THE Water Research FOUNDATION

PROJECT NO.
4729B

Water Utility Business Risk and Opportunity Framework

A Guidebook for Water Utility Business Function Leaders in a Changing Climate

DENVER WATER

WUCA
Water Utility Climate Alliance

Water Utility Business Risk and Opportunity Framework

A Guidebook for Water Utility Business Function Leaders in a Changing Climate

Abstract

This *Guidebook for Water Utility Business Function Leaders in a Changing Climate* is the supplement to *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions*, an adaptive, flexible, and tailorable approach 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. This supplemental guidebook 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.

WRF ISBN: 978-1-60573-464-4

WRF Project Number: 4729b

Acknowledgments

We thank The Water Research Foundation, Water Utility Climate Alliance (WUCA), and Denver Water for funding this project, without which, we would not have been able to conduct this important work and generate this Guidebook. We also gratefully acknowledge our primary points of contact with our Water Utility Practitioner Group members and their colleagues: Shannon Halley with Austin Water, Alan Cohn with the New York City Department of Environmental Protection, and Laura Briefer with the Salt Lake City Department of Public Utilities. A very special thank you to Keely Brooks with Southern Nevada Water Authority, Khuram Shah with San Diego Public Utilities Department, Tirusew Asefa with Tampa Bay Water, and Meagan Smith with the City of Fort Collins Utilities for serving as members of our Water Utility Practitioner Group (WUPG) and the four primary case study contacts for development of *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions* and associated Guidebook. This guidebook results from a coproduction among partners and reflects the collective wisdom of the utility participants.

Research Team

Principal Investigators:

Emily Wasley, CMAP
Cadmus

Kathy Jacobs
University of Arizona

Project Team:

Jeremy Weiss, PhD
University of Arizona

Morgan Richmond
Cadmus - (Formerly)

WRF Project Subcommittee

Erica Brown
Association of Metropolitan Water Agencies

Patrick Davis
Orange Water and Sewer Authority

Alexis Dufour
San Francisco Public Utilities Commission

Maureen Holman, JD
DC Water

Laurna Kaatz, PhD
Denver Water and Water Utility Climate Alliance

WRF Staff

Maureen Hodgins
Research Manager

Valerie Roundy
Project Coordinator

We also gratefully acknowledge our other WUPG members and their colleagues: Shannon Halley with Austin Water, Alan Cohn with the New York City Department of Environmental Protection, and Laura Briefer with the Salt Lake City Department of Public Utilities.

Water Utility Practitioner Group (WUPG)

Common Terms and Definitions

Business Function

A category of processes or operations that are performed routinely to carry out a part of the utility's mission.

Climate Drivers

Climate drivers include both of the following:

- *Acute:* An extreme weather event that is affected (not necessarily caused exclusively) by climate change; its intensity, duration or frequency (or any combination) may be expected to change over time and may cause injury, illness, or death to people, or damage to built, natural, or social infrastructure or assets. Examples include hurricanes, floods, heatwaves, blizzards, and drought.
- *Chronic:* Longer-term conditions or trends related to longer-term changes in the climate system. Examples include higher temperatures, sea level rise, and changes in precipitation patterns.

Impacts

The impacts associated with the acute and chronic climate drivers (as noted above), such as snowpack declines, water shortages, wildfires, increases in storm surge, infrastructure damages, biodiversity losses, ocean acidification, disease outbreaks, and land loss.

Cascading Impacts

Cascading Impacts occur as a direct or indirect result of an initial event, which, due to linkages between systems, results in major disruptions across an organization, supply chain, community, or region. The following two examples illustrate this concept:

- Flash flood-> electrical grid failure-> disrupts electricity-> traffic accidents-> hazardous materials spills-> local stream contamination-> neighborhoods evacuated.
- Higher temperatures-> more intense drought-> forest stress-> more severe wildfires-> poorer air quality-> increase in human respiratory issues (e.g., the Bay Area in fall 2018).

Risk

Risk is the likelihood of a hazard's occurrence, multiplied by the consequences.

Opportunity

The potential to derive positive outcomes from understanding and preparing for climate-related challenges, including resource efficiency and cost savings, development of new products and services, access to new markets, improved reputation of the utility, and building resilience across the utility and along its supply chain.

Critical Pathway

A critical path includes processes, knowledge and equipment essential for successfully conducting a business function.

Climate Adaptation

Actions taken to help limit risk and maximize opportunities associated with changing climate conditions.

Climate Resilience

The capacity to anticipate, plan, adapt, and thrive in a changing climate.

Table of Contents

Section I

Introduction

Executive Summary

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, 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 such as *Effective Utility Management (EUM): A Primer for Water and Wastewater Utilities*.

To support water utilities in their efforts to better understand, assess, prepare for, and respond to business risks and opportunities associated with climate change, WRF sponsored the *Water Utility Business Risk and Opportunity Framework* Project (WRF Project #4729) which had the following objectives:

- 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; and.
- Provide insights on the types of available data that can be used (and have been used by some utilities) to assess climate risks and the opportunities associated with particular water utility business functions.

Through use and application of the framework and this accompanying Guidebook, it is envisioned that water utilities will develop an enterprise-wide understanding and prioritization of the exposure, sensitivities, and opportunities that water utility business functions face in a changing climate. 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 of emerging risks and opportunities associated with the intersection climate drivers and the array of utility systems and functions. When these new and/or increased risk levels intersect with underlying vulnerabilities, such as degrading infrastructure and interdependent systems that may have 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 at risk the people, businesses, and industries that rely on safe and reliable water.

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 project's 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.

This guidebook directs readers through the steps they need to take to use the Business Function and Climate Risk and Opportunity Mapping Framework in their utility. The framework is meant to be usable regardless of the size, location, or mission of the utility and can be tailored to meet the goals of the water utility business functions and the climate risks and opportunities today and into the future.

Purpose

This *Water Utility Business Risk and Opportunity Framework Guidebook* details the process the research team developed to assess and map climate-related risk and opportunities to water utility business functions. The framework we have developed is intended to serve as a replicable, iterative, and tailorable approach that other utilities across the nation can follow, aided by this step-by step Guidebook. The framework will help water utilities understand the risks and opportunities associated with climate change, and to consider, perhaps for the first time, how climate considerations intersect with specific business functions. The approach requires considerable internal conversations to discover the multiple risks posed by climate change and ways that managing climate change appropriately may provide some advantages. The framework is applicable across a wide range of circumstances facing water utilities. This document:

- Clarifies what types of guidance will be most helpful to utilities seeking to map climate exposure and information needs to their core business functions.
- Informs the development of alternative approaches to responding to climate stresses.

This Guidebook directs the reader through the steps they need to take to use the *Water Utility Business Risk and Opportunity Framework* in their utility. It provides step-by-step guidance on how to conduct a water utility business function risk and opportunity mapping exercise, and how the framework can be used to inform strategic planning decisions to enhance business resilience across a water utility.

This supplemental Guidebook 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.

What's in It for Me?

If you apply these tools, you can strengthen your agency's effective utility management program, which in turn provides benefits including but not limited to:

- *Improving the long-term resiliency and reliability of critical infrastructure and business functions*
- *Promoting more cost-effective and resilient investments*
- *Minimizing the future rate of shock from physical, transitional, or regulatory changes*
- *Identifying and acting on strategic opportunities for collaboration with other utilities and agencies on efforts and investments to assess, address, and mitigate climate change risks*
- *Promoting greater communication, collaboration, and strategic thinking among utility staff*

"All projects with opportunities for cross-departmental brain-storming sessions provide value to Utility planning efforts. This research process was no exception. It created the venue for targeted conversations around the risks of climate change to individual business unit operations, highlighting the need for coordinated efforts across all Utility departments."

Meagan Smith, City of Fort Collins Utilities

Background

This Guidebook is associated with WRF and WUCA Project 4729, Mapping Climate Exposure and Climate Information Needs to Utility Business Functions conducted between February 2018 – March 2019. The goal of this project was to develop a comprehensive, enterprise-level framework for understanding the exposure and sensitivities of water utility business functions to a changing climate and for accelerating the mainstreaming of climate considerations into utility management. The framework was designed to be replicable for use by a range of utility sizes, impacts, and functions. Though this framework specifically focused on drinking water utilities, its approach has broader applicability across a variety of utilities. With this goal in mind, the Cadmus research team conducted interviews and virtual workshops with seven utilities to achieve the following:

1. Develop a suite of common water utility business functions.
2. Identify "critical" paths (defined below) within each business function to be analyzed.
3. Assess the potential risks and opportunities of climate drivers to affect the critical path of water utility business functions.
4. Compile relevant climate data and information for business functions.
5. Design a flexible and replicable Water Utility Business Risk and Opportunity Framework and associated guidebook.
6. Test the framework through 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 Risk and Opportunity Framework* and associated guidebook in collaboration with four utility case studies; and ongoing feedback from our project partners throughout the duration of the research project.

This research resulted in an improved understanding and lessons learned related to various business functions across

multiple water utilities, key drivers for and barriers to assessing climate risks and opportunities, capabilities needed to support business function leaders through this process, the type of data and information needed to assess business function risks and opportunities at various scales, and a step-by-step framework for water utilities to map climate-related risks and opportunities across their business functions. Although this approach did not include a full-scale vulnerability assessment, it recognized the contributions of underlying vulnerabilities—including land use, economic conditions and aging infrastructure—as a starting point for the climate-related risk and opportunity conversation.

For more information about WRF Project 4729, please see the report, Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions." This report details the methodology, process, and key findings associated with the research behind the project that generated this framework and guidebook.

> "This project helped SNWA think beyond water supply impacts. It helped us think more broadly about how risks to the organization can change from climate change."
>
> *Keely Brooks, Southern Nevada Water Authority*

Section II

The Water Utility Business Risk and Opportunity Framework and Steps

The Framework

This *Water Utility Business Risk and Opportunity Framework*, co-produced with seven U.S.-based water utilities, is adaptive, flexible, and tailorable to help 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. Based on our research teams' expertise in assessing climate-related risks and opportunities across water and energy utilities, government agencies, and corporations, we designed, tested, and synthesized the framework steps as the research on WRF Project 4729 was conducted.

Biases and Assumptions

Overcoming climate biases and assumptions is critical to gauging the full impact of climate on utility business functions. There is a need to consider "What if" climate impacts beyond recent experience.

The following step-by-step framework is designed for individual utilities' use in exploring climate risks and opportunities associated with their business functions. Although this process seems very straightforward, one pitfall to avoid arises from failing to recognize biases among staff engaged in this exercise. For example, it is very difficult for people to become aware of their own assumptions and/or preexisting biases about elements most at risk. This occurs partly because most people assume that future risks will be similar to past risks, but this can be an erroneous assumption.

The Climate Question

How are the assets, people, resources, activities, and/or projects within your business function affected (either negatively [risks] or positively [opportunities] by climate change today and into the future?

Though the fact that particular impacts have occurred in the past makes them likely to occur in the future, the changing nature of institutions, communities, land use, infrastructure, and communication systems—not to mention climate change impacts—makes it important to remain open to potential future risks, opportunities, and impacts that look very different from those today.

For this framework to function most effectively, personnel engaged in the conversation should adopt a "what if?" scenario planning approach and consider that possible system failures may be triggered by new kinds

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

of events, both locally and in remote locations, that result in cascading effects from linkages in systems and the supply chain. Preparedness means imagining the unimaginable, and considering the possibility of low-probability, high-consequence events as well as multiple, high-probability events happening simultaneously. Exploring these ideas in the context of imagining a future not yet arrived can be thought-provoking and rewarding, even if some possible futures seem very unlikely now. Understanding the array of possible future risks helps in identifying individual or multiple approaches that increase resilience.

This framework is presented as a "Plan-Do-Check-Act" approach: users can follow the framework to plan risk management and resilience improvements, take action and track trends, check progress towards resilience improvements, and act to revise the plan accordingly. The framework is an iterative process, designed to be used quarterly, annually, or as deemed necessary to analyze all potential underlying conditions, climate impacts, and associated risks and opportunities for priority business functions, keeping in mind, however, that priority business functions may also evolve over time.

Adaptive resilience can be developed through replicating this exercise on a regular basis to explore elements changed since the last event, whether underlying conditions, climate, staff capacity, climate expertise, new regulations, or other factors. Each time new personnel are added to the conversation, a new set of perspectives and ideas can lead to new outcomes, so it is worth experimenting to gauge how outcomes differ with various personnel groups within a utility.

Although the framework leads to identifying risks and opportunities for use in strategic planning and prioritization activities, it stops short of moving into selection and implementation of adaptation options. That said, we offer a well-sorted listing of data and resources that can be used to take next steps in defining specific climate risks, opportunities, and adaptive pathways relevant the utility's specific needs and conditions. The data sources were selected in response to identification of climate drivers expected to impact business functions, as analyzed within the four case study utilities. See Chapter 4 and Appendix E of the 4729 report, *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions*. Figure 1 provides a visual representation of the *Water Utility Business Risk and Opportunity Framework*.

Step 1: Define the Focus for Risk and Opportunity Assessment

STEP 1: DEFINE THE FOCUS FOR RISK AND OPPORTUNITY ASSESSMENT

Step 1a: Identify all water utility business functions and sub-functions

Step 1b: Identify a cross-functional team of representatives

Step 1c: Identify existing resources, expertise, and capacity for risk assessment and management

This critical step in the analysis of climate risks and opportunities across water utility business functions starts with identifying the full array of business functions, but then narrows the conversation's scope to specific business functions and their associated sub-functions for in-depth analysis. It is very important that participants avoid discussing only business functions that they know best or those recently under scrutiny, considering functions that may currently be "beneath the radar" but quite fundamental to utility operations—and hence a high priority. For example, failure to consider community-wide climate implications as well as internal utility impacts could lead to missing important risks.

In addition, our case study experience found it much easier and clearer to conduct mapping exercises when focusing on sub-functions rather than on the utility's core business functions. Core functions often include subcomponents that experience climate stresses very differently, and the resulting map may prove less useful (as noted previously, more like spaghetti than a series of logical flows) if only the core functions are mapped.

Step 1a: Identify all water utility business functions and sub-functions

Using the suite of water utility business functions and sub-functions compiled through this research and summarized in Figure 2, identify business functions relevant to your utility's activities, noting that if some are present but clearly peripheral to the utility's mission, you may not wish to emphasize them. A useful place to start is your utility's organizational chart. This will help you identify the broad business functions from which you can focus your efforts to inform this process.

Figure 2. Specific and Other Business Functions*

WATER-SPECIFIC BUSINESS FUNCTIONS

Drinking Water	Water Supply	Wastewater	Water/Environmental Monitoring and Management	Stormwater Management
• Drinking water treatment (sub business function) • Drinking water distribution	• Conservation • Drought planning/water shortage stage management • Seawater desalination • Recycled water/effluent management • Reservoir and surface water management • Groundwater management • Wholesale water supply	• Wastewater collection • Wastewater treatment • Biosolids management	• Groundwater and surface water quality/management • Watershed management/land management • Stream rehabilitation • Ocean water quality monitoring • Environmental monitoring • Environmental compliance	• Flood control • Drainage basins and infrastructure • Stormwater quality

OTHER BUSINESS FUNCTIONS

Business Affairs, Accounting and Human Resources	Procurement	Planning, Modeling, Forecasting and Analysis	External Affairs	Engineering, Design, and Construction	Operations
• Contracts, business services, recordkeeping, and billing • Finance and insurance • Rate setting, charges and fees • Grant preparation and management • Human resources, employment, and staff training • Asset inventories and tracking	• Energy procurement and management • Procurement of goods and services	• Water supply planning • Water demand planning • Sustainability planning • Forecasting and analysis	• Customer service (residential, commercial) • Public education and outreach • Community relations and advocacy • Legal services, legislative and regulatory affairs • Cross-agency coordination • Communications • Emergency management/ hazard mitigation	• Infrastructure planning • Construction	• Asset management • Infrastructure maintenance • Field operations • Meter reading and maintenance • Security (physical, computer, and data) • Information technology • Laboratory services

* This is intended as a general overview and starting point for discussion. We recognize that business functions and organizational structure vary widely among individual water utilities.

Through the development of the four case studies for this research project, we identified example subfunctions within several of the utility's core business functions, illustrated in Table 1.

Table 1. Selected Critical Business Functions and Associated Sub-functions from the Four Case Study Utilities

City of Fort Collins Utilities	San Diego Public Utilities Department	Southern Nevada Water Authority	Tampa Bay Water
Stormwater Management Forecasting, water quality management, design and maintenance of collection and storage infrastructure, floodplain management, land use planning and development, regulation	**Drinking Water Treatment and Delivery** Treatment facilities, facility maintenance, pipelines, physical and chemical treatment of raw water, remedial treatment for impaired water, reuse of municipal effluent, stormwater runoff quality, upstream watershed conditions	**Administration** Customer care and field services, Environmental, Health, and Safety and security, human resources, information technology, public services	**Physical and Cyber Security** Communications, physical plant management, information technology, detection, sensors, supervisory control and data acquisition systems (SCADA)
Asset Management Lifecycle analysis, service levels, reliability, maintenance standards, infrastructure development, mapping, strategic planning, data collection	**Water Supply (Key Function: Operational Considerations within San Diego's Local Storage/Reservoir System)** Water supplies, groundwater rights, reservoir water supply and storage agreements with county, water rights agreements with Colorado River water, prioritization process for water purchases, native water, imported water prices, water supply availability	**Engineering and Operations** Energy management, engineering, infrastructure management, operations, resources and facilities, water quality and treatment	**Drinking Water Treatment and Distribution** Incoming water quality, treatment facility capacity, treatment technology, distribution system, storage, treatment type (physical and chemical), monitoring, desalination
Engineering and Design Surveying, sizing, layout, design standards	**Staff Experience and Training** Staff operations, risk protocols, operating manuals, capital improvements management, engineering training and protocols, staff outreach, projections, scenarios, integrated long-range planning	**Finance** Accounting, financial services, purchasing and rate structures	**Engineering, Design, and Construction** Construction standards, construction specifications, constructability of assets, site selection, design standards, material selection, useful life analysis, physical construction

Step 1b: Identify a cross-functional team of representatives

Considering the business functions selected, compile a cross-functional team of leaders familiar with the underlying conditions, inner workings, regulatory requirements, and strategic processes of those functions. To the extent feasible, select participants with very different backgrounds and training, and some familiarity with the way the utility currently functions. Table 2 illustrates some example cross-functional water utility representatives, their example titles, and divisions within the water utility that should be included in this type of exercise.

Table 2. Example Cross-Functional Water Utility Representatives

Example Title and Division
Director
Managing Director, Integrated Water Management or Water System Management and Operations
Project Manager, Water Supply Planning and Water Supply Assessments
Policy Analyst, Climate Change
Manager, Planning and Decision Support
Engineer, Water Resources
Deputy Director, Long Range Planning
Deputy Director, Environmental Monitoring & Technical Services
Chief Financial Officer
Manager, Legal Services
Director, Human Resources
Manager, Information Technology
Deputy Director, Public Services and Customer Relations

It is essential to also include a representative who is considered a "climate expert" or someone familiar with the impacts of climate change to the various business functions and the cascading implications. This representative can ask the climate questions and help navigate the climate data, information, and impacts space for the other team members who may not be as familiar with how climate change can affect the utility business functions.

Step 1c: Identify existing resources, expertise, and capacity for risk assessment and management

In conversations with the gathered cross-functional team, identify existing resources, long-term plans, risk assessments, and strategic plans that may be useful in assessing current and future preparedness for climate-related events as well as in potentially recognizing climate-related opportunities. Some example resources that jurisdictions may have access to are listed in Table 3.

Figure 3 includes the number of currently available climate-related resources by case study jurisdiction and climate stressor.

The four in-depth case studies in Appendix E of the 4729 report, *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions*, also include resources that other utilities may want to explore.

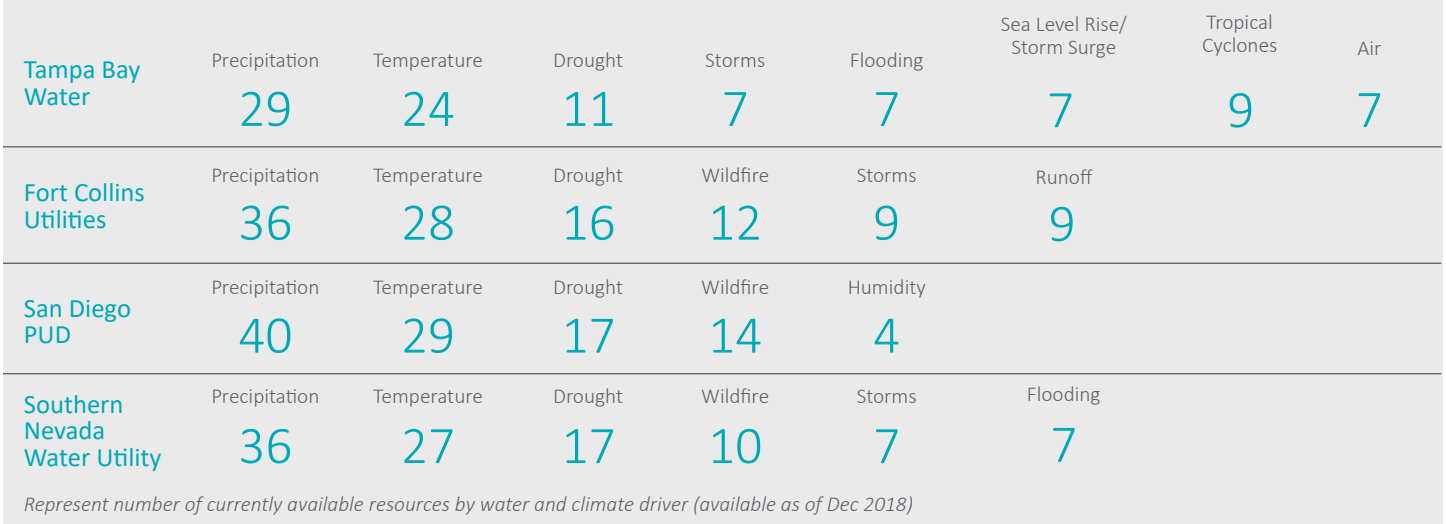
To create a common foundation for team members and ensure a familiar organization-wide baseline, it is useful to provide them with a list or summary of these resources for review before initiating conversations.

Table 3. Example Resources for Climate Risk Assessment and Management

Scale	Resource Type
Utility	Long-Range Water Resource Plans
	Urban Water Management Plans
	Water Supply and Demand Studies
	Climate Resilience Evaluation and Awareness Tool (CREAT) 2.0[1]
	Climate Change Sensitivity, Risk, or Vulnerability Assessments or Studies
	Integrated Modeling Projects
Local	Local University Climate Centers/Advisory Panels and Climate Action Plans
	City or Community Vulnerability, Risk, and/or Resilience Assessments or Plans
	Local, City, or County Climate Action Plans
	Local Hazard Mitigation Plan
	Corporate Sustainability or Responsibility Plan/Strategy (these occasionally include or have been informed by materiality, risk, and/or vulnerability assessments with findings and actions that can be useful to review)
State	Technical State Climate Summaries
	States at Risk Reports[2]
	State Hazard Mitigation Plans
Regional	Third National Climate Assessment (2014)[3]
	Fourth National Climate Assessment, Volume 2: Impacts, Risks, and Adaptation in the United States*[4]
	Fourth National Climate Assessment, Volume 1: Climate Science Special Report[5]
International	Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report[6]
	Country-level Vulnerability Assessments, Climate Profiles, and/or Adaptation Plans
Federal	Climate Resilience Toolkit: Water Resources Dashboard; Drought Response and Recovery; and Flood Resilience
	U.S. Department of Agriculture (USDA) Cooperative Extension System and Climate Hubs
	U.S. Department of the Interior (DOI) Climate Adaptation Science Centers
	National Oceanic and Atmospheric Administration (NOAA) Climate Program Office, Regional Climate Centers, and Regional Integrated Sciences and Assessment Programs

**Volume 2 was not available during our analysis of data availability, but, given its relevance to this project, we include it in this final report as a reference for water utilities' use.*

Figure 3. Currently Available Climate-Related Resources by Case Study Jurisdiction



Represent number of currently available resources by water and climate driver (available as of Dec 2018)

Step 2: Address Key Questions

STEP 2: ADDRESS KEY QUESTIONS

Step 2a: With the team, discuss the underlying conditions and vulnerabilities within the business functions	Step 2b: Discuss the known climate drivers of greatest concern	Step 2c: Discuss how the underlying conditions and vulnerabilities identified in Step 2a might intersect with climate drivers noted in 2b, leading to significant impacts for business functions

In this step, participants explore underlying vulnerabilities within a utility's geographic region along with its political and economic context, and its previous experiences with extreme weather or climate-related events. This way, participants consider how critical business function paths may be affected by such factors. It is important to build a joint understanding of these factors, as this will help in prioritizing which business functions will be considered in the mapping exercise. It is also important not to limit consideration to events and conditions that have existed in the past, but to consider potential future events and conditions as well.

Step 2a: With the team, discuss the underlying conditions and vulnerabilities within their business functions

Climate change tends to act as a threat multiplier, exacerbating existing climate conditions and underlying vulnerabilities. If the assessed business functions have underlying conditions to start with (e.g., aging infrastructure, limited human capacity, political issues), it is important that the team understands these from the start. This allows an assessment of the ways climate change may exacerbate the conditions or create new conditions problematic to the utility's mission. Discuss historic vulnerabilities, experiences, and events affecting continuity of service, utility functions, and the health, safety, and welfare of employees and community members. Explore "what if" scenarios, including changing policy and physical impacts, that seem improbable now, but which address long-term risks that could impact the utility's business functions.

Step 2b: Discuss what climate change-related drivers you already care about most

Once the team has a clear understanding of underlying conditions for each business function under assessment, climate drivers appearing to pose the highest initial concern for the business function can be layered in. These may include climate drivers such as sea level rise, extreme heat, poor air quality, wildfires, drought, flooding, and strong storms. Think about drivers that have affected the utility in the past as well as drivers affecting utilities in your region and drivers that may pose issues in the future.

Step 2c: Discuss how the underlying conditions and vulnerabilities identified above might intersect with climate drivers you already know about, leading to significant impacts for business functions

After identifying the various underlying conditions and climate drivers of concern, discuss how they intersect. This involves considering direct and cascading climate impacts on—for example—business function operations, facilities, assets, employees, and supply chains. Table 4 outlines some example business functions and impacts mapped with the case study utilities:

Table 4. Example Business Functions and Mapped Climate Impacts

Business Function		Impacts from Climate Change
	**Administration**	• Intensity of heat and flood events from extreme storms put employees and communication systems at risk
	External Affairs	• Increased need to apply for hazard mitigation and resiliency funding • Following major events, External Affairs is called upon to communicate to public, state, Federal, and municipal decision-makers • Opportunities to communicate with customers and disclose each utility's future planning processes
	Employee Education	• Uncertainties about future climate conditions can impair a utility's ability to consider risks in large-scale planning
	**Engineering Design, Construction, and Operations**	• Wildfires, extreme heat, and drought require more energy and costs to pump and treat water before distribution to customers • Failure to consider climate change projections in design and throughout master planning could have serious impacts on critical business functions and the ability to meet demand • Cost-effective management of equipment requires robust material analyses as climate-related uncertainties persist • Cascading impacts from flooding and algal blooms have affected operations as infrastructure has required extensive repairs
	Physical and Cyber Security	• Field electronics and servers are sensitive to increased heat, humidity, and precipitation
	**Finance**	• Intensity of drought and unstable economic futures resulting from extreme temperatures in the region could reduce the utility's consumer base due to inhospitable living conditions • Bond rating impacts are associated with revenue loss from drought restrictions
	Asset Management	• Increased frequency of extreme climate-related events may increase asset maintenance and replacement costs • Infrastructure cracking and failure may result from aridification
	Procurement	• Major events spur a rush to procure disaster clean-up services to respond to infrastructure challenges
	Business Affairs	• Extended drought and conservation efforts reduce water demand and impact revenue, resulting in required rate structure adjustments
	**Environmental Monitoring and Management**	• Increased difficulty in balancing Clean Water Act compliance and adaptation measures • Increased spending to comply with the Safe Drinking Water Act
	**Stormwater Management**	• Storm surge and sea level rise impact flood mitigation measures and a utility's stormwater system capacity • Precipitation intensity puts utility stormwater management systems at risk
	**Drinking Water Treatment and Delivery**	• Sea level rise threatens water quality and existing delivery structures • Water quality and delivery become increasingly risk-prone as temperatures and storms become more intense
	**Water Supply**	• Water supplies are increasingly exposed to pollutants from wildfires and high temperatures
	**Wastewater Treatment**	• Employees have difficulty accessing major wastewater treatment plants during large flooding events
	**Planning, Modeling, Forecasting, and Analysis**	• Utilities may need to consider a broader array of future conditions in planning, including changes in precipitation, temperature, and evaporation projections • Long-term climate projection trends and extremes may change

Step 3: Identify Key Risks and Opportunities Relative to Mission-Critical Business Functions

STEP 3: IDENTIFY KEY RISKS RELATIVE TO MISSION-CRITICAL BUSINESS FUNCTIONS

Step 3a: Identify the critical path activities, functions, and equipment for each business function.

Step 3b: Map business functions to underlying conditions and climate drivers, to identify associated and significant impacts

Repeat until all business functions have been mapped

Prioritize the list of business functions in light of how the intersection of underlying conditions and climate drivers might affect them. Consider the full range of activities necessary to allow for institutional excellence, a healthy work environment, positive relationships with the community, environmental stewardship, fiscal responsibility in the short and long term, and continuity of service. The following steps can be executed at an organization-wide level or by smaller teams, as long as diverse expertise is included in the discussion, so risks can be addressed comprehensively.

Step 3a: Identify the critical path activities, functions, and equipment for each business function

Thinking through the activities required to conduct each business function selected for analysis over a variety of time horizons (e.g., daily, weekly, monthly, annually), consider the following:

- Critical decisions, facilities, or processes required to deliver services, products, or resources to your customers
- Potential failure points and what functions can "make or break" the capacity to perform this service
- Whether employees must travel to a certain location or be at a particular location to ensure continuity of operations and services to customers
- The type of equipment or supplies required
- Whether computers and sensors are required that may be affected by a power supply disruption resulting from climate-related or extreme weather events (e.g., heat wave, high wind and storms, flooding, other similar factors)

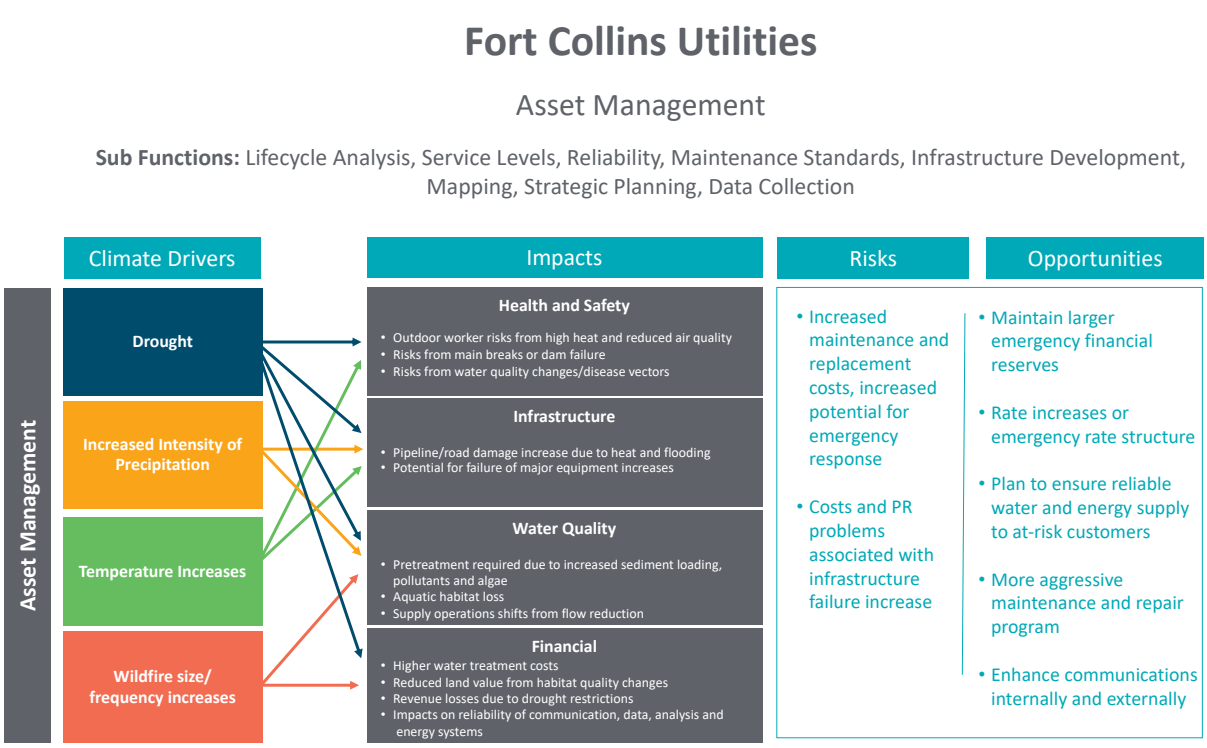
List all critical path activities, functions, and equipment required over multiple time horizons, both on a day-to-day basis and in the face of extreme weather events for the business function under analysis to operate effectively, efficiently, and safely.

Step 3b: Map business functions to underlying conditions, climate drivers, and associated impacts

Taking each critical path item individually, discuss the underlying vulnerabilities and the ways climate drivers might exacerbate those conditions over time. It is critical for the team to take a systems approach for this step as so many business functions must work together to maintain continuity of service. Additionally, successful water delivery requires energy, transportation, land use, and other resources and considerations when thinking about the lifecycle of this process. Using boxes and arrows (as in Figure 4), show critical pathways that identify multiple impacts from individual drivers, and then map the cascading effects from interactions between drivers and impacts. Repeat this process until you have discussed all mission-critical business functions selected.

> "What was an eye opening for us through this project, was that we were able to see potential climate change impacts into different business functions that we may not have thought about before. We typically tend to concentrate climate change impact assessments on demand and supply. But it is much more than that."
>
> *Tirusew Asefa, Tampa Bay Water*

Figure 4. Example Climate Data and Impact Mapping Exercise



Step 4: Identify and Prioritize Risks and Opportunities across Business Functions

STEP 4: IDENTIFY AND PRIORITIZE RISKS AND OPPORTUNITIES ACROSS BUSINESS FUNCTIONS

Step 4a: Compare climate drivers, impacts, and risks across business functions and establish a risk priority list

Step 4b: Identify the opportunities to manage impacts and/or create innovative services

Step 4c: Select business functions requiring further analysis

This step involves pulling together collective learning across analyses of individual business functions to build an integrated list of risks and opportunities that can feed into strategic planning, human relations, communications, engineering, finance, and operations considerations (among others).

Step 4a: Compare climate drivers, impacts, and risks across business functions and establish a risk priority list that includes considerations from all mapped risks

Establish a priority risk list to guide decision-making and planning activities. These can be used as motivators across the utility, encouraging a "supply-chain" view of the ways climate considerations penetrate all components of business activities and produce cascading impacts.

Step 4b: Identify the opportunities to manage impacts

Develop a list of existing opportunities to manage risks (e.g., hazard mitigation plans, interconnection agreements) as well as additional risk management opportunities. Further, discuss ways to take advantage of climate change adaptation to accomplish co-benefits (e.g., improved habitat preservation options, recreation opportunities, health outcomes that could be associated with risk management efforts). Look for ways that asking the "climate question" can offer advantages to the utility (e.g., perception as a leader in the community, attracting more young professionals to work at the utility, positioning leadership to influence broader outcomes [such as recovery planning] if/when future extreme events occur). Table 4 provides example business functions and mapped climate impacts while Figure 4 provides an illustration of how to map the climate impacts to the business function.

Moving into implementation, evaluate the ways that managing risks and opportunities can be mainstreamed into day-to-day utility operations (rather than being considered as outside of normal business function activities), and plan to revisit this conversation regularly to assess lessons learned and new impacts arising since the last conversation.

Step 4c: Select business functions requiring further analysis

Once water utilities have identified the priority and critical business functions to initially analyze, there will be other business functions that would benefit from this type of analysis and others that will need more in-depth analysis. It is important that all critical business functions be analyzed periodically as they evolve or when emerging trends in climate data and information indicate the need for analysis, review, and refinement.

Endnotes

1 U.S. Environmental Protection Agency. n.d. Climate Resilience Evaluation and Awareness Tool (CREAT) 2.0. Accessed January 11, 2018. https://www.epa.gov/crwu/creat-risk-assessment-application-water-utilities.

2 Climate Central. n.d. "States at Risk." Climate Central. http://statesatrisk.org/.

3 U.S. Global Change Research Program. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Eds. Melillo, J. M., T. C. Richmond, and G. W. Yohe. Washington, D.C. https://nca2014.globalchange.gov/.

4 U.S. Global Change Research Program. 2018. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II*. Eds. Reidmiller, D. R., C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart. Washington, D.C. https://www.globalchange.gov/nca4.

5 U.S. Global Change Research Program. 2017. *Climate Science Special Report: Fourth National Climate Assessment, Volume I*. Eds. Wuebbles, D. J., D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock. Washington, D.C. doi: 10.7930/J0J964J6. https://science2017.globalchange.gov/downloads/CSSR2017_FullReport.pdf.

6 Intergovernmental Panel on Climate Change. 2013: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Eds. Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. M. Midgley. Cambridge University Press, Cambridge, United Kingdom and New York, NY. doi:10.1017/CBO9781107415324.