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An Enhanced Climate-Related Risks and Opportunities Framework and Guidebook for Water Utilities Preparing for a Changing Climate

An Enhanced Climate-Related Risks and Opportunities Framework and Guidebook for Water Utilities Preparing for a Changing Climate

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

July 2021

Abstract

Between 2019 – 2021, Denver Water and the San Francisco Public Utilities Commission (SFPUC) collaborated to test, update, and refine the *Mapping Climate-related Risks and Opportunities to Water Utility Business Functions Framework* (see **page 8** for the framework) through a series of internal, interactive tabletop exercises (TTX). This guidebook is a supplement to the framework intended for water utility business function leads to use as they begin to assess the climate-related risk and opportunities associated with their critical business functions.

The framework is adaptive, flexible, and tailorable to help water 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 into the framework steps, examples of how the framework steps were implemented by Denver Water and SFPUC, and templates that business function leads can use as they work through the framework.

Once business function leads work through the framework and utilize this supplemental guidebook, they will be establishing a solid foundation to begin mainstreaming climate considerations across the enterprise.

Please note: This guidebook is an update to the 2020 supplemental guidebook to [Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions](#), where seven U.S.-based water utilities co-created a comprehensive, enterprise-level framework to help business function leads understand the exposure and sensitivities of their business functions in a changing climate.

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Section 1 – The Framework

Background

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, inter-annual, 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.

Climate change is already impacting water utilities and these changes will continue to exacerbate existing and future underlying conditions and vulnerabilities, putting ever increasing pressure on water utility business functions. Water utilities need to prepare and plan for all hazards that may impact their business functions – climate change being one of many.

To help water utilities and their critical business function leads understand how to incorporate future climate-related risks and opportunities into utility planning processes and mainstream climate risks, adaptation, and resilience through critical business functions, a trusted and tested framework was imperative. Between 2018 – 2020, seven U.S.-based water utilities co-created a comprehensive, enterprise-level framework to help business function leads understand the exposure and sensitivities of their business functions in a changing climate.

A water utility climate-related risks and opportunities framework was published in early 2020, and further refined and detailed through a series of tabletop exercises (TTX) with two water utilities: Denver Water and SFPUC throughout 2020. The enhanced framework described in this guidebook is the result of over three years of research, co-creation, testing, and refining in partnership with the following nine water utilities across the United States: Austin Water, Denver Water, Fort Collins Utilities, New York City Department of Environmental Protection, San Diego Public Utilities Department, San Francisco Public Utilities Commission (SFPUC), Salt Lake City Department of Public Utilities, Southern Nevada Water Authority (SNWA), and Tampa Bay Water (**Figure 1**).



Figure 1. Water Utilities Involved in the Framework Development

Though this framework was designed with drinking water utilities, its approach has broader applicability. It was designed to be replicable for use by a range of utility types, sizes, impacts, and functions, as well as for other organizations who wish to better understand the ways climate change may exacerbate existing underlying conditions and stressors, which may combine to impact business continuity and employee health and safety.

Purpose

The *Mapping Climate-related Risks and Opportunities to Water Utility Business Functions Framework*, tested and refined by two large U.S.-based water utilities, Denver Water and SFPUC, is intended to serve as a replicable, iterative, and tailorable approach that utilities and other organizations can follow. This supplemental, step-by-step guidebook will help water utilities understand, map, and assess the risks and opportunities associated with climate change, and to consider, perhaps for the first time, how climate considerations intersect with specific business functions.

Working through the framework and guidebook requires considerable internal conversations to understand the underlying conditions across each business function, discover the cascading climate-related risks and opportunities, identify the appropriate measures to manage these risks and opportunities, and begin mainstreaming climate considerations across the water utility enterprise.

The approach taken with Denver Water and SFPUC to test and refine this framework was through a traditional tabletop exercise (TTX) method but tailored to address climate change and the systemic risks and opportunities water utilities face now and into the future. Traditional TTXs require an exercise planning team (EPT) – a small, trusted team made up of a business function representative from each function being assessed – that will work with the internal water utility assessment leader to prepare for, design, and conduct the TTX. The EPT is essential to the success of the TTX given the vast knowledge and insights they can provide from their unique business function.

Some water utilities already conduct TTXs on other threats the enterprise faces or could face in the future. Feel free to use this framework and the associated steps with your existing TTX approach, design a standalone TTX that focuses on all of the steps outlined in this framework, or if resources and staff are limited, host a small workshop that goes through the steps you believe are relevant, useful, and appropriate for the utility. The goal is to enhance the understanding of climate-related risks and opportunities across business functions and begin the process of mainstreaming climate considerations across the enterprise.

Please see **Figure 2** and the coloring scheme to help determine which steps are applicable if utilizing the TTX method and which steps are relevant if hosting a simpler workshop.

What's in It for Me?

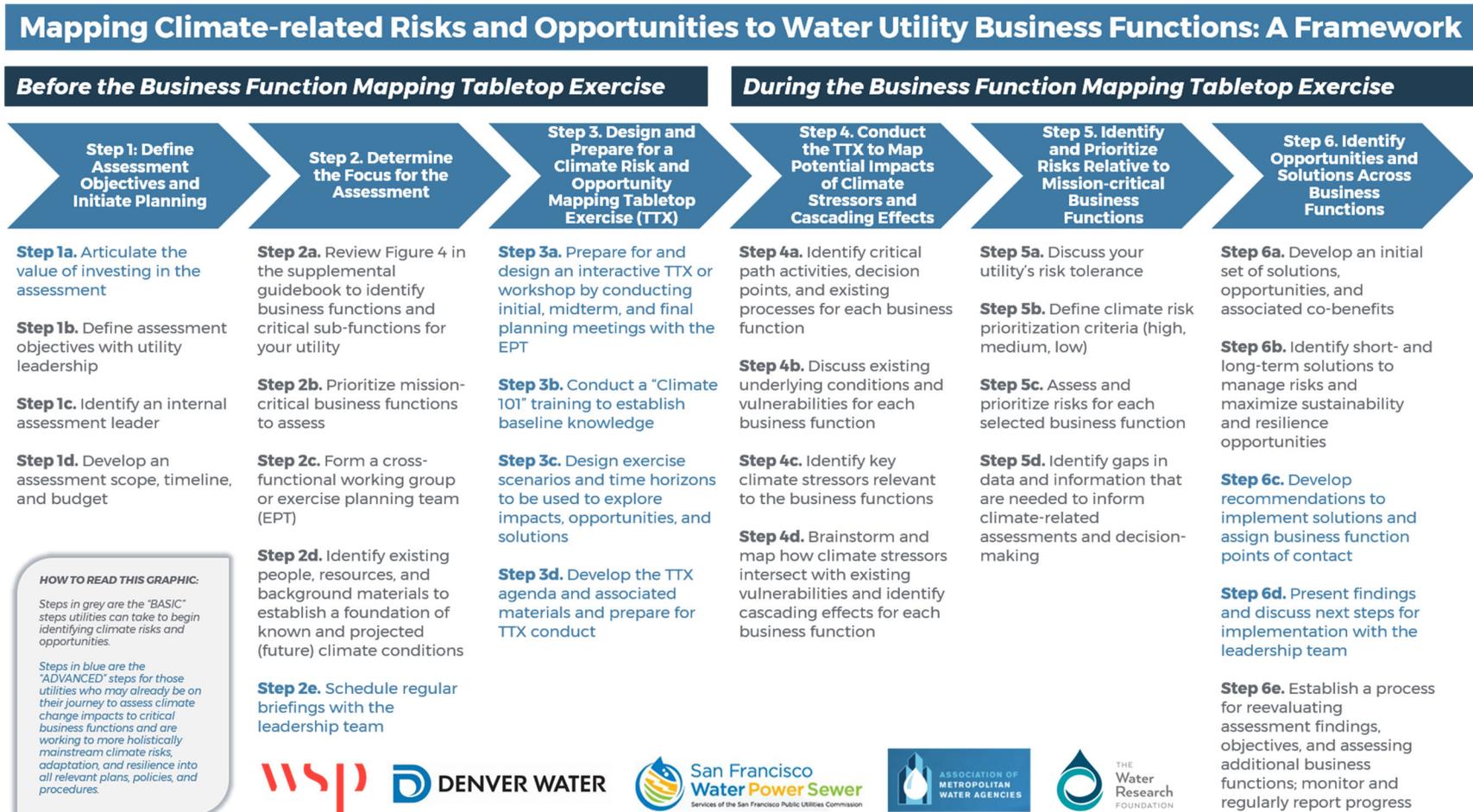
If you apply these tools, you can strengthen your agency's effective utility management program, which in turn provides benefits including, but not limited to:

- Improving the long-term resilience and reliability of critical infrastructure and business functions;
- Enhancing the safety and wellbeing of utility staff;
- Promoting more cost-effective and resilient investments;
- Minimizing the shock from physical hazards or regulatory changes to achieve a low-carbon future;
- Identifying and acting on strategic opportunities to collaborate with other utilities and agencies on efforts and investments to assess, address, and minimize climate-related risks and maximize climate-related opportunities; and
- Promoting greater communication, collaboration, and strategic planning across utility staff.

The Framework

The *Mapping Climate-related Risks and Opportunities to Water Utility Business Functions Framework* (illustrated in **Figure 2**) provides the steps designed for individual utilities to understand, assess, and address climate-related risks and opportunities associated with their critical business functions.

Figure 2. The Business Function Mapping Framework



Framework Color Coding

The color coding indicated in the framework above distinguishes the steps to use if you are preparing for, designing, and conducting a TTX (Advanced) versus steps for hosting a simpler workshop (Basic).

- **The Advanced steps**, appearing in blue, are for those utilities who may already be on their journey to considering climate change impacts on their business functions and are working to more holistically mainstream climate resilience into their plans, policies, and procedures.
- **The Basic steps**, appearing in grey, are for those utilities who may be new to considering how climate change may impact their business functions and therefore can consider the minimum steps to complete a water utility business risk and opportunity assessment.

Implementing the Framework

For this framework to function most effectively, water utility business function leads engaged in the process should adopt a “what if?” future scenario planning mindset. It is important for participants to remain open to potential future risks, opportunities, and cascading impacts that look very different from those today.

The exercise planning team (EPT) should help the participants understand the underlying conditions of their business function, consider how possible system failures may be triggered by new kinds of events, both locally and in remote locations, and the potential cascading impacts to system dependencies 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. Understanding the array of possible future risks helps in identifying individual or multiple approaches that increase resilience.

The framework is an iterative process. Adaptive resilience and climate change mainstreaming can be achieved through replicating this framework on a regular basis. In each new iteration, explore the elements changed since the last assessment, whether underlying conditions, climate, staff capacity, climate expertise, new regulations, or other factors.

Although the framework leads to identifying risks and opportunities for use in strategic planning and prioritization activities, *it does not assess the climate adaptation or climate mitigation measures needed to create a more sustainable and resilient future.* That would be a follow-on assessment process once the utility understands and assesses the climate-related risks and opportunities first.

Section II – Step-by-Step Guide of the Framework

Before the Business Function Mapping Tabletop Exercise

As noted above, some water utilities may choose to take the approach outlined in the framework and conduct a tabletop exercise (TTX). However, others may choose to conduct a simpler workshop. Regardless of the approach you choose, these first three steps should be taken in preparation for the TTX or workshop.

Step 1: Define Assessment Objectives and Initiate Planning

In order to gain buy-in from leadership and utility staff to assess climate-related risks and opportunities, it is important to first articulate the value of investing in this type of assessment (a.k.a. build the business case). Once the business case has been made and an agreement on conducting the assessment has been made, it is critical to then define the assessment objectives with utility leadership. This process can be led by one individual staff, a team, or by utility leadership. No matter how it begins, it is important to engage leadership early on to secure project support, resources, and alignment.

As active members of WUCA, both Denver Water and SFPUC are well established at providing leadership on climate change issues affecting water utilities. Both utilities have been actively taking steps to mitigate and adapt to climate change for over a decade, so the value of this type of investment was already well-known by utility leadership. For smaller utilities, or those who are just emerging on their climate change journey, we recommend connecting with any of the WUCA member utilities to ask about their process for articulating the value of investing in this type of assessment.

Step 1a: Articulate the value of investing in the assessment

There are many competing needs and stressors utility leaders must weigh and make decisions about daily. Climate change is likely to exacerbate those existing stressors. With that in mind, it is useful to obtain support, sponsorship, and leadership from Executive leader(s) across the utility by articulating the value of proactively investing in a climate risk and opportunity assessment. The value-add could include the potential to enhance employee wellness and safety, or the potential to financially prosper in the long-term by investing in climate adaptation measures and resilient infrastructure that will withstand both short-term shocks and long-term stressors in a changing climate. Executive support, sponsorship, and leadership is critical to facilitating the mainstreaming of climate resilience across the utility.

CASE STUDY: Articulating the Business Case

Over 40 staff from Denver Water engaged in the TTX, including members of the Executive leadership team. Participants found the process so helpful and worthwhile, that in 2022 the Denver Water Watershed Planning team will be bringing in external partners to repeat the TTX approach to enhance wildfire preparedness. Using the same future climate scenarios, Denver Water, the Colorado State Forest Service, the United States Forest Service, and other partners will engage in a TTX to discuss how warmer climate scenarios may change state wildfire preparedness, response, and recovery efforts.

Step 1b: Define assessment objectives with utility leadership

Once Executive support is secured, work with the utility leadership to draft assessment goals, objectives, and ideal outcomes. Having utility leadership on board and bought into the assessment goals and objectives from the start will create a sense of empowerment among staff who lead and participate in the assessment planning and conduct. In addition, it could lead to Executive leadership championing climate

action in the long-term. We recommend identifying at least three, but no more than five, assessment objectives that are specific, measurable, achievable, relevant, and time-bound (SMART).

Figure 3. Example Assessment Objectives

Denver Water		SFPUC
1	Collaborate across business functions to co-create solutions to climate-related risks and identify climate-related opportunities and identify competing objectives.	Identify current and emerging climate-related risks and opportunities as they relate to SFPUC business functions and how they are interconnected.
2	Identify potential climate-based risks and opportunities to the natural, built, and business systems, and operational functions, including the ripple effects to other sections and divisions within the organization.	Understand how and to what extent SFPUC business functions are prepared to address current and emerging climate related risks.
3	Prioritize the most urgent risks that can be mitigated through proactive investments and commit to developing and investing in adaptation solutions.	Identify current SFPUC strategies and future opportunities related to climate adaptation, for strengthening business functions' capabilities.
4	Identify risks that cannot be mitigated and commit to developing (emergency and systemic) preparedness and response protocols to enhance risk management and resilience.	Enhance the visibility and consideration of existing SFPUC climate-related risk and opportunity assessment work, broaden internal coordination and expand the number of business functions included in climate-related response development.
5	Create signposts for determining the potential for risks to emerge or decisions be made and create post-TTX implementation evaluation protocol for determining the success of an implemented adaptation action.	<i>Note: Following the completion of the Denver Water TTX, participants reflected that there were perhaps too many objectives to achieve in the amount of time we had dedicated to the TTX. This feedback was applied to the SFPUC TTX, which focused on achieving only on four objectives.</i>
6	Identify additional internal and external partners who share risks and could contribute in proactive investments.	

Step 1c: Identify an internal assessment leader

It is important to identify one utility staff to serve as the assessment leader. This staff should be empowered by leadership to manage the entire assessment process and framework implementation. Ideally this person would be in a management position within the utility, embody collaborative people skills, understand the state of our current and future climate, and be highly organized and responsive. If a climate program already exists within the utility, then the lead of that program is likely the most appropriate person to lead the assessment if that person has the characteristics noted above. It is important that this staff person be supported by additional staff (e.g., junior staff from the existing climate program). If additional staff support is not immediately evident, the assessment leader should discuss with leadership opportunities to leverage other utility staff to support the assessment effort.

Step 1d: Develop an assessment scope, timeline, and budget

Once an assessment leader has been identified, it is important that they detail the assessment scope, timeline, and budget and present it to the utility's leadership for input and approval. Discussion of the scope should include how many and which business functions to assess. Denver Water and SFPUC determined that assessing three business functions at a time was an effective number. This process took approximately one year to run through the entire framework with utility engagement throughout. However, a shorter timeline can be achieved if the TTX approach is not taken.

Step 2: Determine the Focus for the Assessment

The next step in the framework is to identify the full array of business functions that make up the water utility enterprise. A compiled list of common water utility business functions across an array of varying sizes and types of water utilities in the U.S. can be found in **Figure 4** below. It is helpful to begin with this list, add functions that aren't already included but are relevant to the utility being assessed, and then narrow the scope to three mission-critical business functions and their associated sub-functions to conduct the in-depth assessment.

Business functions that are deemed “critical,” are the utility activities and process that are essential for the utility assets and personnel to continue operating safely. Traditionally, these business functions may not have thought about how climate change will impact their essential functions in the future and may not be planning for a changing climate. However, these business functions may already have been impacted by extreme weather events and/or will face considerable impacts (direct and/or indirect) from climate change and should be preparing for these changes now in order to enhance the resilience of the utility.

Step 2a: Review Figure 4 to identify utility business functions and critical sub-functions for your utility

Using the suite of water utility business functions and sub-functions compiled through this research and summarized in **Figure 4**, identify business functions and sub-functions relevant to the utility's activities. A useful place to start is your utility's organizational chart. This will help identify the broad business functions from which the sub-functions can then be identified and will serve as the focus of the assessment.

Our experience found it much easier and clearer to conduct the assessment mapping exercises when focusing on sub-functions rather than on the overarching core business functions. Core functions often include subcomponents that experience climate stresses very differently, and the resulting risk and opportunity map may prove less useful if only the core functions are mapped. **Figure 5** provides examples of the critical business functions and associated sub-functions selected by the water utility partners involved in this process.

Figure 4. Water-specific and Other Business Functions

Water-specific Business Functions				
Drinking Water	Water Supply	Wastewater	Water/Environmental Monitoring and Management	Storm water Management
<ul style="list-style-type: none"> • Drinking water treatment • Drinking water distribution 	<ul style="list-style-type: none"> • Watershed management • Conservation • Drought planning/water shortage state management • Seawater desalination • Recycled water/effluent management • Reservoir and surface water management 	<ul style="list-style-type: none"> • Wastewater collection • Wastewater treatment • Bio-solids management 	<ul style="list-style-type: none"> • Ground water and surface water quality/management • Watershed/land management • Stream rehabilitation • Ocean water quality monitoring • Environmental monitoring 	<ul style="list-style-type: none"> • Flood control • Drainage basins and infrastructure • Storm water quality

- Groundwater management
- Wholesale water supply
- Environmental compliance

Other Business Functions

Business Affairs, Accounting and Human Resources	Procurement	Planning, Modeling, Forecasting and Analysis	External Affairs	Engineering, Design and Construction	Operations
<ul style="list-style-type: none"> • Contracts, business services, recording keeping and billing • Finance • Insurance • Risk management • Rate setting, charges and fees • Grant preparation and management • Health and safety • Human resources, employment and staff training • Asset inventories and tracking 	<ul style="list-style-type: none"> • Energy procurement/management • Procurement of goods and services 	<ul style="list-style-type: none"> • Water supply planning • Water demand planning • Sustainability planning • Forecasting and analysis 	<ul style="list-style-type: none"> • 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 	<ul style="list-style-type: none"> • Infrastructure planning • Construction 	<ul style="list-style-type: none"> • Asset management • Infrastructure maintenance • Field operations • Meter reading and maintenance • Security (physical, computer and data) • Information technology • Laboratory services

Figure 5. Critical Business Functions and Associated Sub-Functions Selected by the Water Utility Partners

City of Fort Collins Utilities	San Diego Public Utilities Department	Southern Nevada Water Authority	Tampa Bay Water	Denver Water	San Francisco Public Utilities Commission
<p>Storm water Management</p> <p>Forecasting, water quality management, design and maintenance of collection and storage infrastructure, floodplain management, land use planning and development, regulation</p>	<p>Drinking Water Treatment and Delivery</p> <p>Treatment facilities, facility maintenance, pipelines, physical and chemical treatment of raw water, remedial treatment for impaired water, reuse of municipal effluent, storm water runoff quality, upstream watershed conditions</p>	<p>Administration</p> <p>Customer care and field services, environmental health and safety and security, human resources, information technology, public services</p>	<p>Physical and Cyber Security</p> <p>Communications, physical plant management, information technology, detection, sensors, supervisory control and data acquisition systems (SCADA)</p>	<p>Natural Systems: Watersheds and Forests</p> <p>Land management, forest management, partnership administration, watershed planning, revegetation and restoration, endangered species management</p>	<p>Business Services</p> <p>Customer Services Bureau, information technology systems, financial services, strategy, innovation and change</p>
<p>Asset Management</p> <p>Lifecycle analysis, service levels, reliability, maintenance standards, infrastructure development, mapping, strategic planning, data collection</p>	<p>Water Supply (Key Function: Operational Considerations within San Diego’s Local Storage/Reservoir System)</p> <p>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</p>	<p>Engineering and Operations</p> <p>Energy management, engineering, infrastructure management, operations, resources and facilities, water quality and treatment</p>	<p>Drinking Water Treatment and Distribution</p> <p>Incoming water quality, treatment facility capacity, treatment technology, distribution system, storage, treatment type (physical and chemical), monitoring, desalination</p>	<p>Built Systems: Water Treatment and Water Distribution</p> <p>Demand projections and sizing of distribution systems, engineering, capital projects, sediment management, materials review, water treatment</p>	<p>Health and Safety</p> <p>Policy and guidance, job safety, monitoring and evaluation, surveys, regulatory compliance, contractor health and safety, engineering design reviews, field support, natural disaster and emergency incident support</p>
<p>Engineering and Design</p> <p>Surveying, sizing, layout, design standards</p>	<p>Staff Experience and Training</p> <p>Staff operations, risk protocols, operating manuals, capital improvements management, engineering training and protocols, staff outreach, projections, scenarios, integrated long-range planning</p>	<p>Finance</p> <p>Accounting, financial services, purchases and rate structures</p>	<p>Engineering, Design, and Construction</p> <p>Construction standards, constructability of assets, site selection, design standards, material selection, useful life analysis, physical construction</p>	<p>Business Systems: Finance</p> <p>Bond disclosure, insurance, accounting, retirement and pensions, demand projections, financial planning, rate design, investment strategies</p>	<p>Watershed Management</p> <p>Design, construction and maintenance, risk monitoring, mitigation and management, public safety, infrastructure installation and maintenance, natural resources monitoring, management and restoration, land acquisition and projection, public education and outreach, environmental regulatory compliance</p>

Step 2b: Prioritize mission-critical business functions to assess

Once the business functions and sub-functions have been identified, it is important that the mission-critical business functions be assessed first. While all of the utilities who went through this process wished they could assess all of their business functions at once, focusing the first assessment on three business functions enabled a good level of cross-collaboration and knowledge sharing while still providing enough time to go more in-depth into the risks and opportunities for each individual business function.

CASE STUDY: Initial Business Functions Assessed by Denver Water and SFPUC

Denver Water engaged four mission-critical business functions: (1) Watersheds and Forests; (2) Water Treatment; (3) Water Distribution; and (4) Finance. SFPUC engaged three mission-critical business functions: (1) Health and Safety, (2) Watersheds Management, and (3) Business Services. Each business function represented a unique perspective, voice, and approach to managing and operating the water utility which added incredible value to the entire process, discussion, and implementation actions taken since.

Step 2c: Form a cross-functional working group or exercise planning team (EPT)

Once the business functions have been selected, the next step is to form a cross-functional exercise planning team (EPT) of one staff representative from each of the three mission-critical business functions prioritized in Step 2b that will be the focus of the assessment. The Denver Water EPT consisted of one assessment leader (the utility's climate lead) and five representatives from their four mission-critical business functions. The SFPUC EPT consisted of two assessment leaders (two of the utility's climate leads) and three representatives from the three mission-critical business functions the selected as their initial focus.

Representatives selected to serve on the EPT should have ample time to participate in the assessment planning process (the entirety of the framework steps). Ideally, they will also be familiar with the underlying conditions, inner workings, regulatory requirements, and strategic processes of the business function they represent. To the extent feasible, select EPT participants with different backgrounds, training, and familiarity with the way the utility currently functions. It is important to also include a representative who is considered a "climate expert" or someone familiar with the current and future potential impacts of climate change to the various business functions and the cascading implications. As mentioned in **Step 1c**, it is likely this climate expert who will lead the assessment process. However, if the internal assessment leader is not a climate expert and in-house climate expertise exists, request that the climate expert be included as a representative on the EPT. This representative can ask the climate questions and help navigate the climate data and information while connecting potential impacts for the other team members who may not be as familiar with how climate change can affect their utility business functions.

In reflection, both Denver Water and SFPUC agreed that selecting the right people to be on the EPT is one of the most important steps in this process. The EPT will play a key role in driving subsequent steps by providing critical insight and visibility into the business function they represent. It is vital for EPT members to have the time, authorization, and ability to participate on the EPT for the duration of the assessment. In our experience, this could be as little as a few months, to over a year depending on the level, scope, timeline, and budget of the assessment.

Figure 6 illustrates some example cross-functional water utility business function representatives, their example titles, and divisions within the water utility that might be included in this type of assessment. The EPT should consist of a selection of these types of representatives – ideally no more than five people, including the assessment leader. As mentioned in Step 1d, when developing the assessment scope, timeline, and budget, it may be helpful to circle back with the utility leadership to identify and empower EPT members to participate in this process and actively represent their business function.

Figure 6. Example Cross-functional Water Utility Business Function Representatives

Example Titles of EPT Representatives	
Climate Program Director	Legal Services Manager
Integrated Water Management Director	Director of Human Resources
Water Supply Planning and Assessments Project Manager	Information Technology Manager
Climate Change Policy Analyst	Distribution Hydraulic Engineer
Planning and Decision Support Manager	Biology Division Supervisor
Water Resources Engineer	Environmental Finance Manager
Deputy Director of Long-Range Planning	Operating Budget Manager
Deputy Director of Environmental Monitoring and Technical Services	Health and Safety Program Manager
Chief Financial Officer	Planning and Environmental Compliance Manager
Deputy Director of Public Services and Customer Relations	Health and Safety Analyst
Water Treatment Technician	Watershed Management Planner
Finance Senior Analyst	Risk Manager

Step 2d: Identify existing people, resources, and background materials to establish a foundation of known and projected (future) climate conditions

In conversations with the gathered EPT, identify existing resources and background materials, such as system plans, risk assessments, and strategic plans. Some example resources that jurisdictions may have access to are listed in **Figure 7**. To create a common foundation for EPT members and ensure a familiar organization-wide baseline, it is useful to provide a list or summary of these resources for review before initiating conversations. These materials will be used again in **Step 3**, so document any key findings that may be relevant to include in the “Climate 101” training and future climate scenario narratives.

It is also important to take stock of existing staff experience and expertise related to assessing current and future preparedness for projected climate conditions and/or a background in conducting TTXs or facilitating multi-stakeholder workshops to assess risks or threats of varying types (man-made, natural hazard, climate-induced).

Figure 7. 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
	Watershed Restoration Plans
	Climate Change Sensitivity, Risk, or Vulnerability Assessments or Studies
	Integrated Modeling Projects
	Climate Resilience Evaluation and Awareness Tool (CREAT) ¹
	Vulnerability Self-Assessment Tool 2.0 ²
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 Mitigation, Adaptation, and/or Action Plans
	Local Hazard Mitigation Plans
	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	State Climate Mitigation, Adaptation, and/or Action Plans
	Technical State Climate Summaries
	States at Risk Reports ³
	State Hazard Mitigation Plans
	State-funded Risk and Adaptation Tools (e.g. Cal-Adapt)
Federal	Climate Resilience Toolkit: Water Resources Dashboard; Drought Response and Recovery; and Flood Resilience
	U.S. Department of Agriculture (USDA) Cooperative Extension Systems 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
Regional	Fourth National Climate Assessment, Volume 1: Climate Science Special Report ⁴
	Fourth National Climate Assessment, Volume 2: Impacts, Risks, and Adaptation in the United States ⁵
International	Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report ⁶
	Country-level Vulnerability Assessments, Climate Profiles, and/or Adaptation Plans

Step 2e: Schedule regular briefings with the leadership team

Throughout the framework implementation step process, utilities have found it helpful to regularly check in with their leadership team and provide an update on the assessment process. This not only reminds leadership of the ongoing climate assessment, but also provides an opportunity to seek continual input and feedback from leadership if any questions or challenges arise.

¹ <https://toolkit.climate.gov/tool/climate-resilience-evaluation-awareness-tool-creat>

² <https://www.epa.gov/waterriskassessment/conduct-drinking-water-or-wastewater-utility-risk-assessment>

³ <https://statesatrisk.org/>

⁴ <https://science2017.globalchange.gov/>

⁵ <https://nca2018.globalchange.gov/>

⁶ <https://www.ipcc.ch/assessment-report/ar5/>

Step 3: Design and Prepare for a Climate Risk and Opportunity Mapping Tabletop Exercise (TTX)

The next step is to prepare for and design an interactive TTX or workshop that will set the foundation and process to achieve the goal of mapping climate risks and opportunities across business functions. The term exercise refers to “an instrument to train for, assess, practice, and improve performance in prevention, protection, mitigation, response, and recovery capabilities in a risk-free environment.”⁷ TTXs have traditionally been used through the military (wargaming), intelligence, and emergency management communities. Leveraging this tried and tested TTX method and applying it to the challenges and opportunities climate change presents is a unique approach and one that had not been done with water utilities before this experience. Now that the TTX approach has been used to identify, understand, and assess climate-related risks and opportunities, it can be replicated, tailored, and repeated for any utility or organization interested in furthering climate action.

Depending on the assessment objectives, scope, timeline, and budget agreed upon in **Step 1**, determining which format – a TTX, workshop, or other format – will achieve your desired outcomes is essential. Recognizing that water utilities vary in size, scope, resources, and risk assessment and management processes, this guidebook was prepared to distinguish between basic and more advanced steps needed to map climate-related risks and opportunities to critical business functions. The sub-steps described below explain the more advanced steps to prepare for, design, and conduct a TTX. However, if resources do not allow this scale of approach, higher-level results can be achieved with a more basic workshop.

Since the sub-steps below may occur over the course of several months, especially if designing and preparing for a multi-day TTX, we recommend initiating several of the sub-steps at once and completing them concurrently. Given the extensive nature of preparing for, designing, and conducting a TTX of this nature, it may be prudent to consider hiring an external consultant to support the sub-steps outlined in Step 3. Denver Water and SFPUC agreed that having external consultant support not only allowed for more effective and non-biased facilitation, but also streamlined the process to prepare, design, and conduct the TTX since utility staff did not have the time or capacity to take this responsibility on.

The **Train-the-Trainer Tool** can help guide utility staff on how to prepare for, design, and conduct a TTX or workshop and can be tailored to the utility’s needs.

Step 3a: Prepare for and design an interactive TTX or workshop by conducting initial, midterm, and final planning meetings with the EPT

Productive TTXs are a result of effective and collaborative design and detailed planning. In this step, the EPT should expect to host initial, midterm, and final planning meetings over the course of several months in order to successfully prepare for, design and conduct the TTX. If the utility is leveraging external facilitators or consulting services for this exercise, these external team members can facilitate the initial, midterm, and final planning meetings so utility staff can participate and engage more effectively.

⁷ “Glossary,” FEMA Emergency Management Institute, accessed June 30, 2020, <https://training.fema.gov/is/course/glossary.aspx>.

Outlined below are suggested objectives for each planning meeting.

Initial Planning Meeting (IPM) Objectives

- Review exercise objectives
- Develop player participation list and clarify and level of effort
- Determine scenario elements
- Discuss timeline
- Confirm exercise locations
- Discuss exercise development and timeline
- Determine next steps and assign action items

Midterm Planning Meeting (MPM) Objectives

- Review planning updates
- Finalize player participation
- Finalize overall exercise objectives
- Review participating agency exercise objectives
- Review and update scenario
- Finalize locations and timeline
- Close out IPM action items
- Discuss action items and next steps

Final Planning Meeting (FPM) Objectives

- Finalize agency participation
- Finalize exercise structure and scenario
- Determine exercise support, including exercise control and evaluation
- Review and finalize exercise documentation
- Close out MPM action items
- Determine action items and next steps

Step 3b: Conduct a “Climate 101” training to establish baseline knowledge

This step involves collecting relevant climate, hazards, and risk management basics and presenting this information to the EPT and TTX participants to establish a baseline understanding of climate change and scientifically based projections of future climate-related risks. The assessment leader may be best suited to compile and present this training, or whoever within the organization has the most climate science background. We recommend giving this training at least one month in advance of the TTX, as this training provides a dual an opportunity to not only introduce the assessment process to the TTX participants, but also enables the participants to feel well-prepared for the TTX discussions with a baseline climate understanding. Feedback from the Denver Water and SFPUC presentations suggest participants felt an increased awareness of many of the climate-related risks that could potentially impact their business function. The “Climate 101” trainings also provide an opportunity to:

- Define key terminology and definitions;
- Encourage open questions/communication before, during, and after the TTX; and
- Empower trained climate champions.

CASE STUDY: “Climate 101” Trainings

Denver Water’s key messages described in detail within the “Climate 101” training included:

1. Climate change is here and now.
2. Climate change is water change.
3. Climate change impacts all areas of Denver Water.
4. We are actively preparing.
5. We need your help!

Due in part to the success of the TTX, the Denver Water Climate Program will be giving their “Climate 101” presentation to other business functions throughout 2021. They are also interviewing the EPT members about their experience with this effort and creating brief videos to showcase the benefit of applying this framework and TTX approach with both internal and external partners.

Step 3c: Design exercise scenarios and time horizons to be used to explore impacts, opportunities, and solutions

With the EPT, leverage the existing staff, resources, and background materials identified in **Step 2d** to decide which climate scenarios and/or time horizons to be used in the TTX. Utilizing the latest and more reputable climate science and localized projections (if these have not already been used at the water utility, they are likely available in the resources listed in **Figure 7** or at the local university) will help ensure the scenario narratives are based on sound-science and relevant. Having feasible and realistic future scenarios ensures the TTX discussion remains focused on risks and opportunities and is not distracted by disagreement with the presented scenario. Best practices for scenario narrative development include:

- Develop **one current scenario** based on observed historic changes in the climate, economy, society, and the world. Denver Water and SFPUC participants reflected that the “current climate” scenario was helpful to reinforce baseline knowledge and get them thinking about underlying conditions, challenges, and risks they face today before discussing how these conditions and risks may change in the future.
- Develop at most **two future scenarios** based on projected changes in the climate, economy, society, and the world (base this on sound science, but some can be hypothetical plausible situations that you want to play out). Denver Water and SFPUC tested two “future climate” scenarios but participants found a high level of redundancy between the scenarios we tested (see **Figure 6**). Depending on the objectives of the assessment determined in **Step 1**, it may be possible to achieve the desired outcomes with only one future scenario.
- **Sometimes including time horizons can distract participants.** For SFPUC, one of the future scenarios took place in 2070 which felt too far into the future for the participants to realistically plan for what other changes the world may face over the next 50 years. Denver Water included a warmer and hotter future without time horizons which turned out to be useful because both scenarios are possible depending on whether global greenhouse gas emissions continue on a business-as-usual trajectory.
- **Include socioeconomic, demographic, technological, customer behavior,** and other data and trend information pertinent to the exercise when designing and documenting the scenarios. There may not be future projections for this type of data in the water utility’s jurisdiction. If this is the case, the EPT can establish some assumptions and project trends that they may want to consider that would affect the water utility (positively or negatively) if the scenario played out in the future.

- Create time in the TTX play to **identify solutions** (this could be a solutions-focused module). Denver Water and SFPUC dedicated an entire module to identifying and discussing opportunities and solutions. Participants were eager to identify solutions as the risks were discussed and mapped. Providing time and space for them to collaboratively identify solutions that provide co-benefits across their business functions is important.
- **Review scenario narrative and components with the Executive leader(s)**. Sometimes EPT members may not have thought of everything that the utility could already be facing or could face in the future. Engaging with Executive leaders on their review of the scenario narratives could help identify gaps that hadn't been considered.

Figure 8 shows the TTX module scenarios used by the Denver Water and SFPUC. It is notable that the two utilities took different approaches to designing their scenarios. To avoid concern about future scenarios being too far into the future to be able to conceptualize, Denver Water did not assign time horizons. Instead, they chose to focus on the cascading impacts of increasingly higher temperatures. Due to SFPUC planning horizons, they felt that thinking about climate impacts in certain planning time horizons would be most useful. There is no right or wrong way to design these scenarios. What is more important than the scenarios themselves is the exercise of getting staff to think through underlying conditions and existing stressors then adding in additional and cascading climate stressors and having them think through the risks to their business function.

Figure 8. Example Exercise Scenarios Used by Denver Water and SFPUC

Denver Water	SFPUC
Module 1: Denver in 2020	Module 1: San Francisco in 2020
Module 2: A Warmer Denver	Module 2: San Francisco in 2040
Module 3: A Hotter Denver	Module 3: San Francisco in 2070

Step 3d: Develop the TTX agenda and associated materials and prepare for TTX conduct

Once scenario narratives are designed, they should be documented in a TTX Playbook. A Playbook, also sometimes referred to as a Situation Manual by emergency managers, details the different scenarios (or modules) the players will work through during the TTX. Because most TTX participants may not be intimately involved in climate-related discussions as part of their day-to-day role, the Playbook should be designed to provide as much context regarding climate change as possible. It should include specific and detailed information about how future climate scenarios may impact the selected business functions, and weave in historical examples for context. For example, if the water utility or surrounding jurisdiction experienced a memorable flood or wildfire event in recent history, build the scenarios based on these lived experiences. Address how these events and future events like it impacted or could impact the utility in the future if multiple events occurred at once. Acknowledge how utility plans, policies, or procedures changed after that event. As you draft the Playbook and scenarios, keep the description of climate projections as non-technical, narrative-based, and brief as possible to ensure the information is accessible for all participants.

An example Playbook template is included in **Appendix B**. Denver Water and SFPUC sent the Playbook via email to participants one week prior to the exercise conduct. Participant feedback indicated they appreciated having at least one week to review the Playbook in advance.

During the Business Function Mapping Tabletop Exercise

Step 4: Conduct the TTX to Map Potential Impacts of Climate Stressors and Cascading Effects

The TTX or workshop conduct begins at this step with a goal to begin mapping underlying conditions, climate stressors, and cascading effects that are already, or could in the future, impact each critical business function. **Steps 4, 5, and 6** all occur during the TTX or workshop, and should be considered stepwise processes for ultimately generating a list of critical path activities, underlying conditions, climate stressors, risks, and potential opportunities and solutions for each business function.

Step 4a: Identify critical path activities, decision points, and existing processes for each business function

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 not to limit consideration to events and conditions that have existed in the past, but to consider potential future events and conditions as well.

Thinking through the activities required to operate and manage each business function 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 utility customers;
- Potential failure points and what events 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 for effective operation; and
- 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 4b: Discuss existing underlying conditions and vulnerabilities for each business function

Climate change is a threat multiplier, exacerbating existing climate conditions and underlying vulnerabilities or creating new conditions problematic to the utility's mission. If the assessed business functions have underlying conditions they are trying to manage now (e.g., aging infrastructure, limited human capacity, political issues, turnover, or staff health concerns), it is important that the participants understand these underlying conditions from the start.

During this step, discuss historic vulnerabilities, experiences, and events affecting continuity of service, utility functions, and the health, safety, and welfare of staff 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. Open discussion about the underlying conditions of each business function during the TTX allows the other business functions to consider if that is also an underlying condition for them, facilitates cross-functional discussion, and may even spark the identification of opportunities to remedy the underlying condition.

CASE STUDY: Exploring Underlying Conditions

Several of the underlying conditions identified by Denver Water and SFPUC were similar. These included:

- Cybersecurity threats
- Employee health (especially during wildfire season)
- Retiring staff, turnover, and lack of knowledge transfer due to challenges with recruitment processes and attracting qualified candidates
- Aging and vulnerable infrastructure
- Lack of organizational ability to adapt quickly
- Inflexibility of state and federal permitting requirements
- Increasing population
- Increasing costs of living and affordability issues

Step 4c: Identify key climate stressors relevant to the business functions

Once the participants have a clear understanding of underlying conditions for each business function under assessment, climate stressors appearing to pose the highest initial concern for the business function can be layered in. These may include both acute and chronic climate hazards such as higher annual average temperatures, changing precipitation patterns, sea level rise, extreme heat or cold stress, wildfires, drought, flooding, and powerful storms. Think about stressors that have affected the utility in the past, those affecting other utilities in your region, and those that may pose issues in the future. Consider the potential cascading impacts of multiple stressors occurring at once (for example, if a major wildfire occurred at the same time as a three-week heat wave, global pandemic, and economic crisis) and the relevant impacts to each business function.

While having these discussions, it was helpful to focus on a single business function at a time, but to allow space for the other business functions to chime in, agree/disagree, ask questions, or provide insights or resources that could possibly help alleviate the strain of the stressor or impacts associated with the stressor. As these discussions unfold, map the direct, indirect, and cascading impacts from the underlying conditions, hazards, and climate stressors to each business function and sub-function. **Figure 9** describes some example business functions and impacts mapped with our partner water utilities and **Figure 10** illustrates an example of a complete business function map connecting underlying conditions, climate stressors, risk, and opportunities.

Figure 9. Example Business Functions and Mapped Climate Impacts

Business Function	Impacts from Climate Change
Administration	<ul style="list-style-type: none"> • Intensity of heat and flood events from extreme storms put employees and communication systems at risk • New hires are seeking employment in climate-active organizations • Increased need to apply for hazard mitigation and resiliency funding
Public Affairs	<ul style="list-style-type: none"> • Following major events, Public 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	<ul style="list-style-type: none"> • Uncertainties about future climate conditions can impair a utility’s ability to consider risks in large-scale planning • Setting expectations to consider climate adaptation and resilience in all work will hasten and motivate mainstreaming
Engineering Design, Construction, and Operations	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Field electronics and servers are sensitive to increased heat, humidity, and precipitation
Finance	<ul style="list-style-type: none"> • Extended drought and conservation efforts reduce water demand and impact revenue, resulting in required rate structure adjustments • Intensity of drought and unstable economic futures resulting from extreme temperatures in the region could reduce or enhance the utility’s consumer base due to inhospitable living conditions locally or in other locations • Revenue variability increases with weather variability • Bond rating impacts are associated with revenue loss from drought restrictions • Impact on coverage and cost of insurance
Asset Management	<ul style="list-style-type: none"> • Increased frequency of extreme climate-related events may increase asset maintenance and replacement costs • Infrastructure cracking and failure may result from aridification and heat waves • Employees have difficulty accessing major treatment plants during large flooding events
Procurement	<ul style="list-style-type: none"> • Major events spur a rush to procure disaster clean-up services to respond to infrastructure challenges • Supply chain disruptions occurring from local or national climate disruptions (e.g., sea level rise impacting port terminals)
Business Affairs	<ul style="list-style-type: none"> • Extended drought and conservation efforts reduce water demand and impact revenue, resulting in required rate structure adjustments
Environmental Monitoring and Management	<ul style="list-style-type: none"> • Increased difficulty in balancing Clean Water Act compliance and adaptation measures • Increased spending to comply with the Safe Drinking Water Act, Clean Water Act, and Endangered Species Act • Identifying species that will not survive in a warmer climate and supporting those that will thrive in future climate conditions • Watershed and forest degradation from aridification, heat stress, and pest infestation
Stormwater Management	<ul style="list-style-type: none"> • Storm surge and sea level rise impact flood mitigation measures and a utility’s stormwater system capacity • Precipitation intensity puts utility stormwater management at risk
Drinking Water Treatment and Delivery	<ul style="list-style-type: none"> • Forest fires threaten water quality and existing delivery structures • 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

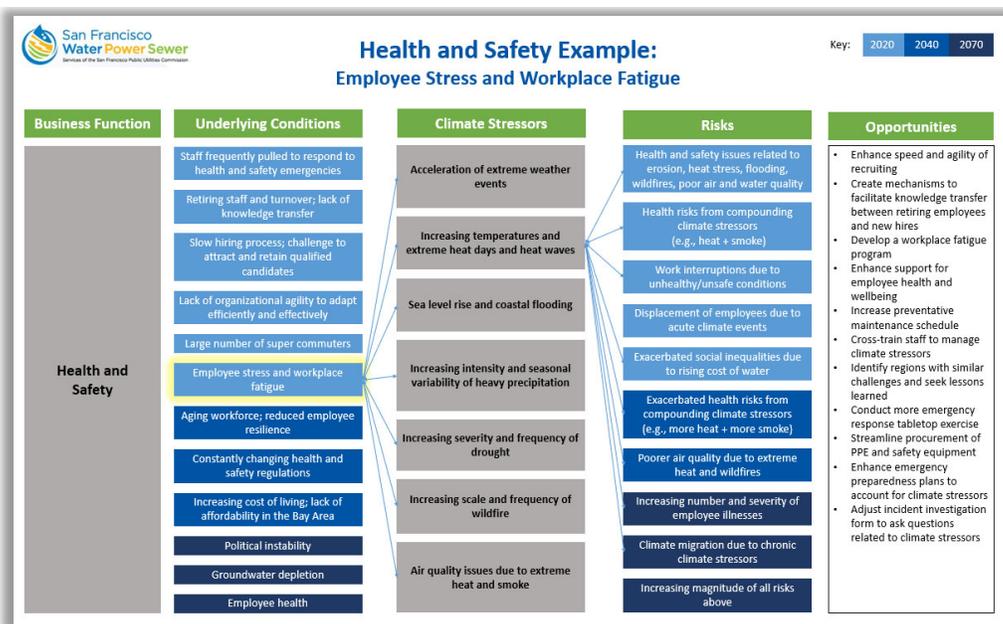
Water Supply & Demand	<ul style="list-style-type: none"> Water supplies are increasingly exposed to pollutants from wildfires and high temperatures Decreasing supplies as snow-to-runoff efficiency decreases and evapotranspiration increases Uncertainty around how customer water demand will change as the climate changes: Will people use more water as it gets hotter? Will there be a drastic shift to xeric landscapes as people become more climate conscious?
Wastewater and Reuse Treatment	<ul style="list-style-type: none"> Decreased effluent water quality Warmer water temperatures overall Employees have difficulty accessing major wastewater treatment plants during wildfire and flooding events
Planning, Modeling, Forecasting, and Analysis	<ul style="list-style-type: none"> Utilities may need to consider a broader array of future conditions in planning, including changes in precipitation, temperature, and evaporation projections Must manage variable year-to-year water patterns along with planning for long-term water supply changes Long-term climate projection trends and extremes may change

Step 4d: Brainstorm and map how climate stressors intersect with existing vulnerabilities and identify cascading effects for each business function

After identifying the various underlying conditions and climate drivers of concern, discuss how they intersect. This involves considering direct, indirect, and cascading climate impacts on—for example—business function operations, facilities, assets, employees, customers, and supply chains.

Discuss the underlying vulnerabilities and the ways climate stressors 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 operation and customer 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 10**), map how underlying conditions are linked to climate stressors, and vice versa. Repeat this process until you have discussed all mission-critical business functions being assessed.

Figure 10. Example Climate Stressors, Risks, and Opportunities Map



Step 5: Identify and Prioritize Risks Relative to Mission-critical Business Functions

This step occurs during the TTX and involves compiling collective learnings across the mapping of individual business functions to build an integrated and prioritized list of risks that can provide insights into strategic planning, human relations, communications, engineering, finance, and operations considerations (among others). The goal is to generate a list of key risks for each business function, an example of which is shown in **Figure 10**.

Step 5a: Discuss your utility's enterprise risk tolerance

If representatives from a risk management business function are participating in the TTX, then leverage their experience to discuss your water utility risk threshold and what would constitute a substantive or material impact (e.g., financially, socially, reputationally, to owned and operated assets, employees, customers). If risk management is not a business function being assessed at this time, then work with the utility leadership to understand enterprise risk management and present that information to the TTX participants to foster a shared understanding of risk tolerance levels. Generating this baseline understanding will aid in the next step of prioritizing risks.

Step 5b: Define climate risk prioritization criteria (high, medium, low)

If the utility has already defined risk prioritization criteria based on risk tolerance thresholds, use those criteria to assess and prioritize risks for each business function in **Step 5c**.

However, not all utilities have a defined or widely communicated risk tolerance thresholds, and fewer include climate risks. If no threshold exists, use the TTX as an opportunity to discuss risk thresholds for each business function and the overall utility. For example, perhaps the information technology business function knows cyber security is a risk and they already managing that known risk by installing certain security software and providing staff trainings to mitigate risk, but is there a certain point, such as a city-wide cyber-attack, at which that risk becomes too substantive to manage?

Step 5c: Assess and prioritize risks for each selected business function

Using the risk prioritization criteria established above, develop a priority risk list to guide decision-making, planning, and implementation activities. These prioritized risks can be used as motivators across the utility, encouraging a holistic and cross-functional view of the various ways in which climate considerations penetrate all components of business activities and produce cascading impacts. They can also be used as ways to identify co-benefits to address multiple risks through one or two major mitigation measure.

As in Step 4d, identify which risks are relevant to each selected business function and explore linkages between the underlying conditions, climate stressors, and risks. **Figure 10** shows an example of the cascading linkages and ultimate risks associated with the underlying condition of employee stress and workplace fatigue, which was a common underlying condition voiced by all utilities.

CASE STUDY: Assessing Risks

When discussing risks, participants were surprised to learn that sea level rise is a risk to Denver Water's supply chain. The Distribution business function is dependent on materials sourced from overseas and they have been unable to identify an affordable domestic supplier. Most of their materials arrive via container ship via ports in the Gulf of Mexico, which are vulnerable to sea level rise. Since Denver Water is located in the center of the United States, we did not originally consider sea level rise as a risk, which was an identified gap for further investigation.

CASE STUDY: Prioritizing Risks

When prioritizing risks, SFPUC chose to focus first on risks with clear solutions. For example, during the discussion they realized that if the utility continued to build their infrastructure and forecasting models based on historic conditions, the SFPUC Business Services may become exposed to a range of climate drivers that can ultimately cause operational, financial, regulatory, and reputational risks. At the same time, these changes can also present an opportunity. For example, investments in new technologies and forecasting models now could improve data quality and automation of data processing and facilitate the integration of climate-related considerations into capital planning and project screening.

Step 5d: Identify gaps in data and information that are needed to inform climate-related assessments and decision-making

As the risk and opportunity mapping unfolds, it will become clear that there are gaps in current and projected data and information needed to inform decisions. As these gaps are identified, it will be important to determine whether this data or information (and the scale of the data) is considered critical to inform adaptation or resilience decisions moving forward. For some decision-makers, the granularity of climate data and downscaling is imperative to design or retrofit infrastructure. For others, existing data may be all that is needed to make decision on where and when to invest in addressing and minimizing the risks identified. A discussion about data needs and the gaps that exist will help the utility understand what decisions it can make now to prepare for what's to come and what data and information they may need to research or invest in further in order to adequately inform their decisions.

Step 6: Identify Opportunities and Solutions Across Business Functions

A key component of this assessment is the identification of opportunities, or solutions, to address the identified risks. These opportunities and solutions are likely to be identified organically through open cross-functional discussion during the TTX. They can be collected and compiled throughout the TTX, or specific time can be dedicated during the TTX to focus on opportunity and solution identification (e.g., have a separate module dedicated to identifying opportunities and solutions).

Denver Water and SFPUC both developed a fourth Playbook module that allowed for the exploration of opportunities and solutions. Since this approach allowed a dedicated time period to identify and discussion solutions (3 hours in the case of the Denver Water and SFPUC TTXs), a robust list of solutions were generated relevant for the business functions assessed collectively and individually. At the very least, dedicating at least 1 hour to the discussion and mapping of opportunities and solutions will be useful, but the more time spent, the more refined and actionable the opportunities and solutions list can become.

Step 6a: Develop an initial set of solutions, opportunities, and associated co-benefits

As mentioned above, several solutions will arise naturally during the risk discussion in Step 5. For instance, some potential solutions are often already known because business functions are already aware of and working to manage certain risks, but often there are barriers – such as lack of resources or policies, political challenges, or infrastructure limitations – that have prohibited their implementation to-date. These such limitations and needs should also be captured as part of this process. Other solutions may need to be teased out more, which can be accomplished by reviewing the key risks for each business function and asking the participations to brainstorm a suite of solutions that could be implemented to minimize, manage, or mitigate that risk. Documenting and organizing the solutions in a matrix may be helpful as solutions can be categorized into thematic buckets and sorted in **Step 6b**.

During both Denver Water and SFPUC TTXs, the external consulting team compiled the solutions throughout Days 1 and 2 and presented the compiled list on Day 3 for the participants to refine and build upon. This facilitated more robust discussion about specific solutions on Day 3.

Step 6b: Identify short- and long-term solutions to manage risks and maximize sustainability and climate resilience opportunities

As these discussions unfold, take the time to discuss the solutions that are most feasible and necessary across the business functions and consider prioritizing and labeling those as short-term solutions, or those that could possibly be implemented in the immediate to near future. Consider if there are certain solutions that resonate for multiple business functions or provide co-benefits across the utility and make note of those, as they may be more likely to be prioritized and implemented first.

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 solutions, opportunities, and co-benefits 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).

As you are discussing and documenting solutions, consider:

- Does the solution address multiple risks?
- Which business function(s) is the solution relevant for?
- Is it a shorter-term solution that could be implemented in the next couple of years, or a longer-term solution that may require other (e.g., short-term) solutions to be implemented first?
- Is there a particular business function or participant that is keen to champion the solution and lead it through to implementation?

CASE STUDY: Identifying Solutions

During the Denver Water TTX, participants identified over 70 different actions, or solutions, to the risks identified. Some of these actions were new efforts or projects, while others were simply shifting existing plans, processes, or procedures to embed climate change information. One example is Denver Water’s robust main replacement strategy and program. Following the TTX, Denver Water decided they wanted to embed, or mainstream, climate considerations into the strategy to ensure the program is *Climate Ready*. In 2021, they will be going through their existing strategy and analyzing current practices to see how climate hazards, such as increasing temperatures, may impact the strategy for future main replacements.

Step 6c: Develop recommendations to implement solutions and assign business function points of contact

As done in **Steps 4d and 5c**, continue to explore which solutions and opportunities are relevant to each business function. Some opportunities may be relevant for two or more business functions and those can be mapped to each. Others will be relevant to individual business functions but are no less important. As the utility identifies which solutions are most relevant to each business function, ask the representatives of that business function if they readily able to take action to implement that solution. If they are, ask whether they can commit to lead the solution implementation and co-design with that lead follow-up actions and next steps. If they are not, ask and document what other resources may be needed for that business function to take action on the solution. Document all of this in a solutions matrix that can be continually populated and updated as progress occurs.

CASE STUDY: Collaborating Across Business Functions

The Climate Program at SFPUC had been hosting monthly Climate Coordination meetings for some time but group participation did not include staff from all business functions. Expanding participation was one of the solutions identified during the TTX, so in 2021 they opened the meeting up to more business functions. They are now collaboratively developing a climate policy that will apply to the entire SFPUC enterprise, as well as actively working to embed climate considerations into existing plans and policies related to employee health, safety, and wellbeing.

Step 6d: Present findings and discuss next steps for implementation with the leadership team

After completing the TTX, it is helpful to circle back with the utility leadership team to report out the findings and discuss next steps. Leveraging the risk and opportunity map format of **Figure 10** will help conceptualized and communicate the findings of the assessment and exercise or workshop results in a concise way. However, these maps should be supplemented with a brief report or memorandum summarizing the assessment objectives, key findings, recommendations, and next steps identified during the TTX. Having the assessment leader oversee the preparation of the report or memorandum and deliver brief the leadership team will help increase a full-circle understanding of the process and may lay the foundation, and possibly even the expectation, that this type of assessment be repeated with additional business functions in the future.

Step 6e: Establish a process for reevaluating assessment findings, objectives, and assessing additional business functions; monitor and regularly report progress

Following the completion of the TTX, develop a list of immediate next steps, leads, and timeline, including:

- Identify which business functions may require further analysis;
- Identify synergies and opportunities for collaboration between business functions; and
- Identify business functions to assess next.

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

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.

This framework was informed by a variety of other climate risk assessment frameworks, one of which is the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD). The goal of the TCFD recommendations is to improve the effectiveness and utility of climate-related disclosures. As the U.S. moves closer to regulatory requirements on climate-related risk and opportunity disclosures, this framework can be used for water utilities to publicly disclose the impacts that climate change has and may have on the business over time.

Appendix A. Common Terms and Definitions

Adaptive Capacity	The ability of a person or system to adjust to a stressor, take advantage of new opportunities, or cope with change. ⁸
Business Function	A category of processes or operations that are performed routinely to carry out a part of the utility's mission. ⁹
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: <ul style="list-style-type: none">• 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.¹⁰
Climate	The generally prevailing weather conditions of a region, throughout the year, averaged over a series of years. ¹¹
Climate Adaptation	Actions taken to help limit risk and maximize opportunities associated with changing climate conditions ¹² or adjustments in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities. ¹³ Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation.
Climate Mitigation	With respect to carbon emissions, measures to reduce the amount and speed of future climate change.
Climate Stressor	Events and trends related to weather, climate, and climate change that have an important, generally negative effect on exposed systems.
Community Resilience	Enabling the recognition, understanding, communication of, and planning for risk and empowering individuals and communities to make informed risk management decisions necessary to adapt to, withstand, and quickly recover from future incidents.
Exercise Planning Team	Utility staff who participate in the planning and design of the Tabletop Exercise and Playbook.
Governance	The structure of relationships and processes through which the objectives of the organization are set, progress against performance is monitored, and results are evaluated.

⁸ Ibid, 16.

⁹ Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions, 131.

¹⁰ Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions, 131.

¹¹ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 17.

¹² Wasley, E., K. Jacobs, and J. Weiss. *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions*. Project 4729a. The Water Research Foundation, 2020. <https://www.wucaonline.org/assets/pdf/project-4729B-guidebook.pdf>, 131.

¹³ Wasley, E. *California Adaptation Form Pre-Forum Drought Exercise: Situation Manual*. Cadmus, 2016.

http://cdn2.hubspot.net/hubfs/472557/Situation_Manual_CAF_Drought_Exercise_0902_Cadmus.pdf?__hssc=121325015.1.1592530318019&__hstc=121325015.88669e8617d1e4e944ffa7fe08790257.1591140862832.1591922957115.1592530318019.3&__hsfp=204825244&hsCtaTracking=a4ffba1d-d34e-446c-8b79-4ef3daea37c1%7C85783f6c-35d3-4941-a295-e7daaa33d659, 16.

Governance involves a set of relationships between the utility's management, its Board of Commissioners, its shareholders, and other stakeholders.¹⁴

Hazard	The potential occurrence of an event that may cause injury, illness, or death to humans, damage to assets or infrastructure, or adverse effects on ecosystems. ¹⁵
Hazard Mitigation	Any sustained action taken to reduce or eliminate the long-term risk to life and property from hazard events. It is an ongoing process that occurs before, during, and after disasters and serves to break the cycle of damage and repair in hazardous areas. ¹⁶
Impacts	Effects on natural and human systems due to extreme weather, climate events, and climate change.
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. ¹⁷
Risk	Threats to things of value (life, environment, etc.), evaluated by probability of hazardous event occurring multiplied by the effects event would have. ¹⁸
Resilience	The capacity to anticipate, plan, adapt, rapidly recover, and thrive in a changing climate. ¹⁹
Scenario	A scenario provides the storyline that drives an exercise to accomplish objectives. The scenario selected for an exercise should be informed by the actual threats and hazards faced by the exercise participants. ²⁰
Tabletop Exercise (TTX)	A tabletop exercise (TTX) is typically held in an informal setting intended to generate discussion of various issues regarding a hypothetical, simulated emergency. TTXs can be used to enhance general awareness, validate plans and procedures, rehearse concepts, and/or assess the types of systems needed to guide the prevention of, protection from, mitigation of, response to, and recovery from a defined incident. Generally, TTXs are aimed at facilitating conceptual understanding, identifying strengths and areas for improvement, and/or achieving changes in attitudes. ²¹
Vulnerability	The propensity or predisposition of human and other systems to be adversely affected by climate change. ²²
Weather	The actual state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. ²³

¹⁴ Task Force on Climate-Related Financial Disclosures. Implementing the Recommendations of the TCFD. 2020. <https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf>, 78.

¹⁵ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 17.

¹⁶ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 17.

¹⁷ Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions, 131.

¹⁸ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 18.

¹⁹ Ibid, 131.

²⁰ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 18.

²¹ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 19.

²² Ibid, 19.

²³ Ibid, 19.

Appendix B. Exercise Playbook Template

GRAPHIC OF THE WATER UTILITY

Date

Location

Mapping Climate Risks and Opportunities to Critical Water Utility Business Functions

Playbook for [INSERT WATER UTILITY NAME HERE] Tabletop
Exercise

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HANDLING INSTRUCTIONS

The title of this document is the *Mapping Climate Risk and Opportunities to Critical Water Utility Business Functions: Playbook for [INSERT WATER UTILITY NAME HERE] Tabletop Exercise*.

This playbook reflects the information provided to the exercise planning team in advance of the tabletop exercise (TTX). This document is FOR [INSERT WATER UTILITY NAME HERE] PLANNING PURPOSES ONLY and should be handled as sensitive information not intended for any other use.

For more information on this exercise, please consult the following point of contact:

Internal Assessment Leader Name

Title

Phone: XXX-XXX-XXXX | Email:

Exercise Planning Team		Exercise Design Team (generally consultants)	
Name	Title	Name	Title

OVERVIEW

Exercise Name	Mapping Climate Risks and Opportunities to Critical Water Utility Business Functions
Exercise Date	
Scope	
Objectives	
Scenario	
Participating Organizations	
Point of Contact	

COMMON TERMS AND DEFINITIONS

Adaptive Capacity	The ability of a person or system to adjust to a stressor, take advantage of new opportunities, or cope with change. ¹
Business Function	A category of processes or operations that are performed routinely to carry out a part of the utility's mission. ²
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: <ul style="list-style-type: none"> • 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.³
Climate	The generally prevailing weather conditions of a region, throughout the year, averaged over a series of years. ⁴
Climate Adaptation	Actions taken to help limit risk and maximize opportunities associated with changing climate conditions ⁵ or adjustments in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities. ⁶ Various types of adaptation can be distinguished, including anticipatory, autonomous, and planned adaptation.
Climate Mitigation	With respect to carbon emissions, measures to reduce the amount and speed of future climate change.
Climate Stressor	Events and trends related to weather, climate, and climate change that have an important, generally negative effect on exposed systems.
Community Resilience	Enabling the recognition, understanding, communication of, and planning for risk and empowering individuals and communities to make informed risk management decisions necessary to adapt to, withstand, and quickly recover from future incidents.
Exercise Planning Team	Utility staff who participate in the planning and design of the Tabletop Exercise and Playbook.

¹ Ibid, 16.

² Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions, 131.

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⁴ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 17.

⁵ Wasley, E., K. Jacobs, and J. Weiss. *Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions*. Project 4729a. The Water Research Foundation, 2020. <https://www.wucaonline.org/assets/pdf/project-4729B-guidebook.pdf>, 131.

⁶ Wasley, E. *California Adaptation Form Pre-Forum Drought Exercise: Situation Manual*. Cadmus, 2016.

http://cdn2.hubspot.net/hubfs/472557/Situation_Manual_CAF_Drought_Exercise_0902_Cadmus.pdf?__hssc=121325015.1.1592530318019&__hstc=121325015.88669e8617d1e4e944ffa7fe08790257.1591140862832.1591922957115.1592530318019.3&__hsfp=204825244&hsCtaTracking=a4ffba1d-d34e-446c-8b79-4ef3daea37c1%7C85783f6c-35d3-4941-a295-e7daaa33d659,16

Governance	The structure of relationships and processes through which the objectives of the organization are set, progress against performance is monitored, and results are evaluated. Governance involves a set of relationships between the utility's management, its Board of Commissioners, its shareholders, and other stakeholders. ⁷
Hazard	The potential occurrence of an event that may cause injury, illness, or death to humans, damage to assets or infrastructure, or adverse effects on ecosystems. ⁸
Hazard Mitigation	Any sustained action taken to reduce or eliminate the long-term risk to life and property from hazard events. It is an ongoing process that occurs before, during, and after disasters and serves to break the cycle of damage and repair in hazardous areas. ⁹
Impacts	Effects on natural and human systems due to extreme weather, climate events, and climate change.
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. ¹⁰
Risk	Threats to things of value (life, environment, etc.), evaluated by probability of hazardous event occurring multiplied by the effects event would have. ¹¹
Resilience	The capacity to anticipate, plan, adapt, rapidly recover, and thrive in a changing climate. ¹²
Scenario	A scenario provides the storyline that drives an exercise to accomplish objectives. The scenario selected for an exercise should be informed by the actual threats and hazards faced by the exercise participants. ¹³
Tabletop Exercise (TTX)	A tabletop exercise (TTX) is typically held in an informal setting intended to generate discussion of various issues regarding a hypothetical, simulated emergency. TTXs can be used to enhance general awareness, validate plans and procedures, rehearse concepts, and/or assess the types of systems needed to guide the prevention of, protection from, mitigation of, response to, and recovery from a defined incident. Generally, TTXs are aimed at facilitating conceptual understanding, identifying strengths and areas for improvement, and/or achieving changes in attitudes. ¹⁴
Vulnerability	The propensity or predisposition of human and other systems to be adversely affected by climate change. ¹⁵
Weather	The actual state of the atmosphere with respect to wind, temperature, cloudiness, moisture, pressure, etc. ¹⁶

⁷ Task Force on Climate-Related Financial Disclosures. Implementing the Recommendations of the TCFD. 2020. <https://www.fsb-tcfd.org/wp-content/uploads/2017/06/FINAL-TCFD-Annex-062817.pdf>, 78.

⁸ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 17.

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¹¹ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 18.

¹² Ibid, 131.

¹³ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 18.

¹⁴ California Adaptation Form Pre-Forum Drought Exercise: Situation Manual, 19.

¹⁵ Ibid, 19.

¹⁶ Ibid, 19.

GENERAL INFORMATION

Background

An exercise is defined as “an instrument to train for, assess, practice, and improve performance in prevention, protection, mitigation, response, and recovery capabilities in a risk-free environment.”¹⁷ Exercises play a vital role in whole community preparedness and climate resilience. Preparedness means imagining the unimaginable, and considering the possibility of low-probability, high-consequence events as well as multiple, low-probability and high-probability events happening simultaneously. Resilience is the capacity to anticipate, plan adapt, and thrive in a changing climate.

Exercise Goal

The goal of this exercise is to [STATE THE EXERCISE GOAL HERE].

[INSERT WATER UTILITY NAME HERE] Key Business Functions:

- Natural Systems:
- Built Systems:
- Business Systems:

Exercise Objectives

1. [INSERT EXERCISE OBJECTIVE 1 HERE]
2. [INSERT EXERCISE OBJECTIVE 2 HERE]
3. [INSERT EXERCISE OBJECTIVE 3 HERE]

Participant Roles and Responsibilities

The term *participant* encompasses many groups of people, not just those playing in the exercise portion of the event. Groups of participants involved in the exercise, and their respective roles and responsibilities, are as follows:

- **Players.** Players are personnel who have an active role in discussing or performing their regular roles and responsibilities during the exercise. Players should discuss or initiate actions in response to the simulated emergency based on expert knowledge of response procedures, as well as how they would perform their functions in their current role.
- **Facilitators.** Facilitators guide the overall exercise play and moderate discussions. They are responsible for ensuring that participant discussions remain focused on the objectives of the exercise during the Modules. They also provide additional information or resolve questions as required. Key Exercise Planning Team members also may assist with facilitation as subject matter experts (SMEs) during the exercise.

¹⁷ “Glossary,” FEMA Emergency Management Institute, accessed June 30, 2020, <https://training.fema.gov/is/course/glossary.aspx>.

- **Support Staff.** Exercise support staff are members of the project consulting team who may perform administrative or logistical support tasks during the exercise. As designated note takers, support staff may ask clarifying questions for the purposes of accurate record keeping.
- **Observers.** Observers are outside groups that view the TTX exercise. They are stakeholders that would be impacted by the outcome of the results. They will be given an opportunity to participate at specific points of time but not through the whole exercise.

Exercise Guidelines

Participants should consider the following exercise ground rules to ensure the exercise runs smoothly and meets objectives in a reasonable amount of time:

- The exercise will be conducted in a no-fault learning environment, wherein systems and processes, not individuals, are evaluated.
- The exercise scenario is realistic and plausible, containing sufficient detail for an effective discussion.
- The goals and objectives of the exercise are consistent with discussion-based exercises focusing on operations and technical plans and procedures.
- There is no “hidden agenda,” nor any trick questions.
- The participants may need to balance exercise play with real-world emergencies. It is understood that real-world emergencies will take priority.
- Players are encouraged to participate openly – ask questions, share thoughts, offer forward-looking, problem-solving suggestions.
- Do not fight the scenario; it is designed to prompt discussion.
- This is to be a safe space to ask questions and bring up all ideas, even ‘silly’ ones. Outcomes will not be attributed to individuals.

Exercise Structure

This tabletop exercise will be scenario-based facilitated discussion split into X number of modules. Each module will begin with a scenario update, followed by a series of relevant discussion questions that will be posed to the exercise participants. The discussion will be driven by [INSERT WATER UTILITY NAME HERE] existing research, assessments, plans, policies, and procedures. The modules will be focused on the following:

- Module 1: Current Scenario
- Module 2: Future Scenario 1
- Module 3: Future Scenario 2
- Module 4: Potential Solutions

Exercise Schedule

DAY 1 – DATE (DAY)	DAY 2 – DATE (DAY)	DAY 3 – DATE (DAY)
10:00 – 11:00 AM Welcome Exercise Background Guidelines and Structure	9:30 – 10:00 AM Summary of Day 1 Discussion	1:00 – 1:30 PM Summary of Days 1 & 2 Discussion
11:00 – 11:30 AM Situation Overview	10:00 AM – 12:00 PM Module 2	1:30 – 3:30 PM Module 4
<i>11:30 AM – 12:30 PM Lunch Break</i>	<i>12:00 – 1:00 PM Lunch Break</i>	3:30 – 4:00 PM Summary and Next Steps
12:30 – 3:00 PM Module 1	1:00 – 3:30 PM Module 3	4:00 PM Adjourn

SITUATION OVERVIEW

Overarching State- or Regional-level Context

Describe and provide graphics illustrating the current and projected (if available) economic state, GDP, critical sectors, and any other information relevant to set the scene of this state or region.

Water Customer Demographics

Describe and provide graphics illustrating the current and projected (if available) water customer demographics.

Planning for Change

Describe and provide graphics illustrating the current and planned changes the water utility is preparing for now.

Natural Systems Context

Describe and provide graphics illustrating the utility's natural systems and any relevant context.

Built Infrastructure Context

Describe and provide graphics illustrating the utility's built systems and any relevant context.

Denver Water: Business Context

Describe and provide graphics illustrating the utility's business systems and any relevant context.

MODULE 1: CURRENT SCENARIO

Module 1: Current Scenario

It is the year XXXX in [INSERT LOCATION JURISDICTION HERE]. Insert the scenario narrative here.

Module 1: Discussion Questions

Based on the information provided, participate in the discussion concerning the issues raised in this module. Identify any critical issues, decisions, requirements or questions that should be addressed.

1. QUESTIONS TO BE ASKED VIA ZOOM CHAT FUNCTION

- What risks to your business function keep you up at night (by individual and business function)?
- What climate change drivers have been of most concern to your business function to date?

2. UNDERLYING CONDITIONS

- What non-climate-related underlying vulnerabilities exist within your business function today?
 - Underlying conditions could include degrading infrastructure and interdependent systems that may have a common point of failure, aging workforce, lack of updated technology systems, diminished financial reserves, or competing priorities.
- What were your 2-3 most recent significant non-climate-related challenges (man-made or natural) within your business function?
- What non-climate-related risks (man-made or natural) are you preparing for into the future?
- Could climate change impact any of the non-climate-related risks?

3. LESSONS AND INSIGHTS FROM PAST EVENTS

- Based on your experiences, what have been the lessons relative to risk management learned to date?
- What lessons did you learn during COVID-19?
- What were your experiences and lessons learned when simultaneous events occurred in the past? (e.g., 2002 drought → fire → flood events)
- What do you wish you had in place now that you don't currently have to prepare for the future?

4. CLIMATE CHANGE DRIVERS, RISKS, AND IMPACTS

- Over the last 20 years, which impact(s) (acute and chronic) seem to have the most direct impact on your business function?
- What is the impact to assets and systems from floods, fires, extreme heat, extreme cold, or other climate drivers? Are there any constraints in the capability to respond?
- What new risks or opportunities emerged over the last 5-10 years that were not anticipated or planned for prior to 2020?
- What are the cascading impacts to your business function from these climate drivers?
- Are these cascading impacts affecting your operations, staffing, communication, ability to prepare and respond?
- In the event of an acute climate-related disaster, what plans do you have for maintaining critical work (e.g., communications, food, shelter and equipment for utility and mutual aid workers)? How long will these logistical support services or supplies last?

5. CLIMATE RISK MANAGEMENT AND ADAPTATION PLANNING

- How do you currently keep employees safe and healthy in extreme weather conditions, and how can you ensure continued health and safety as these conditions occur more frequently?
- What actions is your business function taking now to manage, mitigate, and adapt to the climate-related risks your business functions face today (both acute and chronic)?

- In terms of assets and systems to protect, how do you currently determine which are most important to prioritize and protect?
- What fire proofing measures have you implemented for facilities and properties owned by Denver Water?
- Have you experienced any impacts from climate-related events (acute or chronic) on your business functions financial performance?
- How are you managing financial and supply chain risks associated with water quality, water resource and availability, and/or purchasing goods and services?
- What opportunities do you see for enhancing resilience going forward?

6. CLIMATE CHANGE DATA, INFORMATION, TOOLS, AND PLANS

- What climate data, information, or tools do you currently use to help inform decisions related to your business function?
- What data, information, or tools don't you have currently that you think would be useful for your business function?
- What climate-related data or information, do you collector tools have you generated?
- What climate-related plans have you used to help inform decisions related to your business function?

7. COORDINATION WITH OTHER BUSINESS FUNCTIONS

- What do you need to know about the other utility business functions that would help you to manage climate-related risks and enhance resilience?
- What questions, climate-related or other, do you have for the other business functions in the room?

Module 2: Discussion Questions

Based on the information provided, participate in the discussion concerning the issues raised in this module. Identify any critical issues, decisions, requirements or questions that should be addressed.

1. UNDERLYING CONDITIONS

- What existing underlying conditions and vulnerabilities might be exacerbated by this scenario?
- What new underlying conditions and vulnerabilities might exist within your business function in this scenario (e.g., operations, workforce, finance, resources, technology)?
- How will climate change impact these new vulnerabilities?

2. CLIMATE CHANGE DRIVERS, RISKS, AND IMPACTS

- What climate change drivers might be of most concern to your business function in this scenario?
 - How does alternating between heatwaves and fires year-round impact your business function?
 - How does a wet spring and/or wet summer impact your business function?
 - What about a dry spring and/or dry summer?
- How will these conditions impact existing or new natural, built, and business infrastructure?
- How will these conditions impact your operations, staffing, communication, ability to prepare and respond in this scenario?
 - How do you currently keep employees safe and healthy in extreme weather conditions, and how can be ensure continued health and safety as these conditions become regular?
- What cascading impacts might keep you up at night in this scenario (by individual and business function)?
- What will be the impact on financial performance within your business function?
- Do funds currently exist to adapt to this type of future, or do funds need to be allocated/reserved for hazard mitigation, climate adaptation, or resilience?

3. CLIMATE RISK MANAGEMENT AND ADAPTATION PLANNING

- Are there current plans or processes that your business function has now that address the impacts discussed as a result of this scenario?
 - What redundancies do you need if there are multiple, simultaneous fires throughout the collection system in this scenario?
- What actions will your business function need to take in this scenario to manage, mitigate, and adapt to the climate impacts expected in this scenario (both acute and chronic)?
- What might be the impact on financial performance within your business function in this scenario?
- If there are limited financial resources due to the response to previous climate-related disasters, how can your business function prioritize funding?
- How do you currently keep employees safe and healthy in extreme weather conditions, and how can be ensure continued health and safety as these conditions become regular?
- Are there new technologies that will become available for water resource management that should be considered in budgeting and future planning?
- Are there behavioral changes that need to be taken into consideration to minimize the impacts to your business function in this scenario?
- What actions is your business function taking, or should be taken, to mitigate greenhouse gases.

4. CLIMATE CHANGE DATA, INFORMATION, AND PLANS

- What climate data, information, assessments, or plans do you need to help inform decisions related to your business function in this scenario?

5. COORDINATION WITH OTHER BUSINESS FUNCTIONS

- Is there capacity within your current teams to manage the challenges outlined in this scenario?
- Is there capacity or services you require outside of your business function but in another business function that you should collaborate or partner with to further assess and manage the challenges outlined in this scenario?
- What do you need to know about the other utility business functions that would help you to identify signposts/threshold conditions, manage climate-related risks, and enhance resilience in this scenario?

6. STAKEHOLDER COLLABORATION, COMMUNICATION, AND OUTREACH

- Are there partnerships your business function or Denver Water might want to more broadly explore to help address the gaps in capacity to manage these challenges?
- What external stakeholders do you need to collaborate with to advance risk assessment, management, adaptation, and resilience at various levels and scales (business function, water utility, city, county, state, national)?

Module 3: Discussion Questions

Based on the information provided, participate in the discussion concerning the issues raised in this module. Identify any critical issues, decisions, requirements or questions that should be addressed.

1. UNDERLYING CONDITIONS

- What existing underlying conditions and vulnerabilities might be exacerbated by this scenario?
- What new underlying conditions and vulnerabilities might exist within your business function in this scenario (e.g., operations, workforce, finance, resources, technology)?
- How will climate change impact these new vulnerabilities?

2. CLIMATE CHANGE DRIVERS, RISKS, AND IMPACTS

- What climate change drivers might be of most concern to your business function in this scenario?
 - How does alternating between floods and fires year-round impact your business function in this scenario?
 - How does a wet spring and/or wet summer impact your business function?
 - What about a dry spring and/or dry summer?
- How might these conditions impact existing or new natural, built, and business infrastructure?
- How might these conditions impact your operations, staffing, communication, ability to prepare and respond in this scenario?
 - How do you currently keep employees safe and healthy in extreme weather conditions, and how can be ensure continued health and safety as these conditions become regular?
- What cascading impacts might keep you up at night in this scenario (by individual and business function)?
- What might be the impact on financial performance within your business function?
- Do funds currently exist to adapt to this type of future, or do funds need to be allocated/reserved for hazard mitigation, climate adaptation, or resilience?

3. CLIMATE RISK MANAGEMENT AND ADAPTATION PLANNING

- Are there current plans or processes that your business function has now that address some of the challenges laid out in this scenario?
 - What redundancies do you need if there are multiple, simultaneous fires throughout the collection system?
- What actions will your business function need to take in this scenario to manage, mitigate, and adapt to the climate impacts expected in this scenario (both acute and chronic)?
- What might be the impact on financial performance within your business function in this scenario?
- If there are limited financial resources due to the response to previous climate events, how should you prioritize funding?
- Are there new technologies that have become available for water resource management that should be considered in budgeting and future planning?
- Are there behavioral changes that need to be taken into consideration to minimize the impacts to your business function in this scenario?
- What actions is your business function taking, or should be taken, to mitigate greenhouse gases.

4. CLIMATE CHANGE DATA, INFORMATION, AND PLANS

- What climate data, information, assessments, or plans do you need to help inform decisions related to your business function in this scenario?

5. COORDINATION WITH OTHER BUSINESS FUNCTIONS

- Is there capacity within your current teams to manage the challenges outlined in this scenario?
- Is there capacity or services you require outside of your business function but in another business function that you should collaborate or partner with to further assess and manage the challenges outlined in this scenario?
- What do you need to know about the other utility business functions that would help you to identify signposts/threshold conditions, manage climate-related risks, and enhance resilience in this scenario?

6. STAKEHOLDER COLLABORATION, COMMUNICATION, AND OUTREACH

- Are there partnerships your business function or Denver Water might want to more broadly explore to help address the gaps in capacity to manage these challenges?
- What external stakeholders do you need to collaborate with to advance risk assessment, management, adaptation, and resilience at various levels and scales (business function, water utility, city, county, state, national)?

MODULE 4: POTENTIAL SOLUTIONS

Module 4: Purpose

During this module, players will focus on identifying and prioritizing potential solutions related to risk management, adaptation actions, and mainstreaming resilience across the business functions and whole utility. Module 4 will begin with reflection and discussion of solutions identified in Modules 1, 2, and 3, and then transition to identify additional solutions. The players will consider pros and cons of the various solutions. Some solutions will be competitive – in terms of conflicting priorities or competing for resources – while others will be additive or complementary across the business functions. All solutions will be documented, and synergies will be identified, where applicable.

Once an exhaustive list of solutions has been identified, the players will discuss how to prioritize the solutions, with the anticipation of identifying 5-10 key solutions that the EPT may present to the Board of Commissioners as staff recommended ways **[INSERT WATER UTILITY NAME HERE]** can mainstream adaptation and resilience utility-wide.

Module 4: Discussion Questions

Based on the information provided, participate in the discussion concerning the issues raised in this module. Identify any critical issues, decisions, requirements or questions that should be addressed.

1. TOP RISKS TO NATURAL, BUILT, AND BUSINESS SYSTEMS (SUMMARIZE)

- What are the top climate risks to these natural, built, and business systems, and operational functions, including the ripple effects to other sections and divisions within the organization?
- How do we prioritize the most urgent risks that can be mitigated through proactive investments and commit to developing and investing in adaptation solutions?
- What risks cannot be mitigated and how do we commit to developing (emergency and systemic) preparedness and response protocols to enhance risk management and resilience?
- What are the critical signposts or early warnings needed to identify threshold conditions and/or determine the potential for risks to emerge?

2. SOLUTIONS NEEDED TODAY (2020), IN A WARMER SCENARIO, AND IN A HOTTER SCENARIO FUTURE

- What natural, built, and business solutions or opportunities should we advance to prepare for and adapt to these scenarios?
 - Climate mitigation
 - Hazard mitigation
 - Climate adaptation
 - Monitoring (including key threshold/signpost indicators)
- What are the costs and benefits (pros and cons) of these solutions?
- When should these solutions be implemented? Identify the dependency of solutions (mid-term goals may depend on the completion of short-term goals) and relationship to signposts.
- What do we need to start to get these solutions implemented (e.g., change current plans or create a new plan, practices, decision processes, or policies)?
- What solutions are robust and work to meet the needs of multiple functions and other co-benefits?
- How do we prioritize these solutions or align them with current priorities?
- What internal and external partnerships do we need to form to share the risk and could contribute in proactive investments in solutions?
- What actions can you undertake to incorporate climate change and the results of this TTX into current and future plans, practices, decisions, and financial investments?
- How should you monitor and track the actions taken to implement these solutions?
- What resources and funding are needed to implement these actions?
- How should resilience be mainstreamed into your business functions?
- How can/should you integrate climate change into internal messaging? Into external messaging?

3. BARRIERS TO ACTION

- What barriers and opportunities exist to advance the solutions needed? For example, new design standards, partnerships that need to be built, policy changes, new funding sources or mechanisms, staff training, collective action, R&D (science, technology), strategic hires, staffing needs (addressing aging workforce).
- What hard discussions and decisions need to be collaboratively discussed now as it relates to implementing these solutions?
- What climate risks and impacts might you not be able to manage or minimize?

4. NEXT STEPS

- How should we communicate about the outcomes of this TTX?
- What business functions would you recommend be assessed next (e.g. human resources, emergency response planning, engineering)?
- What is your assessment (evaluation) of the quality of the exercises? How could this exercise could have been planned for and conducted better?
- What three things will you bring to your work and/or team, or take action on after participating in the exercise?
- What was the most notable thing you learned from another business function during this TTX?

APPENDIX 2: VIRTUAL TTX AGENDA



Mapping Climate Risks and Opportunities to
Critical Water Utility Business Functions
Denver Water Tabletop Exercise

VIRTUAL TABLETOP EXERCISE (TTX) JULY 7, 8 & 14, 2020

AGENDA DAY 1: TUESDAY, JULY 7TH

Focus: Map climate risks, impacts, and opportunities across core business functions for Module 1.

10:00 AM	Welcome Introductions Review of Agenda
10:15 AM	Exercise Background Overview of Guidelines and Structure
11:00 AM	Situation Overview
11:30 AM	LUNCH BREAK
12:30 PM	Module 1
2:45 PM	Wrap up and preview Day 2
3:00 PM	Adjourn

AGENDA DAY 2: WEDNESDAY, JULY 8TH

Focus: Map climate risks, impacts, and opportunities across core business functions for Modules 2 and 3.

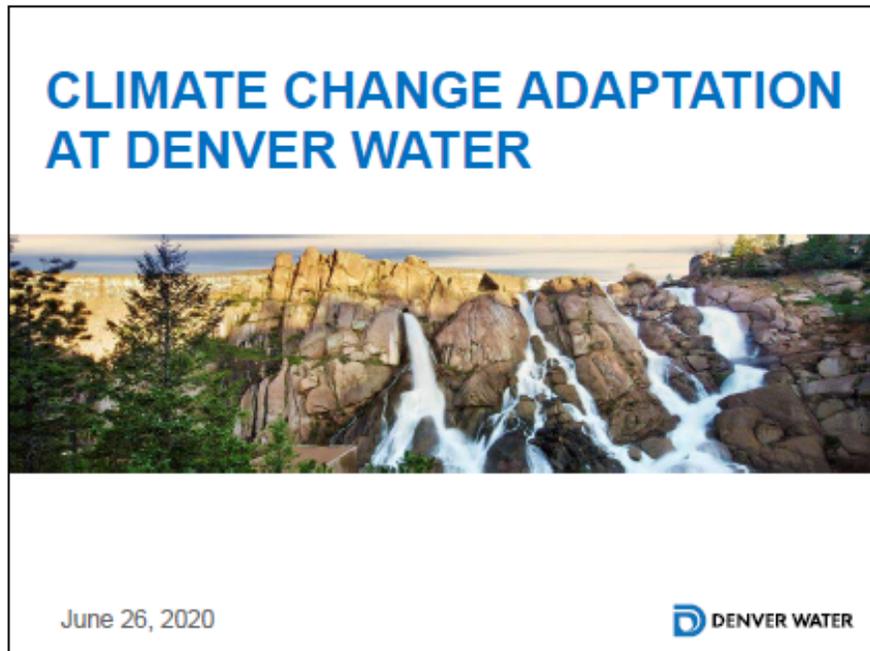
9:30 AM	Welcome Review of Agenda Summary of Module 1 Discussion
10:00 AM	Module 2
12:00 PM	LUNCH BREAK
1:00 PM	Module 3
3:15 PM	Wrap up and preview Day 3
3:30 PM	Adjourn

AGENDA DAY 3: TUESDAY, JULY 14TH

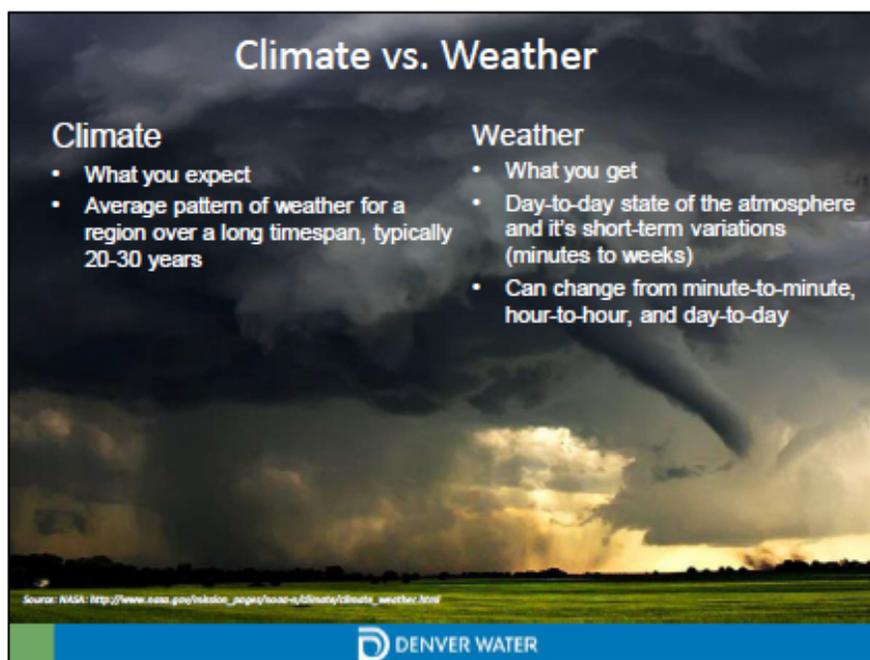
Focus: Use Module 4 to identify and prioritize potential solutions related to risk management, adaptation actions, and mainstreaming resilience utility-wide and across business functions.

1:00 PM	Welcome Review of Agenda Summary of Discussions from Modules 1-3
1:30 PM	Module 4
3:30 PM	Summary and Next Steps
4:00 PM	Adjourn

APPENDIX 3: CLIMATE 101 PRESENTATION



1



2

**A baseball player at bat is like the weather
and their career statistics are like climate**



 DENVER WATER

3

Climate vs. Weather

<p>Climate</p> <ul style="list-style-type: none"> • What you expect • Average pattern of weather for a region over a long timespan, typically 20-30 years 	<p>Weather</p> <ul style="list-style-type: none"> • What you get • Day-to-day state of the atmosphere and it's short-term variations (minutes to weeks) • Can change from minute-to-minute, hour-to-hour, and day-to-day
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Climate Change

- Long-term changes in local, regional, or global climate
- e.g., warmer, cooler, wetter, drier, etc.

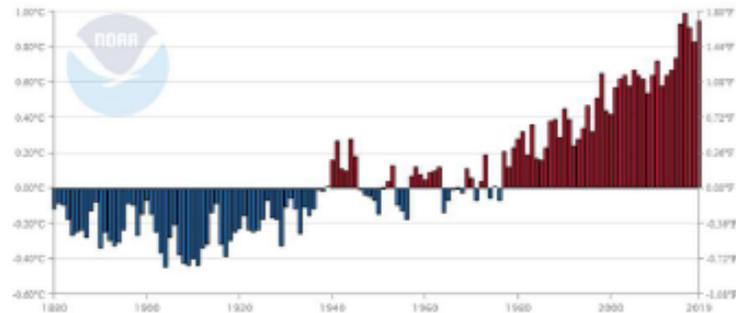
Source: NASA: http://www.nasa.gov/mission_pages/earth/earth-science/Climate_weather.html

 DENVER WATER

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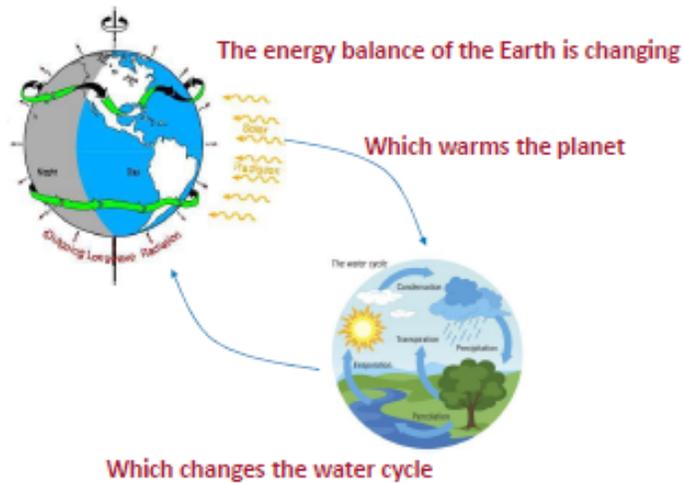
Climate Change is Here and Now

Global Land and Ocean
January–December Temperature Anomalies



5

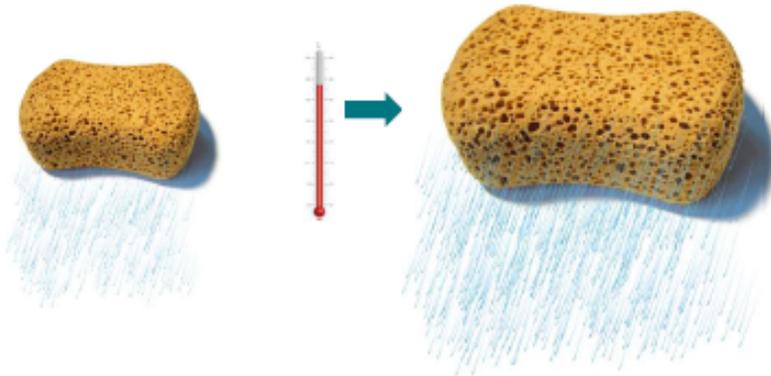
Water Cycle and Climate Cycle



6

6

Warm air holds more moisture than cold air.
"Atmospheric holding capacity"



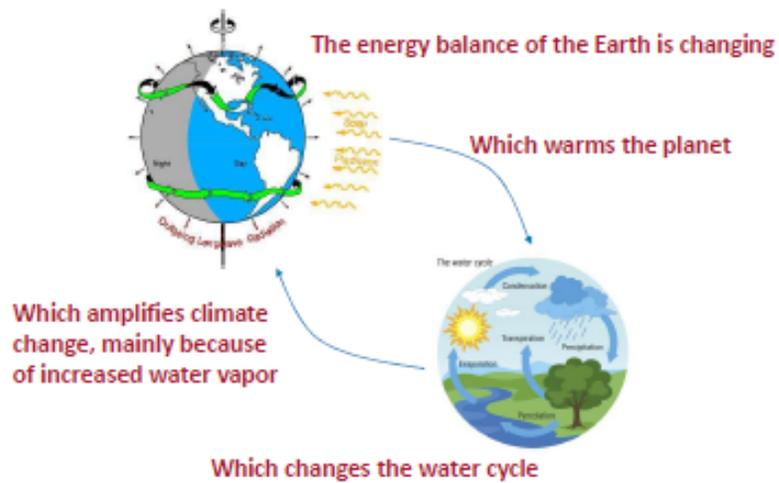
Source: Principles from the Water Research Foundation Project 4381, Effective Climate Change Communication for Water Utilities



7

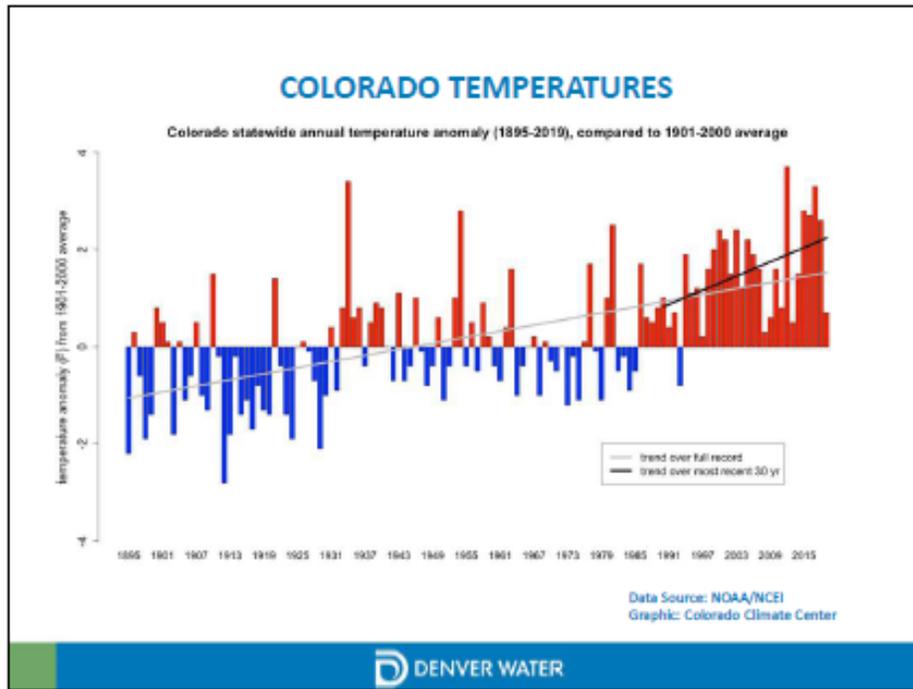
Climate change is water change

Water Cycle and Climate Cycle

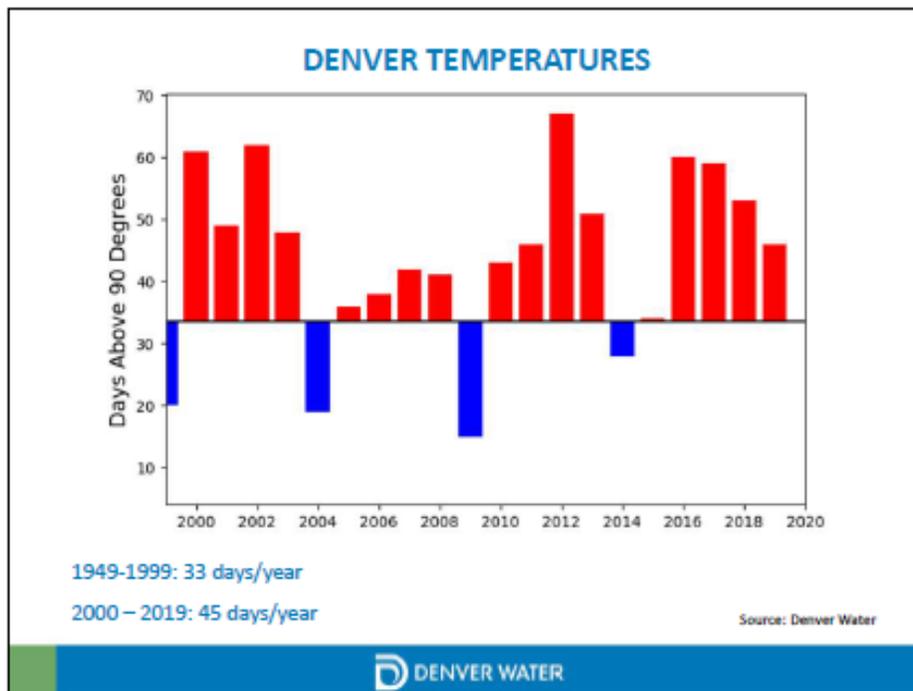


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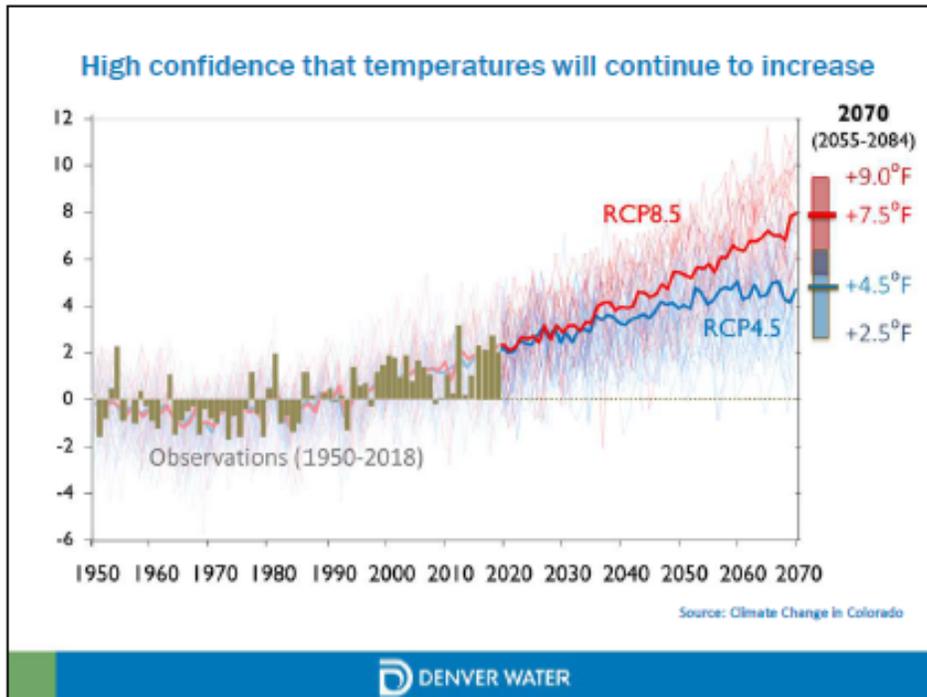
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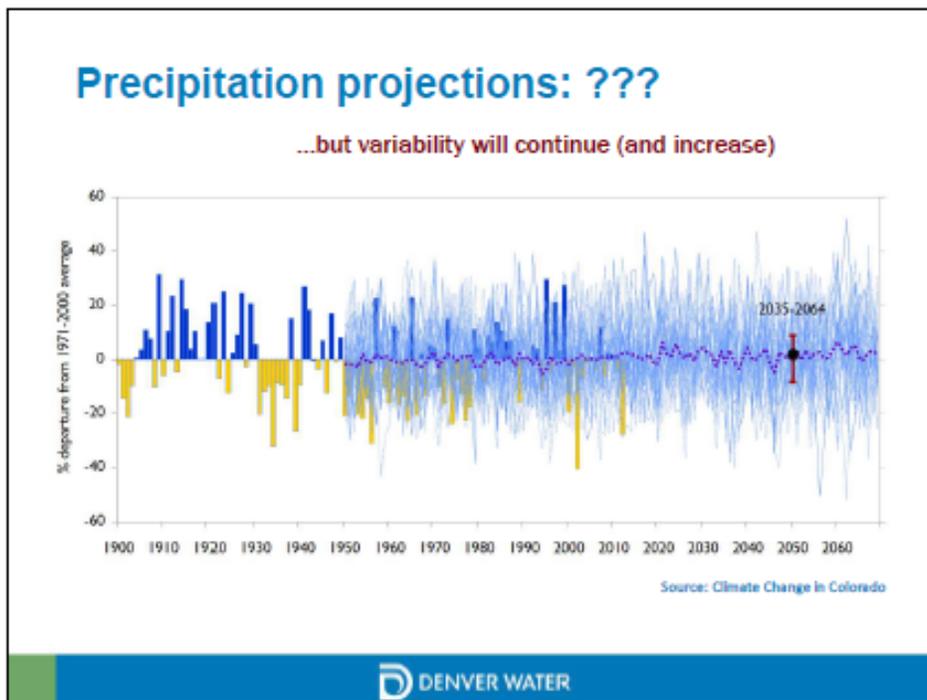
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10



11



12

Projected impacts from warming

Warming has an overall drying effect

- Snow and Snowpack
- Run-Off
- Droughts and Floods
- Extreme heat/heat waves
- Extreme precipitation
- Frost-Free Season
- Evaporation
- Soil Moisture
- Wildfires
- Vegetation
- Water Quality Degradation



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 DENVER WATER

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HOW CAN CLIMATE CHANGE IMPACT DENVER WATER?

 DENVER WATER

14

Customer Water Use

Customers use water in so many ways – watering lawns, taking showers, flushing toilets, cleaning dishes, running swamp coolers, and of course, drinking and cooking. Firefighters depend on water; parks and athletic fields are irrigated with water; and many industries use water, including power plants that use water for cooling. How might climate change alter how water is used?



15

Water Quality

Water quality includes water temperature, water chemistry, and can be impacted by nutrients or the amount of time water spends in pipes. How might climate change impact water quality?



16

Field Staff

Many Denver Water staff members work outdoors. What outdoor working conditions might be faced in the future? How can we prepare in advance to avoid injuries?



17

Finance

Denver Water is funded from the sale of water to Denver and suburban customers, tap fees, and issuing bonds. How might climate change impact Denver Water's finances? How can we prepare for this?



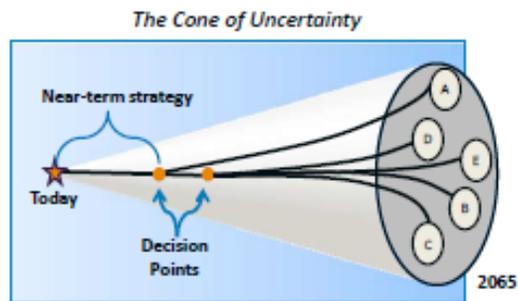
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CLIMATE CHANGE ADAPTATION AT DENVER WATER



19

SCENARIO PLANNING



20

DIVERSIFYING WATER SUPPLY

The collage features four distinct images: a dam with water behind it, a map of the Denver water system with blue arrows indicating 29% and 80% diversification, a photo of a boat on a river with a large amount of debris, and a photo of a worker in a safety vest.

DENVER WATER

21

WATERSHED MANAGEMENT

A landscape photograph showing a watershed area with a lake, green hills, and mountains under a blue sky with clouds.

DENVER WATER

22

PLANNING FOR HEAT STRESS

Assets



Field Staff



23

Business Function Mapping

Water Treatment

Water Distribution

Watersheds

Finance



**Climate change
impacts? Adaptation
solutions?**



24

YOU CAN HELP!

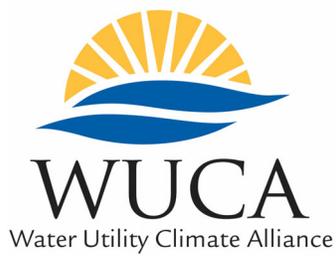
Take home messages:

- Climate change is here and now
- Climate change is water change
- Climate change impacts all areas of Denver Water
- We are actively preparing
- WE NEED YOUR HELP



"All I'm saying is now is the time to develop the technology to deflect an asteroid."
source: The New Yorker





WUCA's mission is to collaboratively advance water utility climate change adaptation

www.wucaonline.org