Climate Change

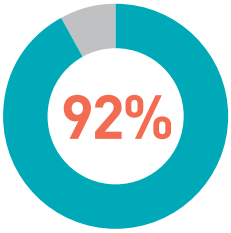
THE CHALLENGE

As Earth's temperatures rise at an unprecedented rate, the water sector will need to adjust to a new set of norms in order to continue to provide critical services. Climate change is already altering the patterns of our natural hydrologic cycle, creating uncertainty when it comes to the quality and quantity of water sources—forcing utilities to rethink practices that have traditionally been effective and seek solutions that will meet different, more-unpredictable conditions. While it is clear that widespread shifts in weather patterns will continue in the foreseeable future, the rate and intensity are not fully known. A recent United Nations' report suggests that at the current rate, temperatures could surpass the critical threshold for catastrophic effects by 2040. Even seemingly slight increases can set off a chain of negative effects, such as lower dissolved oxygen levels, higher contaminant loads, reduced stream flows, altered runoff timing, widespread algal blooms, and increased saltwater intrusion.

Adding to this challenge is the increased frequency of extreme weather, also linked to climate change. From drought to storms to tidal surges, these events can have devastating effects on critical water infrastructure. Because lack of access to clean, safe water is the single biggest threat to human health and economic livelihood, water service providers must be prepared to address these unstable weather conditions.

THE RESEARCH

WRF has been at the forefront of a new climate paradigm, offering sound science to help the water sector continue to meet water demand and quality standards, and to plan for uncertain times. Research helps understand and predict potential effects, prepare for the impacts on water sources and services, and offset changing climate trends by developing solutions that drive down greenhouse gases, optimize energy use, and generate sustainable power—all in an effort to improve resiliency.



92% of Americans think their water utility should play a leadership role in helping communities prepare for the impacts of climate change.

Source: WRF Project #4381

While WRF's body of research in this area dates back to the 1980s, with studies on related trends like the effects of heavier rainfall on water quality, in 2008, WRF launched the Climate Change Strategic Initiative. The effort produced a series of integrated projects specifically dedicated to addressing the effects of long-term shifts in weather patterns.

Because climate change has broad implications, WRF partners strategically to produce the best possible science, pulling in expertise from federal agencies, universities, the private sector, and others. Key collaborators include the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the National Aeronautics and Space Administration, the Global Water Research Coalition, the U.S. Climate Change Science Program Office, the Water Utility Climate Alliance, the Association of Metropolitan Water Agencies, and the New York State Energy Research and Development Authority (NYSERDA).

Impacts and Vulnerability

Because the first step in preparing for climate change is understanding the potential—and often variable—impacts these changes can have on water sources and treatment systems, WRF research tracks potential outcomes, considering a variety of possibilities. This science provides the foundation for resources and tools to help facilities identify and address vulnerabilities in their operations and infrastructure.

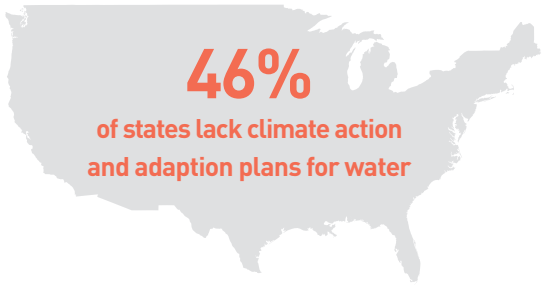
Beginning in the early 2000s, WRF released some of the water sector's first research defining the links between climate change, the hydrologic cycle, and the ultimate water utility impacts. The 2006 handbook, *Climate Change and Water Resources: A Primer for Municipal Water Providers* (2973), offers one of the first overarching views of what climate change can mean for drinking water utilities, helping many utilities see for the first time the nature of risks, as well as possible solutions. This was followed up in 2010 with *Implications of Climate Change for Adaptation by Wastewater and Stormwater Agencies* (CC2R08), which explores the impacts to wastewater and stormwater. The report lays out a series of cause-and-effect diagrams tracing the path from global warming effect to utility implication, for example, warmer winters could lead to more rain rather than snow, which could increase runoff, in turn prompting regulatory compliance issues.

Expanding this same line of research, *Water Quality Impacts of Extreme Weather-Related Events* (4324/CC4C10) continued to identify and characterize impacts, this time with a focus on severe weather events. The two-year project provides a comprehensive collection of case studies on events like hurricanes and heat waves, touching on everything from changes in nutrient levels to often unaccounted-for impacts, such as the increased staffing needs during and after catastrophic events. All of this information is available in a corresponding online tool, designed to help facilities identify and assess weaknesses and limitations in a changing, less-predictable environment.

While climate change will undoubtedly impact water supply, WRF research is also looking at the other side of the coin—how it will impact water demand. Water use is a function of long-term climate patterns as well as short-term fluctuations in weather conditions, and can also be shaped by trends in regional population growth, all of which can be influenced by climate change. To help water utilities better understand the implications of these changes, in 2013 WRF released the results from *Changes in Water Use Under Regional Climate Change Scenarios* (4263), a study that explores potential water use patterns under a range of climate scenarios. The research provides recommendations for utilities to forecast demand based on anticipated weather shifts, which will likely require multiple models—laying the groundwork for standard regional methods to accurately predict water use.

Response and Adaptation

As a clearer picture of climate change continues to emerge, evidence suggests that impacts will vary widely by region; however, it is relatively certain that no area will be untouched. Implementing strategies to adapt will be critical as the water sector moves forward. WRF has been working to provide solutions and tools to help utilities create better long- and short-term adaptation plans, respond more effectively to severe weather, and improve infrastructure and operations to meet changing needs, including the production of onsite energy systems and reliable back-up power to protect critical services.



As of a 2018 survey, 23 states did not have a climate action, adaptation, or resiliency plan that features water resource management. Source: WRF Project #4730

In 2011, WRF teamed up with NOAA, EPA, and several other organizations for a series of six workshops to examine response approaches for extreme weather. The compiled results, featured in *Water/Wastewater Utilities and Extreme Climate and Weather Events* (CC7C11), pulled together experiences from watersheds and river basins across the United States, taking a comprehensive look at how utilities make decisions in response to severe weather. The report highlights successful strategies for dealing with a variety of conditions, which can often be concurrent—underscoring the need for long-term preparedness and emergency response planning that considers multiple risks.

Building on previous collaborations with NOAA, WRF and several of the largest water agencies and organizations joined forces to help in the design of a Water Resources Dashboard (https://toolkit.climate.gov/topics/water/water-resources-dashboard). The online tool is part of NOAA's larger U.S. Climate Resiliency Toolkit and uses real-time data and weather maps to help water professionals make decisions when facing extreme weather. The dashboard is a curated set of tools and resources, offering the ability to do things like determine the likelihood of thunderstorms and tornadoes in an eight-day period, predict the path of hurricanes, monitor flood risks, and determine the probability for droughts.

Because no single strategy for responding to climate change works for all facilities, WRF is helping utilities find the methods that are right for their situation. In 2014, WRF partnered with

NYSERDA and Water Services Association of Australia to deliver a set of risk management tools to help select the most appropriate actions for responding to vulnerabilities. The project, *Developing Robust Strategies for Climate Change and Other Risks* (4262), identifies the top vulnerabilities associated with climate change and provides tools to assess utility-specific risks.

Ongoing research is taking this science further, helping to understand the variability of key water quality parameters and identifying corresponding adaptation strategies. Working through a $1.1M EPA grant, WRF and the University of Colorado Boulder, are investigating the impacts of extreme weather, such as drought and flooding, on water supply quality and availability. The results of the project, *An Integrated Modeling and Decision Framework to Evaluate Adaptation Strategies for Sustainable Drinking Water Utility Management Under Drought and Climate Change* (4636), slated for release in 2020, will include tools that allow utilities to quantify the risks from climate and other natural hazards to water sources and subsequent water treatment processes.

Mitigation

WRF recognizes that future planning goes beyond just preparing for the impacts of climate change—the water sector must also have a hand in mitigating the root causes. By pioneering approaches to improve energy efficiency, including process optimization, improved energy management, and the use of renewable energy, WRF is helping the water sector decrease activity that is driving these changes. WRF has a body of over 100 research projects that work toward improving energy use in the water sector, as well as generating on-site power. To learn more, see WRF's Energy Optimization Factsheet.

Because greenhouse gases are significantly linked to climate change, research in this area is also a high priority for WRF. Studies are shedding more light on the role plant operations play in producing emissions, like methane and nitrous oxide, and calculating contribution levels. The 2009 guidebook, *Greenhouse Gas Emission Inventory and Management Strategy Guidelines for Water Utilities* (4156), outlines a systematic method for tallying the levels, helping water utilities evaluate emissions for potential projects and weigh alternatives. It also highlights emission-reduction strategies that can be incorporated into everyday utility business and operations.

Building on this concept, WRF is also leading efforts to zero in on specific segments of the treatment process that can be contributors and more accurately measuring amounts—with the goal of engineering solutions to minimize gases and walk back the effects. In 2011, WRF released a suite of projects that explores topics in this area, providing some of the water sector's first research on exactly how and where in the treatment process these gases are being formed and how much is actually being emitted, versus consumed in the process.

SOLUTIONS IN THE FIELD: Colorado's Front Range

Concerned about the impact climate change could have on their already fragile water supply, water providers in Colorado's Front Range corridor came together to study the potential effects. Depending on the direction, timing, and magnitude of future changes in temperature and precipitation, the volume of available water could increase or decrease or peak runoff timing could change, leading to water rights complications or challenges for facilities that rely on snowmelt for water supply. Through WRF-funded research, several utilities began working together on the *Joint Front Range Climate Change Vulnerability Study* (4205) to assess the potential changes to stream flow for the three surrounding river basins, looking as far out as 50 years.

The group developed a method for selecting models to project the impact of greenhouse gas emissions on climate, and then created models to simulate the hydrological response to these impacts, including runoff timing and amounts. The results and related tools can be used to further assess climate impacts on the water supplies in the three basins studied or for other locations. Research findings have already been used in several key planning documents, including *Climate Change in Colorado: A Synthesis to Support Water Resources Management and Adaptation* and the *Colorado Drought Mitigation and Response Plan.*

By more accurately pinpointing contributing factors, WRF is opening the door for better-targeted solutions that address the actual problem.

Communication
While the ability to develop strategic, science-based action plans is key to water sector resiliency, without the ability to communicate about potential impacts, these plans have little chance of getting off the ground. Effective communication is critical to build public support, as well as funding, for the utility actions. But due to the nature of the topic, this can be easier said than done—often bogged down in politics, probabilities, and unknowns. WRF has helped to develop fundamental scientific guidance on communicating about the risks, as well as how to open a more direct conversation on climate change with an audience who might have different perceptions of its origins, impacts, and importance.

When it comes to climate change, WRF started with one basic question: Should water utilities talk about it? The research was clear—it is better to talk about climate change than talk around it. In 2014, WRF released *Effective Climate Change Communication for Water Utilities* (4381), a guidebook that walks utilities through crafting evidence-based messages that will resonate with their audience, with an emphasis on building support for climate-related adaptation and mitigation investments. The research features an accompanying worksheet that guides users through the process, as well as an educational video that provides water professionals with the information they need to effectively communicate about the relationship between water, utility needs, and climate change.

WRF is also helping the water sector strengthen infrastructure and other critical assets, to support the needs of today, as well as those of an unpredictable future. Through a $1.95M EPA grant, WRF is collaborating with several universities and national organizations to develop a publicly accessible, cloud-based decision-making tool to enhance stormwater infrastructure, including options like green infrastructure and best management practices. The decision support system, known as the Community-enabled Lifecycle Analysis of Stormwater Infrastructure Costs Tool, or CLASIC, incorporates climate impact assessment modeling, allowing communities to weigh the benefits of stormwater practices with their full life-cycle cost, based on impacts from projected climate scenarios and extreme events. The tool enables communities to assess the level of risk they are willing to incur regarding stormwater services against associated costs to boost resiliency.

Climate change is just one of the many threats that utilities must prepare for to remain resilient. For more information on how WRF is helping to ensure a strong and sustainable water sector, see WRF's Resiliency Factsheet.

LIFT

The Leaders Innovation Forum for Technology (LIFT) is an initiative that helps move water technology to the field quickly and efficiently. Because new technologies and processes will be key to addressing water needs in a changing environment, LIFT has several focus groups related to climate impact, adaptation, and mitigation, including stormwater and green infrastructure, energy from wastewater, and digestion enhancements.

WHAT'S NEXT?

As the water sector becomes more adept at understanding the consequences of climate change, WRF research will provide the support utilities need to assess their vulnerabilities and adjust. With models and tools available to predict potential scenarios, the challenge now is taking that information and incorporating it into short- and long-term plans. Projects like *Mapping Climate Exposure and Climate Information Needs to Utility Business Functions* (4729) are already headed in this direction, looking beyond risks to just water supply and quality, and exploring all aspects of operations and business practices that will feel the effects, including how we design and manage infrastructure.

WRF will also continue to address water sector needs related to extreme weather, such as flooding. WRF is rolling out projects such as *Enhancement of Resilience to Extreme Weather and Climate Events: Proactive Flood Management* (4842) and *Managing Heavy Precipitation, Water Quality, and Flooding in Urban Environments* (5001) to help utilities prepare for, manage, and treat the large amounts of water that go along with increasingly common severe storms.

While the exact impacts of climate change are uncertain, it is clear that this issue has broad repercussions that will resonate across many sectors. WRF will continue to develop strategic cross-sector partnerships, collaborating on all levels to address the challenges associated with environmental stability and public health and safety—as well as to help the water sector do its part in offsetting potential contributing factors.

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