Climate Ready Water Utilities Working Group

Background Synthesis

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This synthesis presents a focused compilation of salient background information for the National Drinking Water Advisory Council's Climate Ready Water Utility (CRWU) Working Group. This text draws on documents referenced in the annotated bibliography and summarizes key topics for consideration by the CRWU including: climate change processes; physical impacts of climate change related to water and wastewater (water sector) utilities; and adaptation and mitigation strategies under consideration in the water sector. Information contained within this synthesis is designed to provide CRWU members with a quick reference and impartial overview of the state of discussion relating to water sector utilities and the potential effects of a changing climate.

Climate Change Processes

The National Center for Atmospheric Research (NCAR) defines "climate change" as any persistent change in the statistical distribution of climate variables. While complete consensus does not exist around the drivers of climate change, scientific research indicates a distinct shift in climatologic conditions around the world.

The Fourth Assessment Report (AR4) by the Intergovernmental Panel on Climate Change (IPCC) released in November 2007 provides an overview of the existing and anticipated effects of a changing climate. This report and additional publications targeted to the water sector provide a basis for understanding the climate change processes most relevant to water sector utilities. In particular, these processes include increasing temperature, increasing evaporation and precipitation, rising sea levels, and increasing extreme weather events.

Increasing Temperature - Globally, the period 1995 – 2006 was among the warmest on record, and in the past 100 years global average surface temperatures have increased by approximately 0.74° C. Climate models overall predict further global warming with the greatest increases expected over land and at higher northern latitudes, and the least increases over the Southern Ocean and parts of the North Atlantic Ocean.

Increasing Evaporation and Precipitation - Increases in global surface temperatures are anticipated to increase the rate of water evaporation, increasing total precipitation on a global scale. Precipitation is predicted to fall less often as snow and more often as rain. The patterns of precipitation change remain highly uncertain with some regions receiving more precipitation and others receiving less than they do now.

Rising Sea Level - Warmer temperatures are predicted to induce further sea level rise through both melting of polar ice and expansion of water volume due to ocean warming. The IPCC reports that the global average sea level rose at an average rate of 1.8 mm per year from 1961 to 2003. The total 20th-century rise is estimated to be 0.17 m.

Increasing Extreme Events - Shifts in the hydrologic cycle are predicted to increase the occurrence and intensity of extreme climatologic events, resulting in more intense and temporally variable precipitation, greater incidence of flooding and drought, more intense tropical storms, and increased wildfire activity.

Impacts of Climate Change on Water Sector Utilities

Several information sources indicate climate change effects present a number of concerns for the world's fresh water resources. Scientific evidence offered by organizations such as the IPCC indicates that climate change will impact water supplies by: increasing the variability of temperatures and precipitation, increasing the frequency and severity of storm events, and raising sea levels. Several recent reports (e.g., AMWA's *Implications of Climate Change for Urban Water Utilities* and NACWA's *Climate Change: Emerging Issues for Clean Water Agencies*) have explored and articulated the potential impacts on water sector utilities from these climate change effects. The impacts and associated potential implications for water sector utilities are listed below and organized by the three primary impact areas identified by the IPCC.

As indicated across a variety of information sources, exploring potential impacts at a regional or local level must be undertaken with a great degree of caution. This need results primarily from the uncertainty associated with "downscaling" from globally-oriented, generalized climate models and indications that the impact of climate change on water infrastructure will vary greatly according to geographic region. The review of impacts and implications presented below should be considered with these caveats in mind.

Increasing Variability in Temperatures & Precipitation

- *Potential Impacts (highly variable depending on geographic region):*
  - Reduced rainfall and runoff in late summer and fall
  - More rainfall in winter and late spring
  - Decreased snowpack with earlier spring snowmelt
  - More rain on snow events
  - More extreme droughts
  - More frequent and longer lasting heat waves
  - Changes in quantity and quality of runoff into surface waters
  - Reduced aquifer recharge
  - Increased water temperature
  - Increased evaporation and eutrophication in surface waters
- *Implications for Water and & Wastewater Utilities:*
  - Lower summer and fall reservoir levels
  - Lower summer and fall base flows in surface waters
  - Increased water temperatures may create treatment and distribution challenges (i.e., disinfection, byproducts, and regrowth)
  - Increased evaporative losses in inter-basin transfers of surface waters
  - Increased difficulty of maintaining minimum in-stream flows in surface waters
  - Lower base flow conditions requiring additional treatment of certain pollutants
  - Need to re-operate water storage systems to adjust to altered run-off regimes and re-balance supply and flood control demands

  - Potential for increased energy costs and/or decreased energy output
  - Warmer water increasing algal by-products, affecting water taste and odor
  - Increased water demand by both water utility customers and competing users (e.g., agriculture, environmental, etc.), with peak demand potentially coinciding with the period of most restricted supply
  - Drawdown of local groundwater supplies to meet increased water demands

Increasing Frequency and Intensity of Storm Events

- *Potential Impacts:*
  - Increased turbidity and sedimentation
  - Increased velocity and peak flows of runoff
  - Increased potential for flooding
- *Implications for Water and & Wastewater Utilities:*
  - Loss of reservoir storage capacity (e.g., increased sedimentation)
  - Potential conflicts between water supply and flood control objectives
  - Risk of direct flood damage to utility infrastructure
  - Potential for increase in CSO and SSO releases and related potential for existing long-term control plans no longer meeting the EPA CSO Control Policy
  - Increased need for more intensive water treatment
  - Increased risk of flooding/higher flows may challenge the capacity of treatment plants and conveyance infrastructure
  - Change in the potential increased applicability and desirability of decentralized and "green infrastructure"

Rising Sea Levels

- *Potential Impacts (applies to coastal areas):*
  - Increased saline intrusion into groundwater aquifers
  - Increased salinity of brackish surface water sources
  - Increased risk of direct storm and flood damage
- *Implications for Water and & Wastewater Utilities:*
  - Coastal facilities may be vulnerable to physical disruption (storm damage) and increased corrosion due to salt water intrusion
  - Water treatment systems may require alteration to address increased salinity

In addition to these "direct" impacts, information sources identify additional "in-direct" impacts that hold implications for water resource managers. These impacts include the following.

Altered Conditions for Ecosystems

- *Potential Impacts:*
  - Shifts in the vegetative composition of terrestrial ecosystems
  - Altered aquatic ecosystems changing the survivability of aquatic species
  - Altered receiving water chemical composition including changes to type and quantity of pollutant loadings (e.g., from flooding)
  - Increase in sediment and non-point source pollution related to larger storm events
- *Implications for Water and & Wastewater Utilities:*
  - Changes in minimum in-stream flow requirements to support aquatic organisms

- Changes in treatment for discharge waters to address altered water quality and quantity

Financial and Institutional Impacts

- *Potential Impacts:*
  - Increased value of water due to increasing demand and competing users (e.g., agriculture, environmental, etc.)
  - Increased/decreased long-term customer base
  - Implementation of state and federal regulations to control greenhouse gases
  - Differential impact of climate change on the baseline operating environments of inter-linked water resource managers
- *Implications for Water and & Wastewater Utilities:*
  - Shifts in regional population may strain utilities by altering customer base
  - Reductions in revenue and the need for a new rate structure to better reflect the increasing value of water and increasing conflict with competing water users
  - Increased strain on existing water management institutional relationships

Overall, current and projected changes in climate are seen to hold the potential to reduce water management system flexibility, reliability, and sustainability. These changes are further seen as complicating (and potentially compromising) the ability to strike a balance among key water management system objectives including delivering sustainable water supplies, providing effective flood management, delivering reliable hydropower, and ensuring adequate quality and quantity of in-stream flows for environmental purposes. As succinctly stated in AMWA's *Implications of Climate Change for Urban Water Utilities*, "[T]he net effect of the direct impacts of global warming will be to change the variability of key parameters affecting the quantity and quality of water that would normally be expected to be available at any specific time and place. In addition, the capacity to store water in various forms and the demand for water will be changed."

Water Sector Utility Response to Climate Change

Uncertainty surrounding the scope, magnitude, and timing of climate change impacts, particularly in the context of regional and local water resource management, poses a complex challenge for water sector utilities and substantially influences current water sector utility climate adaptation thinking. Uncertainty, especially regarding the trajectory of federal and regional greenhouse gas (GHG) reduction strategies, also exists and strongly influences the current water sector dialog regarding investment in GHG mitigation measures. In the context of, but not withstanding, these uncertainties, the water sector has moved ahead with articulating and implementing both adaptation and mitigation strategies.

Water Sector Utility Adaptation Approaches

A prominent theme across much of the water sector climate change-related literature is the belief that utility managers face an "expanding cone of uncertainty" with regard to the scope, magnitude, and timing of potential climate change impacts on their operations and facilities. The increasing evidence of global warming has not translated into the specificity water utilities typically have depended upon to create their long-range plans, and indications are that reliable, predictive models of regional impacts will not be available in the foreseeable future. At the same time, there is growing recognition that climate change will create different conditions from those for which existing systems were designed, leaving water managers increasingly in a position where they can no longer rely on existing models using historical records. In response, a prominent adaptation strategy has emerged that focuses on “flexible responses” that can accommodate uncertain climate change predictions and address a much more ill-defined future.

The flexible response strategy has a number of component parts that utility managers and water sector utility experts have looked to mix and match depending on existing utility conditions and the sense of immediacy and urgency of local climate impacts. These components include the following:

- *Establishing and Maintaining Climate Science Awareness:* Climate science continues to evolve and efforts to “downscale” global climate models to regional and local conditions continue to provide new information for utility use. In light of this rapidly shifting playing field, utility managers have looked to establish on-going relationships with the scientific community to stay abreast of new developments, maintain access to the latest information, and provide input on areas of needed research.
- *Monitoring Local Climate Conditions:* As a means to more clearly establish and understand localized climate alterations, utilities are expanding and/or focusing their monitoring efforts and using this information to evolve and refine their modeling capabilities.
- *Assessing Climate Change-Related Vulnerabilities:* Climate change vulnerability assessment is used to evaluate the vulnerability of water systems to climate impacts. Two alternative, though potentially complimentary, approaches to vulnerability analysis have been articulated: top-down (quantitative scenario risk approach), and bottom up (qualitative threshold risk assessment). The quantitative scenario risk approach seeks to employ “downscaled” outputs of general circulation climate models (GCMs) as inputs to localized hydrologic and other models to simulate a range of water system component responses to climate change-related watershed variation. Bottom up approaches draw on the general findings of climate research, with utilities identifying system components potentially dependent on the status of key climate variables (e.g., temperature and precipitation) resulting in a preliminary risk assessment based on the professional judgment of experts who know the system and local watershed conditions.
- *Integrating Climate Change Findings into Strategic (or other Long Range) Planning:* An important strategy emerging in water sector climate adaptation discussions is the development of an integrated, diversified water supply and management “portfolio” to minimize overall risk to climate change. To support this approach, utility managers have turned to Integrated Water Resources Planning (and similar approaches) that integrates environmental, socioeconomic, and engineering considerations, evaluates a wide range of water supply and management portfolios, ensures a very broad view of problems, and supports maintaining a maximum degree of system flexibility and resiliency. In this context, utility managers seek to identify “no-regrets” strategies and secure multiple benefits from investments.
- *Strengthening Relationships with Potential Partners:* Integrated regional water management is also emerging as a potentially important strategy. This strategy seeks to bring together multiple agencies and utilities on a regional basis to support a “shared risk” approach that increases individual system flexibility while better coordinating and integrating the needs and resources of interdependent systems.

Water Sector Utility Mitigation Approaches

Water and wastewater utilities are considered indirect sources of GHG emissions due to the energy used to transport, treat, and distribute water and wastewater. The US EPA has estimated that drinking water and wastewater services account for three percent of national energy consumption, with associated GHG emissions at about 45 million tons annually.

Water sector utility vehicle fleets directly emit GHGs, while the transportation of supplies such as chemicals to utilities also produces direct GHG emissions. Additionally, wastewater treatment activities are considered direct emitters of methane and nitrous oxide. EPA's 2005 GHG Inventory indicated that wastewater treatment ranks seventh in methane emissions and sixth in nitrous oxide emissions nationally, with wastewater treatment accounting for approximately five percent of national methane emissions. Wastewater treatment carbon dioxide emissions, for emissions inventory purposes, are considered a biogenic gas and are therefore not estimated.

Several information sources also note that certain water sector utility climate change adaptation measures hold the potential to involve more energy-intensive processes with associated implications for increased GHG emissions. For example, utilities have already begun using energy-intensive membrane treatment processes to support water reuse strategies.

Water sector utilities have begun to develop programs to reduce GHG emissions in response to energy cost saving opportunities, a desire to take proactive climate change steps, and/or in anticipation of federal, regional, and state GHG reduction programs. These programs reflect a range of mitigation responses including the following:

- Developing an inventory of current GHG emissions to determine how much specific operations contribute to the organization's carbon footprint.
- Establishing energy management programs to conduct existing operations more energy efficiently and ensure new investments include examination of GHG emissions potential.
- Reforesting utility-owned land for carbon sequestration.
- Constructing renewable energy projects such as wind and solar power and using water sources for hydropower generation.
- Using biogas as an energy source for on-site process heating and electrical generation.
- Converting vehicle fleets to hybrid vehicles.
- Establishing employee transportation programs to encourage carpooling and use of public transport.

References

Referenced below are the documents used to prepare this synthesis. These documents can be found within an extensive annotated bibliography located at the following link http://client-ross.com/crwuwg/, which includes additional climate change resources relevant to drinking water and wastewater utilities.

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