INTERNATIONAL

Water & Climate Forum 2015

Adapt. Mitigate. Evolve.

December 7–9, 2015 | San Diego, CA

SYNTHESIS REPORT

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Rob Pritchard, City of Calgary

Pat Mulroy, Brookings Institution and University of Las Vegas

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J. Carl Ganter, Circle of Blue

Paul Fleming, Seattle Public Utilities

Prepared for the Association of Metropolitan Water Agencies
by Ross Strategic, Seattle, WA
www.rossstrategic.com

International Water & Climate Forum:
SYNTHESIS REPORT

> "Climate change, as a driver of change, is with us."
>
> — *Simon Pollard, Cranfield University*

> "The truest measure of any society, or any person, is the willingness to protect a future they will never personally experience."
>
> — *Philip Levine, Mayor of Miami Beach*

Introduction

The International Water & Climate Forum held December 7 through 9, 2015 engaged a diverse mix of water sector researchers and practitioners from around the globe. This expertise, drawn from different experiences and different climate impact contexts, provided for a rich exploration of what utilities, elected officials, researchers, and innovators are doing on the ground and in their communities to address climate variability and undertake mitigation actions. The Forum was organized by a group of water sector associations led by the Association of Metropolitan Water Agencies (AMWA) and included the American Water Works Association (AWWA), Water Research Foundation (WRF), Water Utility Climate Alliance (WUCA), Water Services Association of Australia (WSAA), and the International Water Association (IWA). Several other water, wastewater, and stormwater associations supported the event.

The Forum expanded on a similar event held in January 2010 in Washington, DC. That event put the important issue of water utility climate adaptation on the map for policymakers. Reflecting the evolution since 2010 in the water utility sector's knowledge about climate change, the vision for the 2015 Forum was to support water, wastewater, and stormwater utility managers, as well as researchers, scientists, government agency staff, and policymakers, to address emerging issues at the intersection of water management and climate change. By showcasing the work of cities and metropolitan utilities around the world, the Forum built on the knowledge and experiences of utilities that are already implementing mitigation and adaptation strategies into their utility plans and operations.

Forum presentations and discussions tackled a wide range of topics including: the key drivers of water and climate risk, resilience, and opportunity; adaptation and mitigation planning; citizen engagement and methods for communicating about climate change; the elements of and approaches to driving greater resilience in infrastructure and water resources management; and the political, policy, and regulatory aspects of addressing climate change impacts. The Forum proceedings supported a wealth of information exchange and provided an optimistic picture of the water sector's role in and contribution to driving greater community climate change resilience and overall improvements in community sustainability. This report provides a thematic synthesis of the Forum proceedings. It begins by presenting six cross-cutting topic areas, then provides a series of key take away points. An appendix contains supplemental information organized by the six topic areas and focused on the specific implementation experiences of presenters at the Forum.

The Key Presentation and Discussion Topics and Themes

Topic 1: Challenges That Are Here to Stay

> "We have to assume it won't end in any "normal" cycle."
>
> — *Felicia Marcus, Chair, California State Water Resources Control Board*

Forum presentations and discussions reinforced, reiterated, and added additional emphasis to the widely discussed climate change impacts that have been on the water sector's radar for some time. Additionally, and equally importantly, the researchers and practitioners present at the Forum highlighted and brought additional clarity and understanding to the all too critical "enabling environment challenges" that hinder climate change adaptation.

Looking across presentations shows a high degree of consistency, though context-specific applicability, of the climate change impacts that challenge the water sector. Drought, floods, high intensity storms with abnormal return periods, loss of snowpack, degrading environments, heat island effect, and sea level rise are all challenges for the sector. Enabling environment challenges - that utilities often do not directly control - and that hinder adaptation efforts include:

- **Revenue Impacts** – demand management efforts in response to drought realities substantially reduce revenues for volumetric rate-based utilities, and can have a cascading effect on stormwater and wastewater-related revenues. Some utilities are needing to cut operating budgets (to a "survival level") and defer capital projects.
- **Behavioral Change and Public Perception** – many adaptation measures depend on individual customer behavior change (installation of water conservation devices) and/or public acceptance of new approaches such as "fit for purpose water."
- **Capital Financing** – while the cost of adaptation measures is known, their long-term economic benefits are much more challenging to derive due to uncertainty, time frames, and the intangible aspect of some benefits. Making the case for large investments becomes challenging under such circumstance. Additionally, there is a question about "who pays" (both capital and O&M) when adaptation measures reflect integrated planning and programming with other institutional actors and the private sector.
- **Uncertainties** – derived from climate impact uncertainties (future emissions of greenhouse gases, imperfect understanding of response of the earth's climate system to increasing greenhouse gases, and the further uncertainties in downscaling General Circulation Models to local conditions) and water planning uncertainties (future available water resources, reservoir inflows, groundwater), future variability of available water resources, future water demand, reliability of physical infrastructure, and future regulations).
- **Liability** – the potential for increased liability associated with climate impacts (such as more intensive storms) and the implications for a legal "shift in duties," (force majeure contract clauses may take on a new role in the context of climate change).
- **Regulatory and Policy** – gaps in new permitting for such adaptation measures as on-site gray and black water treatment and reuse.

Topic 2: The Power and Promise of Results

> "Turn vulnerability into strategic advantage."
>
> — *Tony Wong, Professor and CEO, Cooperative Research Center for Water Sensitive Cities*

While the challenges are many, communities represented at the Forum provided an optimistic picture through the impressive results they have achieved. Many of the communities are operating in the "extreme extremes" of climate variability and impacts. Their success in the face of such challenges suggests water sector utilities and the communities they serve do have the tools and can make the investments to not only tackle the challenges but produce overall community benefits. Overall, the actions of "water sensitive city initiatives" have produced a broad array of utility-specific and broader community benefits.

- Improved property values through proximity to green landscapes and increased flood protection.
- Improved water security and reduced energy needs through alternative water sources (e.g., stormwater harvesting and recycling of treated wastewater).
- Reduced flood damage and avoided costs in drainage infrastructure augmentation through stormwater source control, green spaces, and corridors for flood detention and conveyance.
- Heat mitigation, reduced energy for cooling, and reduced community morbidity associated with heat stress through city greening and keeping water in the landscape.
- Improved environmental health, including improved air and water quality, and biodiversity of terrestrial and aquatic ecosystems.
- Overall improved utility system resilience through diversification of water supply for security, flood management, and aquatic ecosystem health.
- Improved mental health of community citizens and an overall better sense of place for the community.

Topic 3: Enabling the Climate Resilient Water Sector Utility

> "In 2008, we changed the way we think about the future."
>
> — *Jim Lochhead, CEO/Manager, Denver Water*

Forum presentations and discussions provided a wide range of knowledge and insights regarding the creation and implementation of a water sector utility climate adaptation program. These learnings were derived from practitioners and researchers who have been working in some of the most climate challenged contexts on earth. Overall, the Forum spotlighted the substantially changing role of the water sector. The sector is evolving to the provision of centralized and decentralized urban water services, addressing demand management and fit for purpose water usage, third party access to water resources, and development of no regrets infrastructure. Utilities are further moving beyond treating water strictly as a commodity, to engaging in resource management beyond water, managing for flood mitigation, and providing support to urban livability. This shift involves influencing urban design, promoting biodiversity and enhancing/protecting ecosystem health, and enabling micro-climate initiatives. Key areas of Forum presentations and discussion about enabling the climate resilient water sector utility included: Working with Uncertainty; Approaches to Risk Management; the Role of Adaptive Management; Common Elements of a Water Utility Climate Adaptation Program; Institutional Arrangements; and the Energy – Water Nexus and Greenhouse Gas Mitigation.

Working with Uncertainty

Forum presentations and discussions highlighted that a substantial evolution has taken place from "science will solve this problem" to "science can only take us so far." Practitioners and researchers described the challenges of drawing on mitigation science to inform local adaptation planning. Several presenters showed results of Global Climate Model downscaling efforts that presented a broad "scatter plot" of possible futures for such impacts as temperature and precipitation. This reality of an uncertain future has resulted in a substantial emphasis on developing better water utility planning techniques and a need to change the way the sector thinks about the future. Conventional, deterministic planning was discussed as insufficient to address the uncertain and variable future faced by the sector. The need was seen to plan for multiple futures (scenario planning) that support identifying and preserving options, support an adaptive planning approach, and provide for modularity and flexibility (e.g., buy property just in case; recharge aquifer just in case).

As articulated across a number of presentations, the conventional planning approach has been "prediction centric," where science is applied to reduce the uncertainty affecting the decision (the most likely future is condition A, under Future A, Option 1 is best). Under climate change, science has characterized the uncertainty (here is a wide range of possible futures, we're not sure they encompass the true range, and we have limited ability to assign probability), and this has had the potential to paralyze adaptation decision making. Emergent adaptation planning thinking (and science) is accepting that uncertainty of future climate is irreducible, with internal (natural) variability dominant at local scales for the next 30 years. Under this thinking, the focus is on the water system and identifying vulnerabilities to climate changes rather than attempting to predict the specifics of future climate. Adaptation planning in this context draws on the concept of a "climate stress test" for utility infrastructure and operations. The stress test involves identifying and examining a wide range of possible climate hazards and evaluating the types of stress a utility will experience under each (what climate impacts cause what type and severity of disruption – also referred to as identifying "tipping points"). This allows for an analysis of how robust the system is under various climate futures and informs what mix of proactive adaptation measures will optimize the reduction of vulnerability and maximize the robustness of the system.

Approaches to Risk Management

Following directly from presentations and discussions of working with climate impact uncertainty, discussions explored enhanced approaches to risk management. Two areas of risk management received substantial attention: institutional arrangements in support of effective risk management; and the adoption of "portfolio approaches" for the selection and implementation of adaptation measures.

Presentations indicated that utilities will need to consider the changing nature of risk governance and determine how best to drive a risk management culture in their organizations. Emphasis was placed on the reality that not one size will fit all. It was suggested that executives will need a "golden line of sight" with no fracturing from the strategic to the tactical to the operational. A designated risk manager will play an important role to be both champion as well as to structure and manage the flow of information.

Creation of an "optimal adaptation response portfolio" was central to the risk management strategies suggested by researchers and undertaken by practitioners. Presenters stressed that portfolio theory – which uses diversification to address uncertainty and manage risks is well established, dating back to the 1930's. The portfolio approach, when applied in a water sector context, moves the community from reliance on traditional sources to an optimum (efficient) portfolio of water sources which can provide security through diversity. Like a diversified stock portfolio, flexible and cost effective adaptive responses will be underpinned by diversity, such as mixing centralized and decentralized water infrastructure. "Optimum" in this context

refers to an optimum resiliency function, not investments that are optimized for a specific objective. Such portfolios will also need to be adaptive, with their composition reassessed as new information on costs, prices, climate, environmental objectives and impacts, and risks becomes available.

Role of Adaptive Management

Adaptive management was characterized as a fundamental requirement for success in the context of a highly variable and uncertain future. Important elements of an effective adaptive management approach were identified as: indicator value (e.g., sea level rise); threshold value of the indicator when intervention is needed (must be in place and operable); recorded values of the indicator; predicted values based on rate of change; and a decision point based on a best estimate (to provide lead time for an intervention such as time to build a dam). Another key aspect of the adaptive management approach was the suggestion that the water sector will need to build "slack" into their systems to buffer for uncertain futures.

Common Elements of a Water Utility Climate Adaptation Program

Looking across the presentations and discussions, a common set of elements emerge for a water sector utility climate adaptation program. Researchers and practitioners absolutely adapt and mix and match these elements to address local circumstances, community contexts, and needs. Although no one size fits all, these are the elements that were commonly identified:

- Planning across the entire water system (an integrated, urban water resources plan);
- Mainstreaming climate adaptation into long-range thinking;
- Utilizing advanced scenario planning and adaptive planning techniques;
- Deploying a "portfolio" approach to manage risk;
- Maintaining a dual science and planning focus to inform the adaptation program;
- Enhancing internal staff capacities (e.g., hiring staff, such as meteorologists, to build and maintain understanding);
- Engaging in a range of partnerships to execute integrated water management strategies and participate in broader community resiliency and sustainability initiatives; and
- Developing and deploying key tracking metrics to support implementation, monitor resource mix, and understand the need for additional strategies.

A Forum breakout discussion focused on infrastructure resiliency identified several keys to improving infrastructure resilience. These included removing silos (e.g., coordinating all utilities under one umbrella), deploying a mix of centralized and decentralized approaches (recognizing that the optimized mix will be context and locally dependent), updating regulations to increase flexibility to optimize use, and a better understanding of potential unintended consequences of decentralization. In support of moving to infrastructure resiliency solutions, discussions indicated the need for scenario planning, conducting assessments of service risk (understanding assets - asset management), adopting regional planning approaches, coordination/integration with other city services/departments (plan all work together), balancing conservation with rate structures (leak detection, metering), and taking the long-term view on communication with the public.

Institutional Arrangements

Water sector adaptation efforts – from research, to planning, to implementation – have taken utilities well outside of their conventional operational spheres and span of control. The move into integrated water resource planning and/or community sustainability planning and the assemblage of diversified portfolios of adaptation measures has pushed the sector to rethink institutional relationships, form new partnerships, and depend on diverse actors for the effectiveness of its strategies. Within this context, the sector has seen the emergence of "co-development" and "co-governance" in support of a "whole government approach" with other local government institutions and across sectors such as energy, health, and planning. Some utilities have reorganized to be integrated, functional organizations including both water resources management and water services. Partnerships have also been formed and are critical to understanding climate change impacts and ways to mitigate and adapt, including with research and academic institutions, and with other utilities. Although touched on only briefly during the Forum, the regulatory and policy context was identified as another area significant to the success of adaptation efforts. Regulatory needs included allowing the flexibility to find the most efficient path, expecting that there will be more unforeseen contexts requiring swift response, and a greater need for regulatory tolerance for locally tailored solutions (which are currently very resource intensive).

A discussion session devoted to multi-jurisdictional water resources management further explored enabling institutional and environment needs. These discussions indicated that keys to success included key champions who are knowledgeable, empowered, and charismatic (and effective coalition builders), defining mutual definitions of success, establishing acknowledgement of shared risk, and deriving well-articulated (and flexible) priorities. Needed improvements to the enabling environment for multi-jurisdictional water resources management included acknowledging the place-base context, policies needing to be flexible in changing circumstances but in place in advance, and conflict resolution framing, including mutual respect, creating a common vision, establishing a common fact-based foundation, acknowledging constraints, and negotiating in good faith.

Energy – Water Nexus and GHG Mitigation

Presentations and discussions related to water and energy interdependencies addressed moving to solutions and the nature of innovation opportunities. Innovation opportunities included intelligent distribution systems (e.g., smart metering, integration across sectors), developing optimization tools to identify cost-benefits and future opportunities, seeking within-system energy production and resource recovery (e.g., bio-solids, inline hydro, methane recovery), fostering low energy-intensive and water harvesting development, and seeking co-benefits and opportunities for partnerships across sectors and departments. In terms of moving to solutions to better manage the water-energy nexus, several actions were suggested. These included understanding the current baseline water and energy resource portfolio (and associated emissions), benchmarking to support optimization, improving institutional capacity, creating internal alignment and buy-in, achieving consistency with broader environmental plans, seeking triple-bottom-line benefits (across energy, environmental quality, and social equity goals), and enabling two-way engagement and communication and co-development of plans (e.g., customer base, organizations, governments).

Presentations also addressed water-energy management strategy. Water-energy management strategy is built on two pillars: water conservation and energy management. Water conservation reflects that less water = less energy. The focus is on demand management (customer water conservation) and water loss control. Energy management has three aspects: minimizing energy use through actions such as changing lighting, vehicles, pumping, and natural gas microturbines; minimizing energy costs through such actions as

raw water system operation optimization, distribution system pumping optimization, demand response programs, and alternative fuel suppliers; and diversifying energy supplies through such actions as employing hydroelectric, solar, cogeneration, and in-conduit hydroelectric energy generation.

Greenhouse gas emissions reduction (moving to carbon neutrality) has focused on both direct (Scope 1 emissions that result directly from utility operations) and indirect GHG emissions (Scope 2 emissions deriving from purchased power for the utility's use and Scope 3 emissions associated with the production and delivery of purchased materials). Factors that drive GHG emissions from a utility include water demand, raw water source, Renewable Portfolio Standard, the fuel/energy source, and maintenance activities. Additionally, drought conditions can effect energy use and GHG emissions as supplemental supplies may require more pumping and treatment. Driving down GHG emissions begins with an inventory of Scope 1 and Scope 2 emissions to identify priority areas. Addressing direct emissions can include reducing vehicle miles traveled and vehicle idling, switching to alternative on-site energy sources, vehicle replacement, and purchasing carbon offsets. Indirect emissions can be addressed through efficiency upgrades, renewable energy projects, community choice aggregation programs, use of hydropower, water conservation, and the purchase of RECs (Renewable Energy Certificates).

Topic 4: Resilient Utility – Resilient Community

> "If you want to go fast, go alone, if you want to go far, go together."
>
> — *Paula Verhoeven, General Director, Rotterdam Department of City Development*

The Forum spotlighted the emergence of broad-based community sustainability plans that have taken the approach of integrating water management into the overall economic and social fabric of the jurisdiction. These plans in part reflect the perspective that water management cannot be resilient/sustainable in the absence of a resilient/sustainable community, and a community cannot be resilient/sustainable in the absence of resilient/sustainable water management. Often the need and interest to move to a fully integrated, Triple Bottom Line, community-wide plan has come in response to major extreme events (Superstorm Sandy, Hurricane Katrina) or very high challenge local conditions (prolonged drought, below sea level land area and lack of water storage capacity with growing population). These efforts are also reflective of water sector utilities exerting leadership outside of the sector and helping their communities to improve overall resilience and sustainability.

Topic 5: Communications – More Necessary than Ever

> "I am a firm believer in the people. If given the truth, they can be depended upon to meet any national crises. The great point is to bring them the real facts, and beer."
>
> — *Abraham Lincoln*

The critical role of communications in advancing effective adaptation and risk management was a primary and recurring theme throughout Forum presentations and discussions. Presenter after presenter stressed the importance of their efforts to generate understanding and support within their communities for adaptation and/or mitigation efforts. Of equal importance, however, was the critical communication underpinnings to the multi-sectoral and multi-interest partnerships utilities have formed and needed to form to create integrated water management and broader community resiliency and sustainability strategies. Several presentations also noted the criticality of engaging stakeholders in the futures thinking that underpins

scenario planning (both to ensure robust development and acceptability of the scenarios and the portfolio of solutions that result).

An important subtheme of communications discussions was the substantial challenges of communicating in the climate change context where many people do not directly feel an urgency to change. These challenges include the uncertainty of how consequences will unfold, poorly understood risk thresholds and risk appetites, and the slow going – slow burden nature of climate impacts. Several presenters also highlighted the particular challenge of avoiding climate impact skepticism when swings between, for example, drought and flood conditions occur. Further complicating the communications landscape are the multiple audiences that must be reached: internal utility staff; community residents; elected officials; investors; technical and scientific experts; interest groups; etc. Moreover, it can be challenging when you are asking a community to invest to create "slack" in the system. Utilities are also making diverse "asks" to induce residential, commercial, and industrial conservation behaviors (influencing demand) in support of supply augmentation strategies.

Forum participant discussions identified the following as their top climate change-related communication challenges.

- Communicating the difference between weather and climate change. Creating a distinction between near-term weather events and the longer context of climate change impacts - which is it today ("natural" variation or CO2 induced climate alteration) and how do you know?
- Building a productive relationship and trust development with the community.
- Maintaining climate adaptation as a priority among many other growing issues and the impacts on rates all of these can have. There is constant pressure on trade-offs, such as the urgent displacing the important, and the short-term displacing the long-term. This is particularly difficult when communities may not be seeing immediate impacts.
- The difficulty of engendering initial engagement (getting citizens to come to meetings in the absence of a specific crisis) and sustaining public interest over time.
- Presenting the science to be credible without overwhelming with jargon, complexity and the theoretical.
- Internal challenges about the need to plan for multiple futures and shifting from a mindset/practice that wants to plan for a single future (e.g., following conventional engineering design standards).
- Communication/getting buy-in to climate change within a tough political backdrop (e.g., community contexts where climate change has limited support).
- Maintaining scientific and financial credibility to sustain consumer trust.
- Personalizing the impacts to draw and sustain attention.

Forum participants identified the following as effective elements of climate change-related communications.

- Be clear about the impact on communities (show examples as much as possible versus telling/describing them) and make it personal/local (be clear about costs and benefits to the individual).
- Get people with experiential learning to share real events with audiences (e.g., vintner's crops coming in sooner year after year, fisherman catching fish in areas never before).
- Use repetition of messages to reinforce key points.
- Make the utility effort a part of a larger communication effort (e.g., regional agency collaboration).
- Utilize a multi-layered strategy that hits all the "hearts and minds," and recruit and enable other credible messengers to communicate on the utility's behalf.

- Quantify the costs of no action.
- Establish an advisory (or similar) committee and meet to synthesize an understanding, gain consensus, and communicate findings.
- Choose the content of the messaging carefully relative to the context for the messaging (e.g., change the conversation about whether climate change is human caused in communities where there is limited belief in climate change).
- Understand that who is the messenger is important (e.g., conduct workshops with leaders of industry to develop messages that are presented by peers within the community).
- Provide practical, specific ways of how to tackle problems: real examples; local government explaining what they're doing and why.

Topic 6: More to Be Done – Research and Other Needs

> "Our relationship with water has to evolve."
>
> — *Eric Garcetti, Mayor of Los Angeles*

A key objective of the 2015 Forum was to identify further research and other needs. Provided below are the ideas for additional research and other needs shared by presenters and generated during breakout discussion sessions at the Forum. These ideas span four topic areas: resilient infrastructure; water resources management; water and energy; and climate communications.

Resilient Infrastructure

1. Better and more concretely define what is meant by "resilient infrastructure" to enable utility managers to better understand the actions that can and need to be taken.
2. Explore further the type of regulations needed to support integrated urban water management. As communities integrate their planning and investments across the entire water cycle, the current silo regulatory environment can hinder innovation and efficient solutions.
3. Improve the science and methods needed to characterize localized impacts and tie this to utility system responses and tipping points.
4. Identify "green investors" and understand what they seek in a good investment.
5. Improve methods and develop further findings related to the quantification of the cost of no action versus the benefits of taking action.
6. Improve the science behind and the methods for the application of portfolio theory specifically for the water sector.

Water Resources Management

1. Improve the transparency of data, along with improvements to QA/QC procedures and the consistency of methodologies.
2. Identify methods and tactics for overcoming political-institutional barriers (e.g., incentives and political cover) and overcoming parochial thinking.
3. Tactics for managing public perception in the context of potable reuse implementation.
4. Further develop methods for documenting benefits using Triple Bottom Line analysis.
5. Increase social science investments to better understand the cultural, economic, and behavioral aspects of climate impacts and adaptation responses.

Water and Energy

1. Research comparing the efficiency of central versus distributed systems.
2. Seek federal incentives (grant programs, regulatory responsiveness) for demonstration projects (such as clean energy and system optimization) that can reduce risk and start-up costs.
3. Better characterize the trade-offs between resiliency goals and GHG emission reduction goals.
4. Expand research on complete waste recovery and reuse.
5. Develop more refined methods for estimating the energy intensity (EI) of water (include energy intensity mapping of water sector systems).
6. Better characterize the seasonal and spatial effects on energy requirements of utility operations.

Climate Communications

1. Methods to understand a utility's own market: what are customer concerns; where do they consume media and messaging; what branding will they respond to?
2. Develop examples of successful communication methods to inform decision-makers and rate payers – tactics for how to convey complex topics in simple terms.
3. Create an aligned and unified message from political, academic, and utility specialists (consistent messaging and terminology).
4. Assemble a toolbox of pre-scripted messages (comprehensive packaged information) from national water organizations (such as AMWA, WRF, WERF, NACWA, AWWA).
5. Improve local impact data messaging (weather expected, species impacts, health, etc.).
6. Assemble information that translates into the ability to show impacts not just describe them.
7. Create a compilation of actions that focus on multiple benefits.
8. Compile best practices in translation and communication strategies with constituencies.

Take Away Points

Looking across the 27 presentations, questions and answers, structured breakout discussions, and informal side conversations at dinner and breaks, Forum participants came away from the event with an abundance of new ideas and examples of how utilities and communities are pushing ahead with addressing climate change. As the Forum wrapped up, there was an opportunity for reflection with the following nine “take away points” coming to the surface as highlights of the Forum content.

#1 - Water Challenges Reside as Key Climate Change Impacts: Water was more visible at the 2015 UN Climate Conference (COP21) than at any preceding climate summit. Water crises were identified as the number one problem from COP21 discussions. Water-related concerns emerge from trends in groundwater depletion, the substantial gap in financing for water infrastructure, and the effects of competition for water on food and energy.

#2 - The Water Sector Is Responding: The water sector has evolved substantially since the first Forum in 2010. The sector was characterized as moving from “grief, to denial, to anger, to bargaining and depression, to acceptance, and now to productive engagement.” The 2015 Forum explored challenges and highlighted amazing success stories. The sector is reimagining and reinventing itself - going from reactive to proactive, from drought management to drought anticipation, from flood control to stormwater management and harvesting, from silos to “one water” management integrated with community spatial planning. Water sector utilities are leading, rather than following, the resiliency and sustainability initiatives in their communities.

#3 - Uncertainty Need Not Be, and Should Not Be, a Deterrent to Action: Extremes and uncertainty were described as the water sectors' reality going forward. Adaptation needs are here and now - uncertainty need not, and cannot, lead to delayed action. Research efforts and practitioner experience have produced methods, tools, and implementation strategies that embrace uncertainty, preserve options, plan for multiple futures, and through diversification manage risks. Robust responses to climate change challenges are the result. Resilient programs will balance protection from water and living with water, balance technology and nature, and balance big with small scale solutions.

#4 - Practitioners from Around the World Have Proven Adaptation Success Is Possible NOW: The 2015 Forum showcased cities and other jurisdictions from all parts of the globe that have, and are in the process of, addressing "extreme extremes." Cities have tackled prolonged drought, severe storage capacity constraints, massive rainfall events, and intense storms. These leaders have paved the way and shown the path for all jurisdictions to find workable, locally tailored, climate adaptation responses. These veterans of extreme weather challenges have developed the strategies and created the experience and elements of success for a broad range of climate impact conditions. Large utilities and municipalities have driven much of this progress, and they now can and must play a role in supporting smaller utilities and communities to make needed progress. Other jurisdictions, with this support, can now leverage this experience to produce robust climate adaptation programs.

#5 - Inter and Intra Governmental, Sectoral, Jurisdictional Collaboration and Partnerships are Fundamental Elements of Effective Climate Change Response: Water sector utilities can't go it alone. Their adaptation efforts have reflected and will need to reflect integrated planning and execution across the water cycle and across governmental responsibility areas. Water sector utilities will be working outside of their conventional sphere and span of control to accomplish their objectives. To succeed, water utilities will require partnerships with federal, state, and local land use, community design, and watershed actors, public-private entities, technology companies, customers, farmers, researchers, environmental advocates, and others. The current leading communities and utilities also need to engage all levels of government to catalyze policy favorable to innovation and responsiveness to climate impact challenges.

#6 - Climate Adaptation and Mitigation Requires Substantial Resources: Communities actively engaged in climate adaptation and mitigation initiatives can face a two-part financing challenge. Existing infrastructure repair and replacement needs are already substantial and have required focused communication efforts to gain ratepayer support. Climate-related investments, which can have a more uncertain or intangible return, come on top of these needs and further add to the pressure and challenge to gain community support. Responses include both better integration of climate impact considerations into core infrastructure investment strategy, as well as seeking a mix of sources for financing, including various forms of public-private partnerships.

#7 - Water, Energy, and Greenhouse Gases – Utilities Are Engaged and Making a Difference: With the understanding of the high interdependency between water and energy, water sector practitioners have moved to reduce the energy, and greenhouse gas, intensity of water. Reducing the energy intensity of water is built on two pillars: water conservation; and energy management. Water conservation reflects that less water = less energy. Energy management draws on energy efficiency, operational optimization, and diversified (low/no carbon) energy sources. Lower utility operating costs, the potential for diversified revenues, and lower greenhouse gas emissions result.

#8 - Resilient Water – Resilient Community, Neither without the Other: The Forum spotlighted broad-based sustainability plans that integrate water management with the physical, economic, and social fabric of communities. These plans reflect that water management cannot be resilient/sustainable in the absence of a resilient/sustainable community, and a community cannot be resilient/sustainable in the absence of resilient/sustainable water management. The benefits are impressive: reduced heat island effect; improved air quality; enhanced livability; a secure water supply to support growth; and reduced vulnerability to extreme weather events.

#9 - Communication – the Heat Is On: Others are communicating about climate change, so must the water sector. Climate change adaptation success requires effective engagement, partnerships, and a knowledgeable, trusting, and supportive community. All require effective communication. Climate change poses special communication challenges. 2015 Forum presentations and discussions have shown they are not insurmountable. Practitioners have crafted highly effective communication strategies in support of their adaptation and mitigation efforts. This experience can jump start the efforts of other jurisdictions.

Conclusion

Water utilities have witnessed first-hand, before most others, that climate change is largely about changes in water – from sea level rise to precipitation extremes, from drought to melting glaciers. Success stories presented at the 2015 International Water and Climate Forum demonstrated how the water sector has evolved substantially over the past several years in its approach to addressing climate change. The sector is reimagining and reinventing itself and becoming more proactive. Water sector utilities are leading, rather than following, the resiliency and sustainability initiatives in their communities.

While conducting climate vulnerability assessments and working in the policy arena will continue to be essential for water utilities, the sector now recognizes that infrastructure investments, communication with stakeholders, interdependencies with other sectors, the resilience of a whole community and other issues need to be strategically considered in light of climate change. These multi-faceted challenges highlight the need to mainstream climate considerations into utility decision-making and planning in order to develop appropriate management responses. The important lessons learned can be considered and implemented for utilities of all shapes and sizes across the world. For those who wish to dive deeper into the Forum content, audio and PowerPoint files from every Forum speaker are available for free at www.waterclimateforum.org/presentations.

Appendix: SUPPLEMENTAL INFORMATION

Topic 1: Challenges That Are Here to Stay – Community Examples

1. Melbourne, dealing with the Millennium Drought in Australia, experienced a collapse of inflows, predicting 70 percent lower inflows by the end of the century. (Historic average inflow to major harvesting reservoirs had been 615 GL/yr., from 1997 to 2009 the average was 377 GL/yr.).
2. Rotterdam, a city with substantial land area residing below sea level, experiencing flooding, water quality degradation, excessive rainfall, and collapsing levees (from drought), inundated cellars, and heat waves.
3. Calgary moving between severe drought (2002) to severe flooding (2005).
4. Copenhagen experiencing "Cloudburst 2011" with 150 mm rain in 2 hours, and damages close to 1 billion euro.
5. Guayaquil, Ecuador with a March 2013 rainfall recorded at 160 mm – ten-hour duration, 104 mm associated with most intense two hours, with a return period of 50 years.
6. Louisiana looking at the potential for the highest rate of sea level rise in the world (4.3 ft. by 2100), and experiencing temperatures above 95 degrees on 80 plus days per year.
7. The State of California drought has had the worst impact in modern history. The drought is about more than yearly precipitation. It relates to more population, more irrigated agriculture, more endangered and threatened species, making impacts greater than previous droughts in 1924 and 1977. 2013 was the driest year on record, with snowpack a fraction of average normal (in 2015 it was the worst in 500 years). Local emergencies declared: 25 counties; 10 cities; 9 tribal reservations; 12 special districts, with 37 million people affected. Selected impacts include 500K acres fallowed, diminished yields on others, 18K plus out of work directly connected to agriculture, groundwater levels dropping precipitously, communities running out of drinking water, fish and wildlife impacts, and increased wildfires and associated costs and ecological impacts to air, land, water.

Topic 2: The Power and Promise of Results – Community Examples

1. Melbourne, Australia experienced a collapse in inflows as part of the Millennium Drought, and the city is predicting inflows to potentially be 70 percent lower by the end of the century. Their demand management efforts, focused on both consumer actions and water loss, have produced substantial results reducing individual water use from 108 gpd to 66 gpd from 2001 to 2015, and reducing non-revenue water from 60 GL/yr. to 42 GL/yr. between 2001 and 2015. They also have not had a "bounce back" in consumption after restrictions were lifted as the drought eased.
2. Rotterdam (a city that sits substantially below sea level) through its resilience and sustainability efforts, has transformed the city from "ten years ago being on all the wrong lists" to today being number five on the Arcadis Sustainable Cities List and named to the Top Ten List of Best in Travel 2016.
3. San Diego, California, operating under severe drought conditions, has produced a 39 percent decline in per capita water use in the water authority service area since 1990 (going from 235 gpcd in 1990 to 143 gpcd in 2015). The reductions offset the need for over 300,000 acre-feet of water per year. The city's Climate Action Plan focuses on waste, energy, neighborhoods, resiliency, and building water and energy efficiency. The plan anticipates substantial job generation and targets 16 megawatts of clean energy, a 35 percent use target for indirect potable reuse (the least energy

intensive means to provide potable water), an 80 percent GHG reduction, and a move to 100 percent renewable energy.

4. New York City, New York, moving ahead from Superstorm Sandy, has estimated that it has $1.1 billion of vital infrastructure at risk, and sees investing now will save money later. The city has estimated that investing $315 million in construction and strategic fortification can save the city $2.5 billion in emergency response costs over the next 50 years.
5. Los Angeles, California's Green-Blue City initiative estimates producing $22 million in benefits or avoided costs for every $1 million invested. Benefits have included public use open space, habitat restoration, climate resilience, improved water supply and quality, flood protection, and increased jobs.
6. Spartanburg, South Carolina, using the tag line "Where water flows, Spartanburg grows" has focused on enhanced system resilience coupled with an emphasis on innovation to produce added benefits in its community. Spartanburg has combined a focus on operational efficiencies with investments in technology and new ventures (e.g., ice kiosks, hydroelectric power) to create savings for ratepayers and provide new sources of revenue for reinvestment.

Topic 3: Enabling the Climate Resilient Water Sector Utility – Community Examples

1. Demand Management: practitioners portrayed highly diversified approaches to reduce demand (drive conservation) within their systems. The City of Melbourne, in response to Millennial Drought conditions, set a personal target of 40 gpd per person. They implemented staged curtailment (stage 1 garden watering morning/evening alternate days to stage 3 garden watering morning only twice per week), created the "Save Water Target" and made it very public, introduced retrofit programs including toilets, showers, faucets, and clothes washing, implemented rebate and labeling schemes, provided smart bills, and activated "Water Saver Garden Centers" stationing them at shopping malls and providing drought tolerant plants. San Francisco has responded to a state mandated ten percent reduction with free water use audits, water efficiency devices, continued public outreach, establishing recycled water partnerships with golf courses and parks, and using its headquarters building as a demonstration pilot for on-site treatment of grey and black water for flushing to reduce use by 60 percent.
2. Supply Management: for supply diversification, Melbourne has undertaken supply augmentation through desalinization, a constructed pipeline to interconnect with agriculture and form the basis for a robust water market, and modernized the irrigation system to improve efficiencies. The city has also moved to "functional turf" for sport and cooling, mandated recycled water for laundry, toilet, and landscape use, and addressed leakage through a leak detection strategy with zone metering, pressure management, water chasers and active leak detection, and meter testing and replacement strategy. They also plan integrated water management next generation projects such as treating stormwater to potable standards. The City of San Diego provides a further example of the elements of supply diversification to create a balanced portfolio: irrigation transfer; canal lining; recycled water; seawater desalinization; groundwater; local surface water; and potable reuse.
3. Stormwater: diversified approaches relative to stormwater have addressed both flood risk and the capture of stormwater as a valuable resource (in water scarce areas), sometimes simultaneously depending on local conditions.
4. City of Calgary provided an example integrating risk management into planning by identifying a series of "strategic risks:" assets, customers, finances, environment, safety, and employees. The strategic risks flow down to departmental risk teams, and the departmental teams adopt industry best practices. A separate presentation portrayed the key aspects of managing the "Risk Pyramid."

a. First, decisions about corporate strategy and the direction of the business which include risk governance and culture, long-term planning, policy and regulatory climate, and futures and adaptation are made.
b. Second, tactical decisions transfer strategy into action across the business considering behavior and human factors, asset management, water safety plans, and risk management.
c. Third, front line operational decisions are taken for implementing strategy and tactics, including tools and techniques, as well as organizational governance standard.

5. The City of Calgary, after experiencing substantial flooding, now plans in terms of a 1 in 200 or 300 storm event for purposes of land use decisions. They have a Flood Management Plan that addresses: watershed management; event forecasting; storage diversion and protection; infrastructure and property resiliency; and strengthening policies. Copenhagen's Cloudburst Management Plan seeks to deliver protection against a 100 year event. The plan utilizes mixed solutions – owned, constructed, and maintained by the city, but paid through a water tariff. Their efforts include urban space improvement, and also seek to direct water where damage will be minimal (accepting that inundation will happen).
6. Guayaquil, Ecuador's Integrated Urban Water Management program is designed to address both supply (quantity and quality) as well as flooding concerns. Actions under the plan include: macro drainage measures (structural retentions in identified water storage zones); urban gardens; bio-retention basins; low impact development for urban ecosystem and habitat protection; erosion and sediment control through reforestation and limiting growth in key areas; and development of a Water Fund for Conservation and Maintenance of the Daule River Watershed (implemented in partnership with multiple public and private institutions and designed to provide resources for investments in quality and quantity of water). The city also has tide control structures and now plans development for urban ecosystem and habitat protection.
7. Melbourne, Australia provides an example of an adaptive management approach. It has prepared an Adaptive Water Security Framework. The framework has a three "zone" hierarchy. High Storage Zone signals a secure supply situation. The Medium Zone equates to a 5 year supply and a need to take actions (e.g., initial restrictions, activation of a desalinization plant). The Low Zone equates to a 2 year supply signaling a need to take added actions (e.g., greater restrictions, supply augmentation, etc.). The adaptive systems is supported by key performance measures that cover customers, innovation, livability, and environmental conditions.
8. New York City is the largest combined water and wastewater utility in the U.S. It has developed the "Rain or Shine" sustainable water management initiative. Under this initiative, NYC is proactively: reducing greenhouse gases, stormwater runoff, and drinking water demand; and preparing for impacts of extreme weather to drinking water and wastewater infrastructure. NYC's overall water management strategy is multi-faceted: energy neutral wastewater treatment plants; water footprint and population growth; watershed management as an integral part of filtration avoidance (that has energy implications and requires investment in watershed protection, land acquisition, and monitoring); "blue belts" for stormwater management; GSI in streets and sidewalks; and public school playground stormwater retrofits.
9. Spartanburg is defining resilience for its utility as: the ability to cope with, and recover from disruption, trends and variability in order to maintain services for people and protect the natural environment both now and into the future. Their strategy has three aspects: investing in new programs and ideas to increase revenue; engaging and incentivizing its workforce in an innovation culture; operational efficiencies; and stabilizing its rate structure. For example the city has developed packaged ice, hydroelectric investment (now sell power to grid); and green infrastructure.

10. From a state-wide perspective, California has prepared a Water Action Plan, with climate change as an overarching driver. This plan reflects an integrated and multi-pronged approach:
    a. Make conservation a California way of life;
    b. Increase regional self-reliance and integrated water management across all levels of government;
    c. Protect and restore important ecosystems;
    d. Manage and prepare for dry periods;
    e. Expand water storage capacity and improve groundwater management;
    f. Increase flood protection;
    g. Increase operational and regulatory efficiency;
    h. Identify sustainable and integrated financing opportunities;
    i. Accept that there will be loss of snowpack making groundwater management much more critical; and
    j. Use conservation as a near term measure, with sustainable water supplies as the long-term answer.

11. Los Angeles has established the Green-Blue City initiative. This initiative reflects a shift in posture for water infrastructure in the city from "out of sight, out of mind," to "in sight and in mind." At its core, it reflects an effort to manage all water as "One Water." The effort pushes the integration of and collaboration among drinking water, rain/storm water, groundwater, recycled water, and wastewater. The city has placed an emphasis on local water supply development and reliability reflective of an interest in reducing vulnerability to outside, shared resource, water supply. The local development efforts are focused on water conservation and recycled water (the city now treats over 350 million gallons of water per day – most of this resource goes to the ocean). Stormwater capture has been the biggest challenge due to stormwater quality, even as there is a huge opportunity to infiltrate. They will need to undertake advanced water treatment. To further support local supply efforts, they have instituted Low Impact Development ordinances, green building requirements, and are designing new development with groundwater replenishment in mind.

Topic 4: Resilient Utility – Resilient Community – Community Examples

1. The One New York – The Plan for a Strong and Just City – seeks to drive reductions in city-wide GHGs (by 2050 80 percent below 2005 levels) in part supported by solar energy and combined heat and power efforts, zero waste to landfills, improved air quality, further brownfields redevelopment, improvements to parks and natural resources, and address urban flooding in part through the deployment of green stormwater infrastructure as close to the source as possible. The plan's water management aspects seek to reduce the city's water footprint even with expected population growth, achieve energy neutral wastewater treatment plants, and buffer and manage stormwater flows through "blue belts," GSI in streets and sidewalks, and public school playground stormwater retrofits.
2. New Orleans, Louisiana has constructed a community-wide sustainability plan focused on connecting to opportunity and transforming city systems (with a theme of "adapt to thrive"). The plan seeks to invest in household financial stability, lower barriers to workforce participation, continue to promote equitable public health outcomes, continue to build social cohesion, and expand access to safe and affordable housing. The transformation of city systems is focusing on:
    a. Commitment to mitigate the city's climate impact;

b. Redesign of the regional transit system to connect people, employment, and essential services;
c. Promote sustainability as a growth strategy;
d. Improve the redundancy and reliability of the energy infrastructure;
e. Invest in pre-disaster planning for post-disaster recovery; and
f. Develop the preparedness of businesses and neighborhoods.

The hurricane and water management aspects of this plan focus on reducing stressors and improving the capability to come back more quickly. The city is:

a. Advancing coastal protection and restoration;
b. Improving floodwalls and levees to protect the city from storm surge and pumping to evacuate stormwater that falls within these boundaries;
c. Investing in comprehensive and innovative urban water management (50-year urban water plan);
d. Incentivizing property owners to invest in risk reduction (resilience retrofit program and small business resilience program); and
e. Creating a culture of environmental awareness at every stage of life.

3. Rotterdam has gone through a major evolution in its climate resilience and overall community sustainability strategy. This evolution has reflected an effort to balance protection from water and living with water, and balance technology and nature. In 2005, the city's efforts focused on flood management. By 2014, the city had moved to a holistic, multi-level, multi-stakeholder strategy – "Urban by Nature." This sustainability program encompasses several focus areas designed to deliver cleaner air, lower energy bills, and more jobs. These include:
    a. Green, healthy, and resilient city (creation of green areas and water storage, air quality and sustainable mobility, water safety, resilience, and adaptation program).
    b. Strong, innovative economy (circular and bio-based economy, use of LNG and hydrogen, stimulate a clean technology cluster).
    c. Cleaner energy at lower cost (solar and wind power, retrofits to existing buildings).

    The water management aspect of the plan focuses on a multi-faceted approach and multi-functional solutions. It couples sewerage with water squares, dikes with adaptive building design, storm surge barriers with more permeable areas, and pumping with green river banks. Multi-functional solutions include parking and water storage, parks and water squares, adaptive buildings (including green roofs), and sports facilities and water storage (e.g., and joint Sport Department and Water Department rowing facility).

4. Singapore has moved to "managing the whole water loop" in response to a lack of land to store water and a high and growing population. The effort is based on three principles:
    a. capture every drop of rain that falls on Singapore;
    b. collect every drop of used water; and
    c. recycle every drop of water more than once.

    Singapore's highly integrated water management strategy combines capture and treatment of stormwater and desalinization to provide water to its population and industries with treatment of wastewater for direct and indirect potable reuse. By allowing every drop of water to be used and re-used, Singapore's "NEWater" creates a multiplier effect of the water yield. Given a 75 percent water recovery rate, one drop can generate 4 drops. This augmentation to Singapore's water supply has

given the nation confidence to move ahead with growth with the knowledge that a resilient water supply is available.

5. Mexico, situated between the Pacific Ocean and the Gulf of Mexico, is very vulnerable to high impact weather/climate events, including droughts, hurricanes, heat waves, cold fronts, and the impacts of El Niño and La Niña. This vulnerability spawned Mexico's General Law on Climate Change – the second such law in the world. The law underpins a comprehensive climate adaptation approach:
    a. Adaptation to climate change for the social sector, seeking to increase the adaptive capacity of the population to climate change and reduce high vulnerability in 160 municipalities.
    b. Ecosystem-based adaptation, seeking to strengthen actions of ecosystem protection and restoration and attain a deforestation rate of zero percent.
    c. Adaptation of strategic infrastructure and productive systems by generating early warning and preventative systems in the entire country against extreme hydrometeorological events, incorporating adaptation criteria in public investment projects related to construction of infrastructure, and creating a national water reserves program.

    Implementation of the law has included:
    a. The preparation of a national atlas of vulnerability, that in turn supports regional scenario planning (relative to temperature and precipitation minimums and maximums);
    b. Establishing criteria for adaptation to climate change in urban areas;
    c. Creating adaptation measures for non-irrigated agriculture and the water sector; and
    d. Stress testing key economic sectors against climate factors (temperature, precipitation, air quality, water quality, wind) resulting in a plan for each of the major cities.

Topic 5: Communications – More Necessary than Ever – Supplemental Material

Presentations and discussions directly relating to climate change communications worked from a basic premise: many water utilities are facing climate change adaptation costs, and if investments must be made and behavior change created, customers who know they have a problem will be more supportive than customers who don't. Climate change communication research provided several findings designed to help utilities cultivate customer engagement in climate change.

1. Communicate the "Big 5" (to get societal response and support for climate policies): 1) it's real (it is here, now); 2) it's us; 3) experts agree (more than 97 percent of climate scientists); 4) it's bad (harmful to humans); and 5) there's hope (it's solvable, and there is much we can do to protect ourselves).
2. There is a need to close the gap between the physical realities and the psychological experience of climate change. Climate change is seen as distant in space (with long time frames to impact 50, plus years, with the big impacts out 100 years) and seen as distant in species (polar bears).
3. Closing the gap has two dimensions. Recognizing that not all customers are alike, and understanding that brains process risk information in two ways.
4. The climate communication audience breaks down into the "Global Warming Six Americas":
    a. Alarmed = 13 percent, Impact now/motivated reasoning
    b. Concerned = 31 percent, impact 10 to 25 years/experiential learning
    c. Cautious = 23 percent, impact 25 to 50/experiential learning
    d. Disengaged = 7 percent, impact 25 to 50/experiential learning
    e. Doubtful = 13 percent, impact 100/experiential learning
    f. Dismissive = 13 percent, never/motivated reasoning

5. Thinking fast and thinking slow are the two modes of risk information processing.
    a. Thinking fast is the direct, experiential system (think Grizzly Bear encounter) that produces immediate and vivid impressions where experiencing is believing.
    b. Thinking slow is the analytical system – it is challenging and requires mental effort and analysis (pallid numbers, words, logic).

6. Experiential learning usually trumps analytical learning, with the implication that, to cultivate customer engagement in climate change, show local impacts, do not tell about them.

Water utility perspectives on the climate communication challenge came both in the form of presentations and participant discussions. There was a reminder that water utilities, for the most part, are monopolies and largely led by engineers – this has left utilities of the past with little or no advertising budgets and limited emphasis on communication skills. Several compelling reasons and needs to communicate were covered: change is happening requiring a move away from "business as usual;" resources are and will be needed; water utilities cannot address all climate issues – they need partners; climate issues/impacts overlap and exacerbate other infrastructure issues; and stakeholders on all sides will communicate, with or without utility perspectives.

ASSOCIATION OF
METROPOLITAN
WATER AGENCIES

For more information:

Association of Metropolitan Water Agencies
1620 I Street NW
Suite 500
Washington, DC 20006
USA

Phone: 202-331-2820

www.amwa.net
www.waterclimateforum.org