

Effects of Climate Change on Water Utilities

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While climate scientists do not yet know with certainty the full scope of the effects of climate change on our planet, or how fast these changes will occur, the clear consensus is that significant impacts to the environment will be felt in the coming century. There is also a growing awareness that the first and perhaps most critical impacts will be on the world's freshwater resources. These impacts are not theoretical; they are already being felt in many parts of the United States and other countries. Climate change will affect the quality and quantity of water availability for municipal supply, food production, power generation, industrial use, and other vital services in many geographic locations, including areas that are not traditionally considered water-poor. The great variety and regional variability of potential impacts, as well as the many uncertainties associated with predicting the severity of the impacts, compound the challenge of assessing and responding to climate change vulnerability. Nonetheless, water providers in the United States and other countries have already begun to evaluate the possible impacts and to plan responses. Awareness of and interest in climate change impacts in general, and impacts on water resources in particular, is surging among water utilities and the public.

Climate Change Processes

While controversy persists over the relative contribution of human activities to climate change, the basic science behind the greenhouse effect and the data showing a sharp climatologic shift in recent decades are not controversial. Moreover, recent findings indicate that regional climate shifts can be relatively sudden and dramatic, suggesting that climate systems can reach a "tipping point" of greatly accelerated change. The 2006 AwwaRF report *Climate Change and Water Resources: A Primer for Municipal Water Providers (order #91120)*, developed in partnership with the National Center for Atmospheric Research, provides an excellent overview of these processes and the basic science behind them. At the most fundamental level, climate change processes can be summarized as follows.

Increasing Temperature

Over the past century, the global average temperature has increased by approximately 0.6° C. Among the most undisputed predictions of climate change research is that average temperatures, particularly over land, will continue to increase. Estimates of the magnitude of this warming vary widely due to uncertainties in the models used to predict warming; however, the temperature increase is generally predicted to accelerate over the coming century. As reported in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007), 11 of the 12 warmest years in more than 150 years of instrumental records of global surface temperatures have occurred since 1995.

Increasing Evaporation and Precipitation

Another highly certain prediction of climate change research is that warmer temperatures will cause water to evaporate more readily, increasing total precipitation on a global scale. As with predictions of temperature increase, estimates of the magnitude of precipitation increase vary widely. It is generally accepted, however, that the pattern of precipitation change will be highly complex and variable; some regions will receive more precipitation and others less than they do now.

Rising Sea Level

Warmer temperatures will contribute to sea level rise through both melting of polar ice and expansion of water volume due to ocean warming. The IPCC reports that average global ocean temperatures have increased to depths of at least 3,000 meters (m) and that the ocean has been absorbing more than 80 percent of the heat added to the climate system. Estimates of the amount of sea level rise over the coming century range from 0.2 – 0.6 m (IPCC, 2007).

Increasing Extreme Events

Research suggests that climate change processes act to intensify the hydrologic cycle, leading to increases in the occurrence and intensity of extreme climatologic events. This intensification is likely to be manifested by more intense and temporally variable precipitation, greater incidence of flooding and drought, more intense tropical storms, and increased wildfire activity.

Water Utility Impacts

While it is safe to say that the impacts of climate change on water resources will vary widely by region, it is also relatively certain that no area will be untouched by these impacts. Potential climate change impacts on water utilities have been widely reported in publications by AwwaRF and many other organizations. These impacts can be broadly categorized as water quantity impacts, water quality impacts, operational reliability impacts, and financial and institutional impacts.

Water Quantity Impacts

The most widely publicized impacts of climate change on water resources concern availability of water supply. Direct impacts due to increasing temperature and precipitation variability include reduced in-stream flows, decreased snowpack, earlier and more intense snowmelt and runoff, and reduced aquifer recharge. While total precipitation may increase in some areas, it is likely not to come uniformly and predictably, leading to periodic flooding and water storage challenges. In addition, warmer temperatures may lead to increased demand by both water utility customers and competing users, with peak demand potentially coinciding with periods of most restricted supply.

Water Quality Impacts

Extreme precipitation events create well-known water treatment challenges by increasing sediment and pathogen loads, urban stormwater runoff, and combined sewer overflows. Source water quality will likely be impacted by other, more gradual processes such as more widespread and persistent algal blooms, changes in watershed vegetation, and increased water temperature with associated increases in eutrophication, disinfectant demand, and regrowth potential. In coastal areas, rising sea levels and associated salt water intrusion may increasingly impact groundwater resources.

Operational Reliability Impacts

Climate change will potentially impact utility infrastructure through a variety of means, including flood damage and pipe breaks due to soil drying and settling. Coastal facilities may be threatened by rising sea level and increased corrosion due to salt water intrusion.

Warmer temperatures will likely increase the range and proliferation of invasive nuisance species such as quagga/zebra mussels and milfoil. Reservoir management is likely to be greatly complicated by changes in runoff timing and intensity, particularly for reservoirs that are required to balance both water supply and flood control needs.

Financial and Institutional Impacts

The potential for climate change-induced financial and institutional impacts on water utilities is less well recognized, but in some ways more potentially significant, than water supply and operational challenges. Although supply and operational challenges will be intensified by climate change, most water utilities are well-accustomed to dealing with such challenges. Utilities may be less prepared for challenges such as reduced revenue, the need for new rate structures to better reflect the increasing value of water (and associated affordability issues), and increasing conflict with competing water users. In the long term, climate change may lead to population shifts that strain utilities by

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increasing or decreasing their customer base. Greater stakeholder awareness and support will be needed to ensure that utilities can secure the necessary resources they need to adapt to climate change. Finally, utilities, like other enterprises, will be increasingly pressured (and perhaps required through regulation) to be as carbon-neutral as possible by minimizing energy consumption, turning to renewable energy sources, and optimizing fleet efficiency.

Conclusion

While the potential impacts and uncertainties associated with climate change will create unprecedented challenges, there are many reasons to believe that water utilities and the water supply community are up to the challenge. After a long period of deliberation, there is a growing consensus and urgency in the United States on the need to take action on climate change. Water utilities are recognizing and rising to the challenge with a strong clarity of purpose by developing response strategies, forming coalitions and alliances, and raising awareness among policy makers and government officials. Federal, state, and even local governments are responding with legislation to increase funding for climate change research and solutions.

This *Drinking Water Research* special issue on climate change details the efforts that AwwaRF and our many collaborators have completed and are undertaking to equip water utilities to cope with the varied impacts and uncertainties of climate change.