emerging research. At the same time, the National Water Program will begin to play a larger role in defining research priorities and working with the research community to make research results as useful as possible. Three key research topics are addressed below:

- research projects related to water now underway as part of the Federal government interagency U.S. Climate Change Science Program (CCSP);
- research projects underway within the EPA Office of Research and Development (ORD) related to water quality, drinking water and ecosystems that relate to climate change; and

- elements of the ORD Global Change Research Program that relate to water (all of which are consistent with the CCSP Strategic Plan).

Additional research topics were identified by the National Water Program Climate Change Workgroup during the development of this ***Strategy*** (noted in Appendix 5) and will be considered in future research planning.

Although not addressed below, it is important to note the vital and continuing research sponsored by the Intergovernmental Panel on Climate Change (IPCC). ORD scientists and grantees make a significant contribution to the IPCC as authors and through research cited by the IPCC. Much of the work is related to water resource impacts of climate change and a significant portion addresses water issues in North America.

A. U.S. Interagency Research: CCSP Projects Underway

OBJECTIVE: monitor and make good use of Federal interagency climate change research.

The interagency U.S. Climate Change Science Program (CCSP) coordinates and integrates scientific research on global change and climate change, including research related to water, sponsored by 13 participating departments and agencies of the U.S. Government. The planning and implementation of ORD's Global Change Research Program is integrated by the CCSP with other participating Federal departments and agencies to reduce overlaps, identify and fill programmatic gaps, and add integrative value to products and deliverables produced under the CCSP's auspices. ORD coordinates with other CCSP agencies to develop and provide timely, useful, and scientifically sound information to decision makers.

A major activity called for in the 2003 CCSP Strategic Plan is the production of 21 Synthesis and Assessment Products (SAPs) by 2008 that respond to the CCSP highest priority research, observation, and decision support needs. A full list of the 21 CCSP SAPs is available at **http://www.climatescience.gov**. The following SAPs relate to water resources:

- **Weather and Climate Extremes in a Changing Climate: Focus North America, Hawaii, Caribbean, and the U.S. Pacific Islands (SAP 3-3):** Report published 6/08; NOAA lead with NASA, USGS, DOE.
- **Coastal Elevation and Sea Level Rise (SAP 4-1):** Report to be published in 2008; EPA lead with USGS and NOAA.
- **Thresholds of Change in Ecosystems (SAP 4-2):** Report to be published in 2008; USGS lead with EPA, NOAA, DOE and NSF.
- **Effect of Climate Change on Agriculture, Biodiversity, Land, and Water Resources (SAP 4-3):** Report published 5/08; USDA lead with many other agencies.
- **Review of Adaptation Options for Climate Sensitive Ecosystems and Resources (SAP 4-4):** Report published 6/08; EPA lead with other contributing agencies.
- **Effect of Climate Change on Energy Production and Use (SAP 4-5):** Report published 10/07; DOE lead.
- **Analyses of the Effects of Global Climate Change on Human Health and Welfare and Human Systems (SAP 4-6):** Report published 6/08; EPA lead with other agencies.
- **Effect of Climate Change on Transportation and Infrastructure: Gulf Coast Study (SAP 4-7)**: Report published 3/08; DOT lead with USGS, DOE, NASA.
- **Decision Support Experiments and Evaluations Using Seasonal to Interannual Forecasts and Observed Data (SAP 5-3):** Report to be published 2008; NOAA lead.

The National Water Program intends to monitor the development of these key CCSP products and use these reports to refine and improve responses to climate change. As this ***Response to Climate Change*** is revised over time, findings from these reports will be considered.

In addition to the Synthesis and Assessment Products, the CCSP also has detailed implementation plans for each of its priority program elements. This includes a plan for its Carbon Cycle Workgroup's research activities related to carbon sequestration. The National Water Program will work with ORD to integrate information from these activities into the management framework.

KEY ACTION #34:

Monitoring of Water Related CCSP Reports.

The National Water Program will monitor the development of reports by the Climate Change Science Program and name a representative to join an ORD representative on the CCSP Water Cycle Working Group.

B. EPA/ORD Water Research Related to Climate

OBJECTIVE:
EPA research on water issues will address climate change

The National Water Program works closely with the EPA Office of Research and Development (ORD) on a wide range of water related research focusing on the Multi-Year Plans and Strategies for:

- Ecosystem Research;
- Clean Water Research; and
- Drinking Water Research.

Some of this research applies to issues related to climate change.

Ecological Research Program

The Ecological Research Program is undergoing a major shift in direction. The new focus is on "ecosystems services, their value, and their relationship to human well being, for consistent incorporation into environmental decision making" (*Ecological Research Program; Multi-Year Plan*; draft 4/07). It is clear that in adapting to climate change, risk managers make choices involving land use, benefit vs. cost of ecosystem maintenance or restoration, value of preserving endangered species in a particular location, and so forth. Research in ecosystems services will provide direct support in these decisions.

The draft Multi-Year Plan for Ecological Research specifies several outputs that will be of use in managing climate change impacts on water programs:

- measures and dynamic maps of ecosystems services;
- predictive models relating to the response of stressors;
- management options, based on alternative future scenarios; and
- decision support platforms.

Some specific areas of research that are particularly germane to climate change are also described including a focus on nitrogen, concentrated work on evaluating ecosystem services of wetlands, and place-based research—for which, the Willamette River basin and adjacent areas and the Tampa Bay ecosystem have been selected for near term studies.

Clean Water Research Program

The Water Quality Multi-Year Plan includes many areas that will directly support decision making related to climate change impacts including:

- **Multiple Stressors:** Assessment of multiple stressors (i.e., changes in temperature, salinity, water flow, pH and other parameters) on the health of waters.
- **Bioassessment/Biocriteria:** In developing permits and standards to address climate change, the National Water Program will need a greater concentration on bioassessment and biocriteria.
- **Nutrients:** Increased water flow will mean changes in nutrient status of water bodies in some areas of the country and research theme 1.3 is dedicated to nutrients research.
- **Flooding Impacts on Infrastructure:** To the extent that extreme weather events increase, flooding events may increase in magnitude. The Multi-Year Plan addresses research needs in this area in the Aging Infrastructure research theme.
- **Pathogens:** Climate change may result in changes in the range of existing pathogens and a need to revise traditional indicators of pathogens. New means of testing for the presence of microbial pathogens are being developed, including rapid indicators based on genomic and other state-of-the-art techniques. These methods will be relevant not only to recreational waters, but also to shellfish beds and drinking water uses.

Drinking Water Research Program

The Drinking Water Multi-Year Plan also describes research on microbial contaminants, including rapid detection methods and evaluation of emerging pathogens. One area addressed in the Plan that is particularly important is improved and rapid detection methods for algal toxins so that we can better address harmful algal blooms in both freshwater and marine environments.

Underground injection wells figure prominently in some climate mitigation strategies, and the Drinking Water Multi-Year Plan identified several projects in this area under Source Water Protection including:

- a report on CO_2 transport, modeling and risk assessment (2008);
- a report on impacts on drinking water sources of carbon capture and storage (2010); and
- a report on mechanical integrity test methods for CO_2 injection (2011).

In addition to climate change research within these water research programs, there is important research being conducted by research foundations such as the Water Environment Research Foundation (WERF) and the American Water Works Association Research Foundation (AwwaRF). The National Water Program will coordinate with these agencies and foundations to maximize information sharing and to build on research efforts of common interest.

KEY ACTION #35:

Climate Research in Water Related ORD Research.

The National Water Program will work with the EPA Office of Research and Development in development of water research related to climate change and will also coordinate with external research foundations engaged in water and climate change related research.

C. ORD Global Change Research Program

OBJECTIVE:
The EPA Global Change Research Program will address water program research needs.

The EPA ORD also develops a Multi-Year Plan [Plan] for Global Change Research. This Plan provides an implementation plan for the 2001 Research Strategy for ORD's Global Change Research Program, which was externally peer-reviewed. Although the National Water Program has had limited participation in development of this Plan in the past, the current Plan includes a number of important research projects related to the impacts of climate change on water resources.

ORD's Global Change Research Program is stakeholder-oriented, with emphasis on assessing the potential consequences of global change on air quality, water quality, aquatic ecosystems, human health, and socioeconomic systems. ORD uses the results of these studies to investigate adaptation options to improve society's ability to respond to the risks and opportunities presented by global change, and to develop decision tools for resource managers coping with a changing climate.

KEY ACTION #36:

Revision of ORD Global Change Multi-Year Plan.

The Office of Water will appoint a representative to participate in the ORD revision of the Global Change Multi-Year Plan.

The most significant major study called for in the current Global Change Research Multi-Year Plan calls for ORD and the National Water Program to cooperate in the development of an assessment of the sensitivity to climate change of the goals articulated by the Clean Water Act and Safe Drinking Water Act and the opportunities available within the provisions of these laws to address the anticipated impacts of climate change. The assessment will also develop an atlas of vulnerabilities of water resources and aquatic ecosystems in the United States to climate change.

ORD's Global Change Research Program recognizes that there is a lack of empirical data regarding the importance and prevalence of climate-related decisions, including those related to water resources. To fill this information gap, the ORD Global Change Research Program will develop a new "decision assessment" process to help prioritize future climate change/water research needs. This process will provide a foundation for future research. ORD will develop a dynamic "decision inventory" to identify different classes of climate-sensitive decisions related to water resources in different regions of the country and to evaluate the returns from providing better scientific information to inform those decisions.

Other major research projects in ORD's Global Change Research Program related to the water resource impacts of climate change are described in Appendix 4. ORD will also work with the National Water Program to complement research on geologic sequestration. The Office of Water will monitor the development of ORD reports on climate change impacts on water resources, distribute the reports to water program managers, and apply the findings of the reports to program implementation.

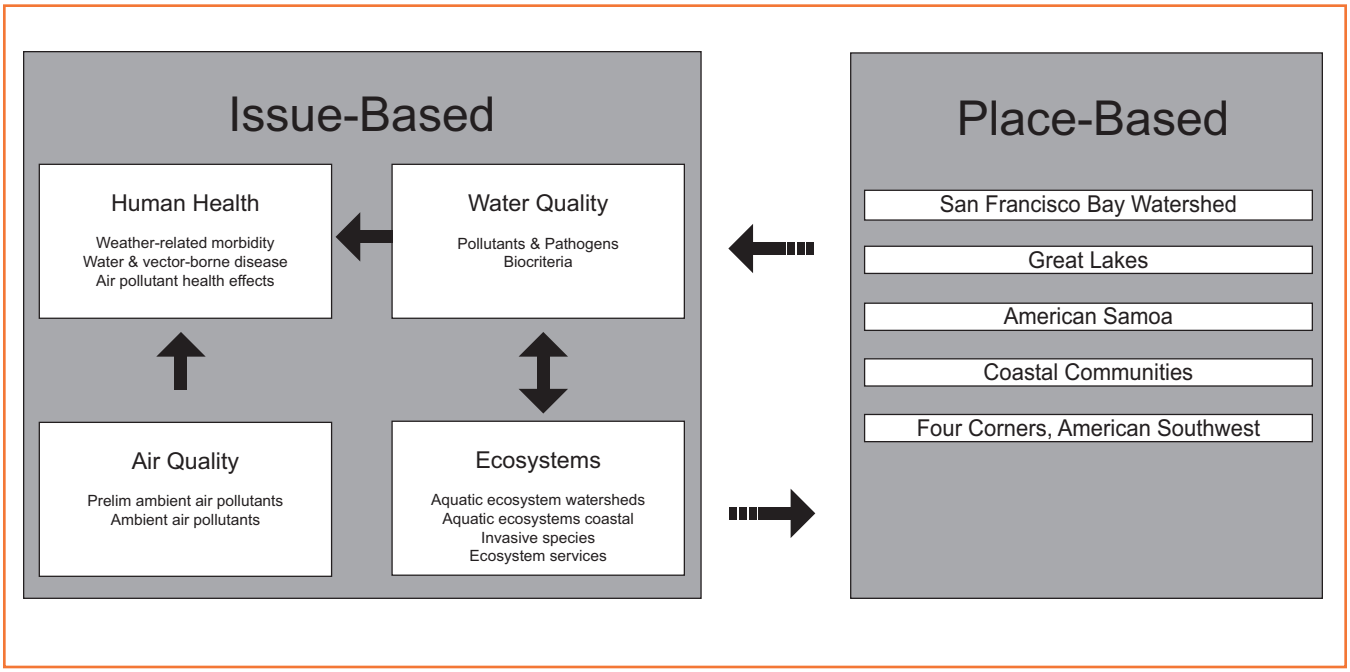

Figure 10: Framework for ORD Global Change Research Program
Source: EPA ORD Global Change Research

4. Water Program Education on Climate Change

Goal 4:
Water Program Education on Climate Change: educate water program professionals and stakeholders on climate change impacts on water resources and programs.

Climate change science and policy is evolving rapidly and today's understanding of climate change impacts on water resources, and conclusions about needed response actions, may change over time. In order for the National Water Program to stay current with climate change issues, new practices are needed to strengthen outreach to partners and stakeholders on climate change–related water program issues and educate water program professionals on climate change generally. This communication needs to involve both EPA informing others about new issues and activities, and EPA listening to and learning from the suggestions of others.

A key first step toward establishing the strong communication linkages that will support successful implementation of water program climate change adaptations is the operation of a water and climate change website and "listserve". These web tools will provide basic information about the impacts of climate change on water programs including copies of related materials and links to the EPA climate change website and other related sites. The "listserve" will provide periodic email updates on climate change–related issues to subscribers.

KEY ACTION #37:
Clearinghouse Website/Listserve.

The Office of Water will work with other EPA offices to establish a website to provide documents related to water and climate change, including research products, and offer as part of this site, a "listserve" to send update emails to interested parties.

Keeping partners and stakeholders informed of progress in implementing the Key Actions identified in this document will be a continuing task. However, for many interested parties, a single, annual report on progress and new or emerging issues will best serve their needs. We expect the reports will identify progress toward key goals identified in the ***Strategy*** and identify "best practices" addressing the water impacts of climate change.

KEY ACTION #38:
Annual Public Reports on Strategy Implementation.

The Office of Water will publish annual reports describing progress in implementing this *Strategy*.

As water program partners and stakeholders become more involved in activities related to climate change, issues and priorities will become clearer and requests for information and analysis will increase. In anticipation of these requests, the National Water Program intends to take the initiative to provide existing advisory groups and related organizations with information on climate change activities.

State and Tribal organizations are also an effective vehicle for providing basic information about climate change to water program professionals. For example, EPA relies on the National Drinking Water Advisory Council to provide guidance on a range of safe drinking water program implementation issues. Some of these other organizations include:

- Association of State and Interstate Water Pollution Control Administrators;
- Association of State Drinking Water Administrators;
- Ground Water Protection Council;
- Association of State Wetland Managers;
- Coastal States Organization; and
- National Tribal Water Council.

The National Water Program intends to work with these organizations to identify meetings, seminars, and other opportunities to provide information about climate change and to identify and address climate change issues related to water programs. As part of this process, EPA will consult with State, Tribal, and local governments and related organizations concerning the best mechanism for establishing and maintaining a dialogue on climate change program and policy issues over the coming years.

KEY ACTION #39:
Outreach to Partners.

The Office of Water will provide material and briefings on the National Water Program climate change response actions periodically to a wide variety of EPA advisory groups, State and Tribal organizations, and stakeholder organizations.

Among the most important steps that the National Water Program can take to respond to the many challenges of climate change is to inform and educate the tens of thousands of water program professionals in Federal, State, Tribal, and local governments and in the private sector concerning climate change issues and potential impacts on water resources. With access to basic information about climate change, professionals can apply this knowledge to numerous specific cases and make countless valuable program adaptations.

Stakeholder Meetings to Date:

The National Water Program Climate Change Workgroup held five listening sessions with stakeholders in 2007:

May 24:	**Environmental Community**
June 6:	**Agriculture Community**
June 13:	**Industry Organizations**
June 14:	**State and Local Government Organizations**
August 10:	**Tribal Officials**

This ***Strategy*** is a first step in building understanding of climate change issues among water program professionals. The background information in Section II of this ***Strategy*** provides key information about a range of potential climate change impacts on water resources and on water programs. The Office of Water intends to make new reports about climate change impacts on water available to a wide range of water program managers on a continuing basis with the goal of helping individual program managers to recognize climate change issues and impacts and to address these problems effectively.

The National Water Program is now making a significant investment in training for water program professionals in the management, policy, and technical challenges arising from the management of core clean water and safe drinking water programs. The Water Quality Standards Academy, the Watershed Academy, and the Drinking Water Academy are just a few examples. By including basic information about climate change in these training programs, the National Water Program can build understanding of climate change issues among water program staff and strengthen the ability of the program to address climate change problems. In addition, short, focused training on climate change issues related to water would be a benefit to water program staff in national and Regional offices.

KEY ACTION #40:

Expand Water Training on Climate Change.

EPA will revise existing training programs to include attention to the impacts of climate change on water programs and will offer training on water-related climate change impacts to national and Regional offices.

5. Water Program Management of Climate Change

Goal 5:
Water Program Management of Climate Change:
establish the management capability within the National Water Program to address climate change challenges on a sustained basis.

Climate change poses significant and long-term challenges for the National Water Program. The development of this ***National Water Program Strategy: Response to Climate***

Change is a key first step in understanding climate change impacts on water programs and the beginning of the process of implementing response actions. To sustain this focus on climate change, the National Water Program will need to establish management practices to build on this initial assessment of climate change impacts.

A first key step in this process is to continue the operation of the National Water Program Climate Change Workgroup. This group is chaired by the Deputy Assistant Administrator for Water and includes senior managers from national and EPA Regional offices as well as representatives of the Office of Air and Radiation and the Office of Research and Development. The Workgroup helps maintain good communication among these offices on climate change issues. For the next several years, we expect the Workgroup will oversee implementation of this ***Strategy***. This work will include oversight of water program coordination with other EPA offices and other Federal agencies on climate-related issues, evaluation of the usefulness of response actions to decision-makers at different levels of government, and development of needed revisions to the ***Response to Climate Change*** document on a periodic basis. As part of this process, the Workgroup will develop an implementation plan for the final ***Strategy***, including more detailed descriptions of schedules and resources for key actions and opportunities for coordination in implementation of key actions. The workgroup will consult with State, Tribal, and local governments and organizations and with stakeholders throughout this process.

KEY ACTION #41:

Maintain Office of Water Climate Change Workgroup.

The Office of Water will maintain the National Water Program Climate Change workgroup and develop an implementation plan for the final *Strategy*.

As the water program begins implementation of the ***Response to Climate Change***, it is likely that issues with respect to coordination of this work with other program implementation work will arise. To address these issues, the National Water Program will integrate climate-related Key Actions with the established water program management tools, including the EPA *Strategic Plan* and the annual water program guidance. The FY 2009 annual *National Water Program Guidance*, published in April 2008, included discussion of implementation of the draft ***Strategy***. The FY 2010 annual guidance will include more detailed attention to implementation of the Key Actions included in the final ***Strategy***.

KEY ACTION #42:

Agency Strategic Plan and Water Program Annual Guidance.

The Office of Water will include Key Actions from this *Strategy* in the FY 2010 annual National Water Program guidance, and when appropriate, make needed changes to the water elements of the EPA Strategic Plan.

EPA Regional water programs will play a central role in responding to climate change by implementing Key Actions identified in this document. Regions will take the lead in helping State, Tribal and local governments understand climate change consequences for water resources and to make sound program adaptation decisions. While this national strategy describes actions to be implemented at the national level and in each of the ten EPA Regions, there is likely to be significant variation in the nature and extent of climate impacts in each Region. For example, drought and water supply issues may be a top priority in western Regions while sea level rise may be more critical in other Regions. Some Regions may want to supplement this national strategy with Key Actions designed to more specifically address the specific needs in the Region.

KEY ACTION #43:

Regional Additions to National Water Climate Strategy.

Each EPA Regional Water Division will review climate change potential impacts in the Region, identify impacts of special concern to that Region, and develop Region-specific additions to this national *Strategy* as needed.

This ***Response to Climate Change*** document is the product of an internal, EPA review of opportunities to better adapt water programs to climate change. Water program staff have discussed this work with staff from other Federal agencies, but have not asked other Federal agencies to endorse the document. It is clear that there are numerous opportunities to coordinate the climate change–related work of the National Water Program with the activities of other Federal agencies. Some of the existing interagency coordination mechanisms are working on matters that have a bearing on climate change. For example, the Federal Advisory Committee on Water Information (ACWI) has a Subcommittee on Ground Water that is working to develop a ground water monitoring framework.

Some of the other Federal agencies with an interest in water-related climate change issues include:

- The Army Corps of Engineers;
- National Oceanic and Atmospheric Administration;
- U.S. Department of Energy;
- Federal Emergency Management Agency;
- U.S. Department of Interior (Bureau of Reclamation, Geologic Survey, and Fish and Wildlife Service);
- U.S. Department of Agriculture (Natural Resources Conservation Service, Forest Service);
- Department of Transportation (Federal Highway Administration); and
- National Science Foundation.

As a first step in strengthening water-related communication among these agencies, EPA will convene a staff level coordination group to exchange information, report on best practices, and improve program efficiency.

KEY ACTION #44:

Federal Agency Water Climate Coordination Group.

The Office of Water will work with other Federal agencies with a significant interest in the water-related impacts of climate change through creation of a staff level coordination group.