

APPENDICES

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Appendix 1: Climate Change Impacts on Water in Regions of the United States

In addition to the general impacts of climate change on water resources described in Section II of this document, the following list provides examples of some effects of climate change on water resources in different parts of the United States that have been projected by various researchers. More information is available at the EPA Climate Change website at: <http://www.epa.gov/climatechange/effects/usregions.html>

The following table is taken from the IPCC Technical Paper on *Climate Change and Water* (2008) and lists observed changes in North America's water resources in the past century (▲ = increase, ▼ = decrease):

Water Resource Change	Examples from the IPCC Fourth Assessment Report (AR4)
1 to 4 week earlier peak stream flow due to earlier warming-driven snowmelt	U.S. West and U.S. New England regions, Canada
▼ Proportion of precipitation falling as snow	Western Canada and prairies, U.S. West
▼ Duration and extent of snow cover	Most of North America
▲ Annual precipitation	Most of North America
▼ Mountain snow water equivalent	Western North America
▼ Annual precipitation	Central Rockies, south-western U.S., Canadian prairies and eastern Arctic
▲ Frequency of heavy precipitation events	Most of USA
▼ Runoff and stream flow	Colorado and Columbia River Basins
Widespread thawing of permafrost	Most of northern Canada and Alaska
▲ Water temperature of lakes (0.1 to 1.5°C) [0.18 to 2.7°F]	Most of North America
▲ Stream flow	Most of eastern U.S.
Glacial shrinkage	U.S. western mountains, Alaska and Canada
▼ Ice cover	Great Lakes, Gulf of St Lawrence
Salinization of coastal surface waters	Florida, Louisiana
▲ Periods of drought	Western U.S., southern Canada

Source: IPCC 2008, table 5.7, p. 102.

In the East:

- “streamflow in the eastern U.S. has increased 25 percent in the last 60 years ...” (Field et al. 2007, p. 621)
- “[s]ea-level rise has accelerated in eastern North America since the late 19th century ... and further acceleration is expected ...” (Field et al. 2007, p. 630); and
- “[u]p to 21 percent of the remaining coastal wetlands in the U.S. mid-Atlantic region are potentially at risk of inundation between 2000 and 2100” (Field et al. 2007, p. 630).
- “[t]he water utility serving New York City has identified heavy precipitation events as one of its major climate-change-related concerns because such events can raise turbidity levels in some of the city’s main reservoirs up to 100 times the legal limit for source quality at the utility’s intake, requiring substantial additional treatment and monitoring costs” (IPCC 2008, p. 44).

In the Northeast:

- coastal erosion, loss of wetland habitat, increased risk from storm surges from sea level rise (IPCC 2007b, as found in EPA 2007j).

In the Southeast and Gulf Coast:

- increased coastal erosion including loss of barrier islands and wetlands (IPCC 2007b, as found in EPA 2007j);
- intense coastal zone development places coastal floodplains at risk to flooding from sea level rise, storm surge, and extreme precipitation events (IPCC 2007b, as found in EPA 2007j); and
- “[s]torm impacts are likely to be more severe, especially along the Gulf and Atlantic coasts” (Field et al. 2007, p. 619).

In the Midwest and Great Lakes:

- lowered lake and river levels, resulting from warmer temperatures and increased evaporation (IPCC 2007b, as found in EPA 2007j);
- “[s]tudies of the Great Lakes of North America ... suggest changes in water levels of the order of several tens of centimet[er]s, and sometimes met[er]s, by the end of the century” (IPCC 2008, p. 30);
- increased agricultural productivity in many regions resulting from increased carbon dioxide and warmer temperatures (IPCC 2007b, as found in EPA 2007j);
- “[i]n the Great Lakes, both extremely high and extremely low water levels have been damaging and disruptive” (Field et al. p. 622);
- “[i]n the Great Lakes and major river systems, lower [water] levels are likely to exacerbate challenges relating to water quality, navigation, recreation, hydropower generation, water transfers, and bi-national relationships” (Field et al. 2007, p. 619);
- “[r]ising temperatures are *likely* to lower water quality in lakes through increased thermal stability and altered mixing patterns, resulting in reduced oxygen concentrations and an increased release of phosphorus from the sediments. For example, already high phosphorus concentrations during summer in a bay of Lake Ontario could double with a 3-4°C [5.4 to 7.2°F] increase in water temperature” (IPCC 2008, p. 43);
- “[r]ecent winters with less ice in the Great Lakes and Gulf of St. Lawrence have increased coastal exposure to damage from winter storms” (Field et al. 2007, p. 623);
- “[r]estoration of beneficial uses (e.g., to address habitat loss, eutrophication, beach closures) under the

Great Lakes Water Quality Agreement will likely be vulnerable to declines in water levels, warmer water temperatures, and more intense precipitation” (Field et al. 2007, p. 629); and

- “[i]n North America’s Prairie Pothole region [in the upper Midwest], models have projected an increase in drought with a 3°C [5.4°F] regional temperature increase and varying changes in precipitation, leading to large losses of wetlands and to declines in the populations of waterfowl breeding there” (IPCC 2008, p. 104).

In the West:

- earlier runoff of snowmelt, stressing some reservoir systems (IPCC 2007b, as found in EPA 2007j);
- “[s]pring and summer snow cover has decreased in the U.S. west” (Field et al. 2007, p. 622), and “[t]he fraction of annual precipitation falling as rain (rather than snow) increased at 74 percent of the weather stations studied in the western mountains of the U.S. from 1949 to 2004” (Field et al. 2007, p. 622);
- “...in the Ogallala Aquifer region, projected natural groundwater recharge decreases more than 20 percent in all simulations with warming of 2.5°C [4.5°F] or greater” (IPCC 2008, p. 41);
- “[t]hreats to reliable supply are complicated by the high population growth rates in western states where many water resources are at or approaching full utili[z]ation” (Field et al. 2007, p. 633);
- increased wildfire potential (IPCC 2007, as found in EPA 2007j); and
- streamflow has decreased by about 2 percent per decade in the central Rocky Mountain region over the last century (Field et al. 2007, p. 621).

In the Southwest:

- annual precipitation has decreased (Field et al. 2007, p. 621);
- “[i]n the southern Great Plains of the USA water temperatures are already approaching lethal limits for many native stream fish” (IPCC 2008, p. 56);
- “[b]y the 2020s, 41 percent of the supply to southern California is likely to be vulnerable to warming from loss of Sierra Nevada and Colorado River basin snowpack” (Field et al., 2007, p. 633); and
- “[h]eavily utili[z]ed groundwater-based systems in the southwest U.S. are likely to experience additional stress from climate change that leads to decreased recharge ...” (Field et al. 2007, p. 629).

In Alaska:

- damage to infrastructure resulting from permafrost melting (IPCC 2007b, as found in EPA 2007j);
- “[r]eductions in the extent of seasonally frozen ground and permafrost, and an increase in active-layer thickness, have resulted in ... [t]he disappearance of lakes due to draining within the permafrost, as detected in Alaska ...” (IPCC 2008, p. 35);
- retreating sea ice and earlier snowmelt alter native people’s traditional life styles (IPCC 2007b, as found in EPA 2007j);
- general increase in biological production from warming, but reduced sea ice and warming disrupts polar bears, marine mammals, and other wildlife (IPCC 2007b, as found in EPA 2007j);
- “[m]any indigenous communities in northern Canada and Alaska are already experiencing constraints on lifestyles and economic activity from less reliable sea and lake ice (for travelling, hunting, fishing, and whaling) ... and more exposed coastal infrastructure from diminishing sea ice” (Field et al. 2007, p. 625); and
- “[s]ome Alaskan villages are threatened and require protection or relocation at projected costs up to US\$54 million” (Field et al. 2007, p. 623).

In Hawaii and the Pacific Islands:

- “[s]ea-level rise will exacerbate inundation, erosion and other coastal hazards, threaten vital infrastructure, settlements and facilities, and thus compromise the socio-economic well-being of island communities and states” (Mimura et al. 2007, p. 689);
- for small islands in the Pacific, changes in temperature, rainfall, and sea level rise are projected to result in “accelerated coastal erosion, saline intrusion into freshwater lenses, and increased flooding from the sea ...” (Mimura et al. 2007, p. 696); and
- the projected sea level rise is expected to result in a 50 percent loss of mangrove area in American Samoa, and a 12 percent reduction in the mangrove area within 15 other Pacific islands (Mimura et al. 2007, p. 696).

For more information on how climate change may affect different regions and States within the U.S., see: <http://www.epa.gov/climatechange/effects/usregions.html>

APPENDIX 2:

Summary List of Climate Change Actions

The following 44 key actions appear in the draft strategy, and this table indicates the lead and supporting offices for each action.

Key Actions		Office of Water Lead with Supporting Offices
1) Greenhouse Gas Mitigation		
Energy Conservation/Production		
1	Improve Energy Efficiency at Water and Wastewater Utilities	OWM (Note that OAR leads this work for the Agency)
Water Conservation		
2	Implement Water Sense Program	OWM
3	Water Conservation at Drinking Water Facilities	OGWDW
4	Water Conveyance and Leak Detection Remedies	OGWDW with OWM
5	Industrial Water Conservation and Reuse	OST
6	Federal Agency Water Conservation Guidance	OWM
Green Building Design and Smart Growth		
7	Promote Green Buildings	OWOW with OWM
Agriculture Related Mitigation		
Carbon Sequestration/Injection		
8	Develop Geologic Sequestration Regulations	OGWDW
9	Continue Technical Workshops	OGWDW
10	Evaluate Ocean and Subseabed Sequestration	OWOW
Biological Sequestration		
11	Pilot Projects for Marketing NPS Biological Sequestration	OWOW
2) Water Program Adaptation to Climate Change		
Water Quality and Technology-Based Standards		
12	Address Impacts of Climate Change on Potential Contamination of Drinking Water Sources	OGWDW
13	Assess Clean Water Microbial Criteria and Risks of Waterborne Disease	OST
14	Consider Criteria for Sedimentation/Velocity	OST
15	Develop Biological Indicators and Methods	OST
16	Link Ecological and Landscape Models	OST
17	Evaluate New Industry Sectors	OST with OWM

Key Actions		Office of Water Lead with Supporting Offices
Watershed Approach		
18	Watershed Climate Change Policy Memo	OWOW
19	Expand National Water Resource Surveys to Address Climate Change	OWOW
20	Assess Fresh Waterbody Spatial Changes Due to Climate Change	OW
21	Promote BASINS Climate Assessment Tool	OST
22	Climate Ready Estuaries	OWOW
23	Continue Coral Reef Protections	OWOW
24	Review/Revise NPS Guidelines	OWOW
NPDES Program		
25	Review Permit Program Tools	OWM
26	Evaluate Climate Impacts on Wet Weather Program	OWM
27	Assess Climate Impacts at Animal Feeding Operation	OWM with OWOW
Water Infrastructure		
28	Continue Implementing Sustainable Infrastructure Initiative	OWM with OGWDW and OWOW
29	Sustainability Handbook with Climate Impacts	OWM with OGWDW
30	Clarify Use of SRFs for Climate Change Related Projects	OWM with OGWDW
31	Expand Emergency Response Planning	OGWDW with OWM
Wetlands Protection		
32	Implementation of 404 Regulatory Framework	OWOW
33	Complete National Wetlands Mapping Standard	OWOW
3) Water/Climate Related Research		
34	Monitoring of Water Related CCSP Reports	OST
35	Add Climate Research in ORD Water Related Research Plans	OST
36	OW Role in Revision of Global Climate Research Plan	OST
4) Education on Climate Change		
37	Clearinghouse/Website	OW
38	Annual Public Reports on Strategy Implementation	OW
39	Outreach to Partners and Stakeholders	OW
40	Expand Existing Training Programs	OW
5) Climate Change Management		
41	Maintain Office of Water Climate Change Workgroup	OW
42	Strategic Plan and Annual Program Guidance	OW
43	Regional Additions to National Strategy	Regions with OW
44	Federal Agency Water Climate Coordination Group	OW

EPA OFFICES:

OAR	Office of Air and Radiation
OGWDW	Office of Groundwater and Drinking Water (EPA's Office of Water)
OST	Office of Science and Technology (EPA's Office of Water)
OW	Office of Water
OWM	Office of Wastewater Management (EPA's Office of Water)
OWOW	Office of Wetlands, Oceans, and Watersheds (EPA's Office of Water)

APPENDIX 3: Adaptations for Alaska Water Infrastructure

Alaska is particularly vulnerable to the effects of climate change. Changes in permafrost have created stability issues for buildings. Greater storm intensity has increased coastal erosion. Freeze-up is occurring later, increasing the risk of storm surges to inundate the numerous villages located in the large river deltas. The Government Accountability Office (GAO) identifies the communities of Kivalina, Koyukuk, Newtok, and Shishmaref as being “in imminent danger from flooding and erosion and are making plans to relocate” (GAO 2004, p. 3).

EPA, the Alaska Department of Environmental Conservation, and others are taking steps to address these concerns.

Existing actions include:

- use of thermal siphons to ensure the stability of buildings located on discontinuous permafrost; and
- avoid funding long-term improvements of water infrastructure where flooding or erosion is an imminent danger to the facility.

Likely future actions include:

- modify designs of buildings and related infrastructure to include hardening to address storm surges and/or sea level rise;
- prepare for extensive retrofitting to protect facilities from melting permafrost, flooding, and/or erosion; and
- refine maps to show climate change impacts on a more local level.

APPENDIX 4: EPA Global Climate Change Research Related to Water

The Global Change Research Program in the EPA Office of Research and Development (ORD) is developing important scientific information on the impacts of climate change on the nation's water resources. Research projects now underway are identified below.

- **Aquatic Ecosystems and Climate Change:** ORD will complete a report assessing the impact of climate change on aquatic ecosystems.
- **Uncertainty of Regional Impacts:** ORD is developing models to improve estimation of climate change impacts on regional and local scales.
- **Regional Climate Change and Invasive Species:** ORD will release an assessment of the effects of climate change and interacting stressors on the establishment and expansion of aquatic invasive species, and the implications for resource management.
- **Climate-Related Decisions in the Chesapeake Bay Program:** ORD will complete an assessment that inventories and prioritizes climate-related decisions related to water quality in the Chesapeake Bay Program.
- **Climate Change Consequences for Biocriteria:** ORD will complete an assessment of the consequences of global change for water quality related to biocriteria in 2008.
- **CSO Control and Impacts of Climate Change:** ORD will release a final report in 2008 on the implications of climate change for Combined Sewer Overflows in the Great Lakes and New England areas.
- **Water Quality–Based Effluent Limits at POTWs in the Great Lakes Region:** ORD will release a final report in 2008 on the implications of climate change for water quality–based effluent limits at POTWs in the Great Lakes region.
- **Water Erosion Prediction Model:** In response to anticipated increases in soil erosion as a result of climate change, ORD is incorporating a Climate Assessment Tool into USDA's Water Erosion Prediction Project Model (WEPP), expected to be available in 2008, to provide online capability for assessing climate change impacts on sediment in streams.
- **National Maps Depicting Land-Use Scenarios:** ORD will release national maps depicting land-use scenarios for the conterminous United States for use in assessments of where climate-land use interactions may exacerbate impacts or create adaptation opportunities.
- **Coral Reefs and Climate Change:** ORD will develop a report identifying adaptation options for protecting coral reefs from multiple stressors, including climate change, land-use practices, and other factors.
- **Geologic Sequestration of CO₂:** ORD will assess and provide decision support related to the behavior of injected CO₂ in the subsurface and impacts to drinking water sources.

APPENDIX 5:

Potential Climate Change/Water Research Needs

Given the extensive range of likely impacts of climate change on water resources, the potential research topics in this field are almost limitless. The work now underway or planned by the IPCC, the CCSP and the EPA ORD will make important contributions to questions concerning water resources impacts of climate change, but additional research will be needed. The National Water Program expects to play an active role in identifying climate change/water resource research needs, both within the context of existing research programs as well as in other forums. A key goal of this process will be to identify from among the many potential research projects, those that are the most important and pressing.

During the development of this Response to Climate Change, members of the Climate Change Workgroup assessed climate change impacts on water resources and, as part of this effort, developed ideas for additional research projects to fill gaps in current knowledge. Although this is an initial list of research needs and is not yet complete or ranked in terms of relative priority, it suggests the range of research needs in this area.

Human Health

- **Better Predict Municipal Water Supply Impacts Associated with Temperature Increases/Snow to Rain Shifts:** Develop more complete estimates of water supply impacts of snow to rain shifts, the correlation of increased use of municipal water supplies, and water loss due to evapotranspiration.
- **Literature Review on Effects of Heat Stress:** It is likely that humans will continue to modify their environment to deal with rising temperature. Nevertheless, given the expected increase in frequency of extreme temperature events, people will be exposed to higher temperatures for at least short periods of time. Toxicological tests for all endpoints are done in animals kept at steady, standard temperatures. Thus, the extent to which temperature increases affects observations in these tests needs to be investigated.
- **Assess Population at Risk of Salt Water Intrusion to Drinking Water Wells:** Identify the population that relies on public and private drinking water wells that may be at risk to intrusion of salt water and the likely impacts on nearby community water systems.
- **Determine Climate Change Impacts on Ground Water and Surface Water Interactions:** Investigate the impacts from climate change on aquifer levels, aquifer recharge, and surface water levels. In turn this should be related to stream flows and wetland health.

Ecosystem Effects

- **Estimate Location of Loss of Shellfishing Areas:** Identify coastal waters used for shellfishing and assess the impact of expected sea level rise on the productivity and viability of these areas, including estimates of economic impacts.
- **Maintaining Water Retention Rates within Watersheds:** Develop methods to scale the rates of retention of watersheds and indices to compare retention rate impacts of land use shifts, including retention rates of various practices (e.g., green roofs, impervious surfaces, retention basins, wetlands).
- **Increasing Resilience of Aquatic Ecosystems:** Identify the elements of aquatic ecosystems that foster increased resilience of the ecosystem and identify ways to strengthen and expand these elements.
- **Estimate Hypoxia/Dissolved Oxygen Events:** Identify coastal and fresh waters most at risk to

decreased levels of oxygen in the water as a result of warmer air and water temperatures, the extent of increase of such events, and the environmental costs and economic impacts of the events.

- **NPS Management Models:** Develop models to forecast NPS loadings under variable climate change scenarios including changes in velocity of flows and pollutant concentrations and describe how these models can be used in design of NPS control plans and watershed plans.
- **Impacts of Salinity Changes on Health of Aquatic Systems:** Identify the waters most at risk of increasing levels of salinity and the likely impacts on fisheries and the health of aquatic systems.
- **Identify Flow Changes on Water Quality:** Identify the water pollutant increases and the hydrologic changes associated with flow changes, i.e., flooding of varying types (e.g., inland, coastal) and drought conditions.

Technology Studies

- **Support Models to Determine Localized Impacts of Climate Change:** EPA will support and work with leading scientific agencies and, academic and research foundations which are working toward downscaling of climate change models. The goal is to provide regional climate data that states and local water resource managers can use to make local predictions of climate change impacts and trends on their water resources.
- **Stormwater Injection Wells:** Identify potential issues and benefits of injection of stormwater into underground geologic formations and recommend how this practice might best be managed in the future.
- **Biofuels Impacts on Water Quantity and Quality:** Evaluate the impact of increased biofuels production on water quality (e.g., increased land in crop production and increased use of fertilizer/pesticides) and use of water for production of biofuels.
- **Assess Drinking Water Treatment Complications Associated with Climate Change Impacts:** Assess the impacts of climate change (e.g., salt water intrusion, increased source water sediment and organic levels, and increased microorganism levels in water) for treatment of drinking water and for compliance with drinking water standards.
- **Energy Savings of Water Conservation:** Evaluate the potential for energy savings associated with different water conservation practices in areas of the country served by different power generation sources (e.g., coal-fired power plants vs. hydropower).
- **Alternative Water Supplies:** Assess issues associated with the development of alternative water sources as part of a suite of water supply management techniques (e.g., the best methods to evaluate the suitability of underground sites for the storage of water for future use; the water quality implications of desalination.)
- **Effects of Water Conservation on Treatment Plant Operations:** Evaluate the impact of water conservation practices that reengineer water conveyance and reuse on the efficiency of conventional sewage treatment plant operations (i.e., dewatering of influent).
- **Methane Cleaning Technology:** Identify technologies to more cost effectively and reliably clean methane from sewage treatment plant digesters to allow for combustion of power of fuel cells.
- **Identify Energy Efficient Treatment Technologies:** Identify energy efficient treatment technologies for drinking water treatment, wastewater treatment, and industrial wastewater treatment.
- **Investigate Energy Conservation Measures:** Topics include assessing less energy intensive treatment methods, identifying opportunities for on-site combined heat and power production efforts (such as utilizing biogas from anaerobic digesters and/or low head small hydroelectric) identifying more efficient processing of biosolids, and assessing the potential benefits of co-location of power plants and water utilities.

APPENDIX 6:

Glossary of Water Program and Climate Change Terms

Key terms used in this **Strategy** related to water programs and climate change are defined below. Many of these terms are further defined on the EPA Office of Water website.

Adaptation (to climate change) – “Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.” <http://www.ipcc-wg2.org/index.html> (click on “glossary” of the Working Group II (WGII) contribution to the Fourth IPCC Assessment Report)

AgSTAR – The AgSTAR Program is a voluntary effort jointly sponsored by the EPA, USDA, and USDOE. The program encourages the use of methane recovery (biogas) technologies at concentrated animal feeding operations that manage manure as liquids or slurries. <http://www.epa.gov/agstar/>

Aquifer storage and recovery (ASR) – ASR is the process of injecting water at times of high supply with the intention to retrieve the stored water at a later date.

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) – BASINS is a multi-purpose environmental analysis system that integrates a geographical information system (GIS), national watershed data, and state-of-the-art environmental assessment and modeling tools. The Climate Assessment Tool (CAT) is an element of the BASINS water modeling program that is useful for learning about climate change impacts on water resources, especially impaired waters. <http://www.epa.gov/waterscience/BASINS/>

Biofuels – A gaseous, liquid, or solid fuel that contains an energy content derived from a biological source. <http://www.epa.gov/trs/>

Carbon sequestration – Carbon sequestration refers to “[t]he process of increasing the carbon content of a reservoir/pool other than the atmosphere” <http://www.ipcc-wg2.org/index.html> (click on “glossary” of the WGII contribution to the Fourth IPCC Assessment Report). The draft strategy refers to several types of sequestration, including subseabed and ocean, geologic, and biological.

Climate Change Science Program (CCSP) – The interagency U.S. CCSP coordinates and integrates scientific research on global change and climate change, including research related to water, sponsored by 13 participating departments and agencies. The CCSP incorporates the U.S. Global Change Research Program (USGCRP) and the Climate Change Research Initiative (CCRI). <http://www.climate-science.gov/>, <http://www.usgcrp.gov>, <http://www.climate-science.gov/about/ccri.htm>

Combined heat and power (CHP) – CHP, also known as cogeneration, is an efficient, clean, and reliable approach to generating power and thermal energy from a single fuel source. <http://www.epa.gov/chp/>

Combined sewer overflow (CSO) – Combined sewer systems (CSSs) are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. During periods of heavy rainfall or snowmelt, the wastewater volume in a CSS can exceed the capacity of the sewer system or treatment plant. For this reason, CSSs are designed to overflow occasionally and discharge excess wastewater directly to nearby water bodies. These overflows are referred to as CSOs. <http://www.epa.gov/npdes/cso>

Contaminant Candidate List (CCL) – The SDWA includes a process to identify and list unregulated contaminants that may require a national drinking water regulation in the future. EPA must periodically publish this list of contaminants—called the CCL—and decide whether to regulate at least five or more contaminants on the list. <http://www.epa.gov/safewater/ccl/index.html>

Effluent limitations guidelines (ELGs) – Effluent guidelines are national standards for wastewater discharges to surface waters and publicly owned treatment works (municipal sewage treatment plants). <http://www.epa.gov/guide/>

ENERGY STAR – ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy designed to help save money and protect the environment through energy efficient products and practices. <http://www.energystar.gov/>

Five Star Restoration Grant Program – The Five Star Restoration Program brings together students, conservation corps, other youth groups, citizen groups, corporations, landowners, and government agencies to provide environmental education and training through projects that restore wetlands and streams. The program provides challenge grants, technical support, and opportunities for information exchange to enable community-based restoration projects. <http://www.epa.gov/owow/wetlands/restore/5star/>

Green building – Green or sustainable building is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition. <http://www.epa.gov/greenbuilding/>

Greenhouse effect – Energy from the Sun drives the Earth's weather and climate. The Earth absorbs energy from the Sun and also radiates energy back into space. However, much of this energy going back to space is absorbed by "greenhouse gases" in the atmosphere. Because the atmosphere then radiates most of this energy back to the Earth's surface, the planet is warmer than it would be if the atmosphere did not contain these gases. Without this natural "greenhouse effect" temperatures would be about 60°F (about 33°C) lower than they are now, and life as we know it today would not be possible. <http://www.epa.gov/climatechange/science/index.html>

Greenhouse gas (GHG) – Gases that trap heat in the atmosphere are often called greenhouse gases. Some greenhouse gases such as carbon dioxide occur naturally and are emitted to the atmosphere through natural processes and human activities. Other greenhouse gases (e.g., fluorinated gases) are created and emitted solely through human activities. The principal greenhouse gases that enter the atmosphere because of human activities are: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride). <http://www.epa.gov/climatechange/emissions/index.html#ggo>

Green infrastructure – Green infrastructure represents a new approach to stormwater management that is cost-effective, sustainable, and environmentally friendly. Green infrastructure techniques utilize natural systems, or engineered systems that mimic natural landscapes, to capture, cleanse and reduce stormwater runoff using plants, soils and microbes. <http://www.epa.gov/npdes/greeninfrastructure>

Green power – Renewable energy resources such as solar, wind, geothermal, biogas, biomass, and low-impact hydro generate green power. Not all sources of power generation share the same environmental benefits. As a result, green power is considered a subset of renewable energy. <http://www.epa.gov/greenpower/whatis/index.htm>

Intergovernmental Panel on Climate Change (IPCC) – The IPCC was established by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. <http://www.ipcc.ch/>

Leadership for Energy and Environmental Design (LEED) – “The [LEED] Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings.” <http://www.usgbc.org/LEED/>

Low impact development (LID) – LID is development that results in low impacts on natural resources. This is done by using planning and designs that preserve green space and manage stormwater to minimize increases in flow and pollutants. LID techniques include conservation of forests and sensitive waters, water reuse, and stormwater controls that detain and retain rainfall throughout the development. http://www.epa.gov/owow/nps/lid/stormwater_hq/pdf/qanda.pdf

Mitigation (of greenhouse gases) – “An anthropogenic intervention to reduce the anthropogenic forcing of the climate system, it includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.” <http://www.ipcc-wg2.org/index.html> (click on “glossary” of the WGII contribution to the Fourth IPCC Assessment Report)

National Dredging Team – The interagency U.S. National Dredging Team was established in 1995 to implement the recommendations in a 1994 report to the Secretary of Transportation on the dredging process, to promote national and regional consistency on dredging issues, and to provide a mechanism for issue resolution and information exchange among federal, state, and local agencies and stakeholders. <http://www.epa.gov/owow/oceans/ndt/>

National Estuary Program (NEP) – EPA’s NEP was established by Congress in 1987 to improve the quality of estuaries of national importance. The NEP is a voluntary program that brings community members together to improve their estuary using a forum to establish working relationships and develop solutions. <http://www.epa.gov/owow/estuaries/>

National Pollutant Discharge Elimination System (NPDES) – As authorized by the Clean Water Act, the NPDES permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. <http://cfpub.epa.gov/npdes/>

National Water Program – The National Water Program is a cooperative effort by Federal, State, Tribal, and local governments to implement core laws, including the Safe Drinking Water Act and the Clean Water Act, to protect and improve the quality of the Nation’s waters.

National Water Program Climate Change Workgroup – This EPA workgroup is chaired by the Deputy Assistant Administrator for Water and includes managers from the Office of Water, the Water Divisions within regional EPA offices, the Office of Air and Radiation, and the Office of Research and Development. The workgroup will oversee water program work related to climate change.

Nonpoint source (NPS) pollution – NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even underground sources of drinking water. <http://www.epa.gov/owow/nps/qa.html>

Radiative forcing – “Radiative forcing is the change in the net, downward minus upward, irradiance (expressed in $W\ m^{-2}$) at the tropopause due to a change in an external driver of climate change, such as, for example, a change in the concentration of carbon dioxide or the output of the Sun.” http://ipcc-wg1.ucar.edu/wg1/Report/AR4WG1_Print_Annexes.pdf

Renewable energy – To be considered renewable energy, a resource must rely on naturally existing energy flows such as sunshine, wind and water flowing. The energy source, or “fuel”, must be replaced by natural processes at a rate that is equal to, or faster than, the rate at which the energy source is consumed. <http://www.epa.gov/greenpower/whatis/renewableenergy.htm>

Sanitary Sewer Overflow (SSO) – Occasional unintentional discharges of raw sewage from municipal sanitary sewers occur in almost every system, which are referred to as SSOs. SSOs have a variety of causes, including but not limited to severe weather, improper system operation and maintenance, and vandalism. <http://www.epa.gov/npdes/sso>

Smart growth – Smart growth covers a range of development and conservation strategies that help protect our natural environment and make our communities more attractive, economically stronger, and more socially diverse. <http://www.epa.gov/dced/>

State Revolving Fund (SRF) – There are two types of SRFs—the Clean Water SRF (CWSRF) and the Drinking Water SRF (DWSRF). CWSRF programs fund water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management. CWSRF monies are loaned to communities and loan repayments are recycled back into the program to fund additional water quality protection projects. <http://www.epa.gov/owm/cwfinance/cwsrf/>

The DWSRF provides capitalization grants to states to develop drinking water revolving loan funds to help finance system infrastructure improvements, assure source water protection, enhance operation and management of drinking water systems, and otherwise promote local water system compliance and protection of public health. <http://www.epa.gov/trs/> and <http://www.epa.gov/safewater/dwsrf/index.html>

Sustainable Infrastructure Initiative – The Sustainable Infrastructure Initiative for Water and Wastewater will guide EPA’s efforts in changing how the nation views, values, manages, and invests in its water infrastructure. <http://www.epa.gov/waterinfrastructure/>

Total maximum daily load (TMDL) – A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant’s sources. <http://www.epa.gov/owow/tmdl/intro.html#definition>

Underground Injection Control Program – EPA’s UIC Program works with State and local governments to oversee underground injection of fluids in order to prevent contamination of drinking water resources. <http://www.epa.gov/safewater/uic/index.html>

Water infrastructure – Water infrastructure refers to the network of infrastructure that provides the public with access to water and sanitation and includes drinking water and wastewater treatment plants, sewer lines, drinking water distribution lines, and storage facilities. <http://www.epa.gov/waterinfrastructure/>

Water quality standards (WQS) – WQS are the foundation of the water quality–based pollution control program mandated by the Clean Water Act. WQS define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing antidegradation policies. <http://www.epa.gov/waterscience/standards/>

Water reuse – Water reuse is the use of process wastewater or treatment facility effluent in a different manufacturing process. <http://www.epa.gov/trs/>

WaterSense – WaterSense is a voluntary partnership program that seeks to protect the future of the nation’s water supply by promoting water efficiency and enhancing the market for water-efficient products, programs, and practices. The WaterSense label will indicate that products and programs meet water efficiency and performance criteria. <http://www.epa.gov/watersense/>

Watershed approach – The watershed approach is a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within hydrologically defined geographic areas, taking into consideration both ground and surface water flow. <http://www.epa.gov/owow/watershed/framework/ch2.html>

Wetland Program Development Grant (WPDG) – The Wetland Program Development Grants provide eligible applicants an opportunity to conduct projects that promote the coordination and acceleration of research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. <http://www.epa.gov/owow/wetlands/grantguidelines/>

7Q10 – 7Q10 refers to the 7-day average low flow occurring once in 10 years. <http://www.epa.gov/trs/>

APPENDIX 7:

Water Program and Climate Change Acronyms

Acronyms used in this **Strategy** related to water programs and climate change are defined below.

AAM	Advanced asset management
AFO	Animal feeding operation
ASR	Aquifer storage and recovery
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BMP	Best management practice
BPJ	Best professional judgment
CAA	Clean Air Act
CAFO	Concentrated animal feeding operation
CAT	Climate Assessment Tool (BASINS)
CCL	Contaminant Candidate List
CCSP	Climate Change Science Program
CHP	Combined heat and power
CSO	Combined sewer overflow
CWA	Clean Water Act
CWNS	Clean Watersheds Needs Survey
CWSRF	Clean Water State Revolving Fund
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
DHS	Department of Homeland Security
DO	Dissolved oxygen
DWNS	Drinking Water Needs Survey
ELGs	Effluent limitations guidelines
EMS	Environmental management system
FEMA	Federal Emergency Management Agency
GS	Geologic sequestration
ICS	Incident Command System
IPCC	Intergovernmental Panel on Climate Change
LEED-NC	Leadership for Energy and Environmental Design for New Construction
LEED-ND	Leadership for Energy and Environmental Design for Neighborhood Development
MPRSA	Marine Protection, Research, and Sanctuaries Act
MS4	Municipal separate storm sewer system
MYP	Multi-Year Plan
NASA	National Aeronautics and Space Administration
NEP	National Estuary Program
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source (pollution)
NWI	National Wetlands Inventory
OAR	Office of Air and Radiation (EPA)

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OGWDW	Office of Groundwater and Drinking Water (EPA's Office of Water)
O&M	Operations and maintenance
ORD	Office of Research and Development (EPA)
OST	Office of Science and Technology (EPA's Office of Water)
OWM	Office of Wastewater Management (EPA's Office of Water)
OWOW	Office of Wetlands, Oceans and Watersheds (EPA's Office of Water)
POTWs	Publicly owned treatment works
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
SONS	Spill of National Significance
SRF	State Revolving Fund
SSO	Sanitary sewer overflow
TMDL	Total maximum daily load
UIC	Underground injection control
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDOE	U.S. Department of Energy
USGBC	U.S. Green Building Council
USGS	U.S. Geological Survey
WEPP	Water Erosion Prediction Project (USDA model)
WPDG	Wetlands Program Development Grants
WQBELs	Water quality–based effluent limitations
WQS	Water quality standards

APPENDIX 8: References and Further Reading

References for works cited in this **Strategy** are provided below along with suggested further reading.

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APPENDIX 9:

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