Executive Summary

Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions (project 4729)

Water utilities provide potable water for use in homes, workplaces, schools, businesses, hospitals, and public buildings for drinking, cooking, showering and bathing, watering lawns and gardens, providing fire protection, and enabling industrial processes.

Water utilities face new and growing challenges in anticipating the risks (and opportunities) posed by climate change. Combined with seasonal, interannual, and decadal variability, climate change leads to more extreme events, such as heat waves, wildfire, drought, and flooding. These events impose a range of direct and cascading impacts and potential failures across multiple systems, sectors, and processes. That said, utilities already recognize the need to anticipate future conditions, including consideration of climate change—issues well documented in water utility guidance documents from organizations like The Water Research Foundation and Water Utility Climate Alliance.

This research project's goal was to co-design and test (through case studies) a replicable water utility business function climate risk and opportunity framework and associated guidebook with water utilities across the United States. In addition, the project provides insights on the types of available data that can be used to assess climate risks and the opportunities associated with particular water utility business functions. Through use of this framework and guidebook, an enterprise-wide understanding and prioritization of the exposure, sensitivities, and opportunities that water utility business functions face in a changing climate can be developed. In turn, this can accelerate the incorporation of climate considerations into everyday utility management.

The core benefits of using this framework include alerting business function managers and staff to emerging risks and opportunities associated with the intersection of climate drivers and the array of utility systems and functions. When these new and/or increased risk levels intersect with underlying vulnerabilities, such as deteriorating infrastructure and interdependent systems that may pose a common point of failure, the result may be catastrophic failures for large water utilities, with significant impacts on their surrounding communities. Energy, water, and healthcare system impacts resulting from these failures can place the people, businesses, and industries that rely on safe and reliable water at risk.

The Water Research Foundation (WRF), the project team, and other contributing partners supporting this research project clearly recognize that some water sector utilities include functions beyond drinking water, including wastewater, reclaimed water, and stormwater. These utilities have an even broader range of risks to manage. Due to funding and time constraints, the project's scope was primarily limited to drinking water functions and their critical pathways. However, the framework, guidebook, case studies, and findings can be readily used to assist other water sector utilities in preparing for, and responding to, Earth's changing climate.

This project investigated a range of water utility business functions and sub-functions, in addition to individual and cascading climate risks and opportunities, that may affect these business practices, including energy use and supply, capital investment decisions, purchasing and supply chain issues, asset management programs, employee and

customer service issues, emergency management, and more, linking available and relevant climate data and information to those business functions. Limiting the consideration of climate change to the direct impacts of individual climate drivers on water supplies and infrastructure can "silo" climate change as an external, physical factor, preventing a full assessment of risks and opportunities across a water utility's core functions. Mainstreaming—including consideration of climate issues in all decision processes across the entire utility enterprise—requires a much more integrated view of systems and critical paths of business activities. Additionally, mainstreaming requires a more integrated system-based view as integration of these considerations into a broad array of activities must be strategically thought through to ensure that decisions address current and future risks and opportunities. Developing cross-functional expertise within a utility at scale requires collaboration, climate awareness, an understanding of the potential cascading impacts, and a broader perspective across all internal leadership.

Through this project, the team accomplished the following:

- Developed a suite of common water utility business functions.
- Identified "critical" paths and components for analysis within each business function.
- Assessed the potential risks and opportunities of climate drivers to affect the critical path of water utility business functions.
- Compiled relevant climate data and information for business functions.
- Designed a flexible and replicable water utility business risk and opportunity framework and associated guidebook.
- Tested the framework with four case-study utilities.

The methodology used to conduct this research included intensive desk research and virtual interviews; interactive and co-produced climate risk and opportunity mapping exercises; analysis of existing scientific data and information relevant to assess water utility business function risks and opportunities; the design of a replicable and easy-to-follow water utility business function climate risk and opportunity framework and associated guidebook, Water Utility Business Risk and Opportunity Framework: A Guidebook for Water Utility Business Function Leaders in a Changing Climate, in collaboration with four utility case studies; and ongoing feedback from the project partners (Table ES-1) throughout the duration of the research project.

Table ES-1. Project Partners

Partner Name	Description	Organizations Involved
Water Utility Practitioner Group (WUPG)	WUPG members served as on-the-ground water utility experts, providing insights into the utility's core business functions, climate science and data needs, and decisions being made to enhance business resilience in the face of a changing climate. These utilities were selected as part of the project proposal process based on their interest, location, size, and utility complexity.	• Austin Water • City of Fort Collins Utilities • New York City Department of Environmental Protection • Salt Lake City Department of Public Utilities • San Diego Public Utilities Department • Southern Nevada Water Authority • Tampa Bay Water
Case Study Water Utilities	To explore the framework and process in more depth, four case study water utilities were selected, representing different geographic areas of the country, water sources, scopes of service, and size ranges, from relatively small to very large. All were enthusiastic about serving as a case study, and already do or will experience different impacts from climate change.	• City of Fort Collins Utilities • San Diego Public Utilities Department • Southern Nevada Water Authority • Tampa Bay Water
Technical Advisory Group (TAG)	To ensure the framework and end results were informed by a wide range of water utility practitioners and experts, a small group of technical advisors was recruited to supplement the team's expertise by providing in kind, overarching advice, guidance, and insight throughout the project's duration.	• American Society of Adaptation Professionals • Cascade Water Alliance • Western Water Assessment • Marie Pearthree, P.E. • Dr. Jeffrey Arnold • Dr. Missy Stults • Paul Fleming

This research resulted in an improved understanding of varying business functions across multiple water utilities, considerations for business functions to assess climate risks and opportunities, capabilities needed to support business function leads through this process, data and information types needed to assess business function risks and opportunities at various scales, a step-by-step framework for water utilities to map climate-related risks and opportunities across their business functions, and some positive progress in risk identification and management for several of the partner utilities since the start of the project in 2018. Although most of the utilities studied in this project were large, the framework proved useful regardless of the utility's size. For example, the same approach was used for Fort Collins and for larger utilities, such as Tampa Bay Water. In fact, the study found that the simpler the utility business functions, the easier it was to analyze the risks. For this reason, the research team found it helpful and more logical to map climate risks and opportunities to the core business functions' sub-components rather than the larger-scale core headline functions, which Table 1-1 shows in bold.

This project's next phase will include guidance on mainstreaming the framework into utilities' internal management practices to enhance overall resilience to climate change.

ES.1 Key Research Takeaways

These key takeaways represent a summary of overarching lessons learned throughout the research project and development of the framework.

- Most water utilities have not assessed climate change risks and opportunities from a business function perspective; rather, if considered at all, climate risks and opportunities usually focus on water supply and flood control issues. Those already assessing these risks have recently experienced significant impacts from extreme weather events that impacted their (or another utility's) ability to provide safe and reliable water to their customers.
- Mapping climate drivers and underlying conditions to critical decisions or requirements for business functions leads to a more integrated, systems-based understanding of risks and opportunities. This business-function oriented approach can lead to a more sophisticated analysis, ultimately affecting and providing the business case to reconsider priorities and strategic investments for utility management. The research team concluded that starting with the business function and understanding risks from that perspective proved more useful than starting analysis with the climate drivers.
- The process and conversations associated with mapping business functions were much more important than the maps themselves, which serve as means to an end. The primary outcomes of the mapping process included more collaborative relationships and improved communication across the business functions; cross-training, understanding of, and identification of impacts related to a complex issue within and across the utility enterprise; an improved understanding of relationships between climate risks and underlying vulnerabilities; explicit discussion of critical decisions or requirements for each business function; and thoughts about the actual conditions and significant imperative for continuity levels of service and operation. Consequently, ongoing conversations of this type can be useful.
- Bringing an array of utility business function representatives together offers multiple benefits. In many cases, they may not have previously worked together closely, and joint exploration of these risks and opportunities builds relationships and capacity for future collaboration – for any complex issue the utility may face. Leadership and climate expertise within the utility for such assessments is also critical when working with business functions not regularly considering climate change as a factor in their decisions. These leaders and experts can help the business function leads navigate the daunting climate science and ask the key climate questions.
- A genuine need exists for guidance and implementation of integrated, long-range, capital improvement and financial planning for acute and chronic climate impacts across water utility business functions (mainstreaming risk and resilience). The research clearly indicated that not all water utilities currently integrate such planning processes and could benefit from more coordinated and aligned efforts.
- Knowing how to find the climate data and what data type, scale, and timeframe to use in evaluating business functions' risk and/or opportunity can prove daunting. The data synthesis developed for this project provides suggestions on how to deal with time, spatial scales, and other geographic considerations. Section 4.2 provides additional guidance for the type, scale, and timeframe of climate data.
- Anticipating extreme weather conditions can be far more challenging than identifying

climate trends. Some utilities have internal climate experts (with some training in climate science and actively following climate-related developments) and/or sustained relationships with external climate experts (including scientists, consultants, or academics); others do not. Therefore, a range of sophistication and/or capacity exists in anticipating future climate conditions. Though even experts can be challenged in approaching these difficult questions, understanding the potential for extremes is very important to most utilities. Collaborating with scientists to understand how to manage uncertainties and generate useful data and information to provide anticipated ranges for extremes will be an ongoing need.1

- The co-production process is essential—the team could not have conducted this work without partner utilities sharing their knowledge of the ways that their utilities function. Conversely, external parties (the research team) asking the questions identified new topics not previously discussed, perhaps helping business function leads move to a more nuanced view of their business function's interdependence and of the potential for cascading risks and associated opportunities to enhance resilience.
- For almost every risk identified, a potential adaptation strategy or opportunity could minimize the risk's impacts. In many cases, the same strategy (e.g., advances in internal communications around building more robust infrastructure, hazard mitigation, human resources/community engagement systems to manage extreme events) could be used to address multiple potential problems, providing co-benefits for the water utilities.
- This climate risk-based business function assessment should be included as one element of a utility's comprehensive effective utility management (EUM) program.

Based on the research objectives, the research team developed the key findings shown in Table ES-2, each of which is described in more detail in the subsequent chapters.

[1] For useful climate data sources, review the climate information sources and types within the Risk and Opportunity Profiles (Appendix E).

Table ES-2. Summary of Key Findings	
Project Objective	**Key Findings**
Chapter 1: Compile a suite of water utility business functions	• **Key Finding 1-1:** Business functions and sub-functions vary across utilities • **Key Finding 1-2:** The level and frequency of collaboration varies across business functions • **Key Finding 1-3:** Extreme weather events and/or emergency response situations that significantly impact a water utility's continuity of operations present a driving force for cross-functional collaboration and strategic planning • **Key Finding 1-4:** Internal climate experts who can translate science into potential risks and opportunities for core business function leads are useful
Chapter 2: Map climate risks and opportunities by business function for four case studies	• **Key Finding 2-1:** Within the utilities studied, extremes drive actions on assessing climate-related risks and opportunities • **Key Finding 2-2:** The length of planning horizons varies across and within utilities making assessments and preparations for climate risks more difficult for utilities with short planning horizons • **Key Finding 2-3:** Improving or updating design standards and protocol to incorporate changing conditions is critical • **Key Finding 2-4:** Regulatory requirements can incentivize consideration of climate risk management within utilities • **Key Finding 2-5:** Decision-making under uncertainty remains a challenge • **Key Finding 2-6:** Leadership within the utility is critical to innovation and preparedness • **Key Finding 2-7:** Mainstreaming resilience across water utility business functions is in its infancy
Chapter 3: Co-produce a Water Utility Business Function Climate Risk and Opportunity Framework	• **Key Finding 3-1:** Most water utilities have not assessed climate change risks and opportunities from a business function perspective • **Key Finding 3-2:** Mapping climate drivers and underlying conditions to critical decisions or requirements for business functions leads to a more integrated, systems-based understanding of risks and opportunities • **Key Finding 3-3:** The process and conversations associated with mapping business functions prove much more important than the maps themselves, which serve as means to an end • **Key Finding 3-4:** Bringing an array of utility business function representatives together offers multiple benefits • **Key Finding 3-5:** A genuine need exists for guidance and implementation of integrated, long-range, capital improvement and financial planning for acute and chronic climate impacts across water utility business functions (mainstreaming risk and resilience) • **Key Finding 3-6:** Knowing how to find the climate data and what data type, scale, and timeframe to use in evaluating business functions' risk and/or opportunity can prove daunting • **Key Finding 3-7:** Anticipating extreme weather conditions can be far more challenging than identifying climate trends • **Key Finding 3-8:** The co-production process is essential • **Key Finding 3-9:** For almost every risk identified, a potential adaptation strategy or opportunity could minimize the risk's impacts • **Key Finding 3-10:** This climate risk-based business function assessment should be included as one element of a utility's comprehensive Effective Utility Management (EUM) program

(continued)

Table ES-2 Continued	
Project Objective	• **Key Findings**
Chapter 4: Identify relevant climate information sources and types by business function	• Key Finding 4-1: Information on climate extremes may require greater reliance on "data" information types • Key Finding 4-2: Spatial scales of interest may not match those of available information • Key Finding 4-3: Timeframes of interest may not match those for available information • Key Finding 4-4: Temporal scales of interest may not match those for available information • Key Finding 4-5: Low-risk tolerance and a desire to minimize disruption to utility functions leads to requiring "worst-case" plausible future climate trajectories for consideration • Key Finding 4-6: Use of downscaled climate projection data must consider information needs, decision context, and methodology limitations • Key Finding 4-7: Various online resources and information portals/hubs serve as collection points for several climate information sources and types • Key Finding 4-8: Existing climate services may help with information requirements and science translation

ES.2 Next Steps

Based on the outcomes of this project (Phase 1), the next phase (Phase 2) will test the framework with two Water Utility Climate Alliance (WUCA) member utilities and enhance the framework and guidebook to identify opportunities to accelerate the mainstreaming of climate considerations and resilience into utility management. To achieve this goal, the next steps in this second phase include:

- Conduct a literature review and compare other climate-related risks, opportunity, and resilience mainstreaming frameworks to the water utility business risk and opportunity framework and identify how the framework relates to existing corporate and utility risk management processes or can be incorporated into existing processes;
- Pilot test the framework for three and five critical business functions with two WUCA utilities, Denver Water and San Francisco Public Utilities Commission (SFPUC), through an interactive one- to two-day tabletop exercise (TTX) and workshop;
- Expand the framework (version 1) to identify steps or opportunities useful in mainstreaming climate risks and resilience across select critical water utility business functions (version 2);
- Update and enhance the Water Utility Business Risk and Opportunity Framework: A Guidebook for Water Utility Business Function Leaders in a Changing Climate to reflect lessons learned from testing the framework and identifying opportunities for resilience; and
- Engage staff through the pilot testing and exercises and generate train-the-trainer materials to create awareness across Denver Water and SFPUC about climate-related risks and opportunities and measures to mainstream climate resilience through critical business functions.

Phase 2 of this project includes considerations for mainstreaming the framework. Having an outside facilitator—with an unbiased view of the utility—asking targeted questions led to fruitful discussions across business functions in each case study. The primary benefit appeared to come from asking questions that challenged

preconceived notions of risk within the utility. Mainstreaming this approach will require adopting a deliberate method for including "what if" scenarios in the conversation to challenge "conventional wisdom," hence the testing of the updated framework through interactive tabletop exercises.

ES.3 Framework

A key output of this research project was the co-production of an adaptive, flexible, and tailorable water utility business risk and opportunity framework (Figure ES-1) that helps utilities define their focus for a risk and opportunity assessment, ask key climate questions, map climate impacts relative to mission-critical business functions, and pinpoint risks and opportunities across those business functions. The supplemental guidebook, Water Utility Business Risk and Opportunity Framework: A Guidebook for Water Utility Business Function Leaders in a Changing Climate, provides further details, images, and templates that utilities can use to map climate exposure and climate information needs to their core utility business functions, and, ultimately, understand cross-cutting risks and opportunities facing their business. Chapter 3 of this report provides additional details on the methodology, framework steps, key findings, and lessons learned. Based on the research team's expertise in assessing climate-related risks and opportunities across water and energy utilities, government agencies, and corporations, the framework steps were designed, tested, and synthesized as the research was conducted.

Figure ES-1. Water Utility Business Function Climate Risk and Opportunity Framework.

Related WRF Research	
Project Title	**Research Focus**
An Integrated Modeling and Decision Framework to Evaluate Adaptation (project 4636)	This project developed an integrated framework to assess water quality and availability impacts under a suite of climate and natural hazards in the water supply watershed, along with evaluation of decision options.
Climate Change in Water Utility Planning: Decision Analytic Approaches (project 3132)	This research identifies vulnerabilities of drinking water utilities to changing climate conditions, and the adaptations utilities will need to make to manage risk, given uncertainties regarding the specific nature of future changes in local hydrologic conditions. It also developed flexible and responsive short- and long-term management strategies to help utilities deal effectively with this new source of uncertainty when planning for and implementing changes in response to climate change.
Developing Robust Strategies for Climate Change and Other Risks (project 4262)	This project identified the most likely vulnerabilities typically associated with climate change, provided utilities with a tool to assess their utility-specific vulnerabilities, and produced risk management tools to assist utilities in identifying appropriate strategies and actions to respond to the vulnerabilities that are identified.
Effects of Climate Change on Water Utility Planning Criteria and Standards (project 4154)	This project evaluated water utility planning criteria and design standards for their effectiveness in equipping utility facilities with the features needed to adapt effectively to future climate conditions, with the purpose of assisting water utilities in the engineering of new facilities.
Impacts of Climate Change on Honolulu Water Supplies and Planning (project 4637)	This project evaluated climate change impacts on the Honolulu Board of Water Supply and its assets, and developed a suite of management and treatment strategies to address the anticipated changes. This project delivered an Adaptive Management Plan for Honolulu based on climatic and hydrologic modeling, scenario modeling, and evaluation of adaptive management strategies.
Risk Governance: An Implementation Guide for Water Utilities (project 4363)	This research advises managers on how to implement and organize corporate risk governance within their utilities. The guidance manual focuses on the organizational competencies required, and provides practical, explicit steps for utility managers to work to best practices.
Securing Value: Integrating Risk Governance With Other Business Functions in Water Utilities (project 4573)	This project addresses the operational principles of organizational risk, resilience, robustness, and adaptation. The project explored how interactions between risk governance and these overlapping agendas generate business value and strategic opportunities for utilities.
Water/Wastewater Utilities and Extreme Climate and Weather Events (project 4416)	This project consisted of a series of workshops that (1) examined the actions taken by drinking water and wastewater utility practitioners who faced recent extreme weather and climate-related events and documented their planning and response; (2) determined and recorded lessons learned; (3) documented and analyzed the decision process, including decision makers, organizations involved, and data needed for making decisions when faced with an extreme event; and (4) summarized communication approaches used to inform the public. A series of case studies highlights lessons learned and recommended actions.

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