WUCA
Water Utility Climate Alliance

Leading Practices in Climate Adaptation

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PREPARED BY WUCA'S LEADING PRACTICES COMMITTEE:

Laurna Kaatz, *Project Lead, Denver Water, WUCA Past Chair*
Julie Vano, *Research Lead, Aspen Global Change Institute*
Heather Dalrymple and Marisa Flores-Gonzalez, *Austin Water*
Mohammed Mahmoud, *Central Arizona Project, WUCA Chair*
Jennifer McCarthy, *Metropolitan Water District of Southern California*
Alan Cohn, *New York City Department of Environmental Protection*
Abby Sullivan and Julia Rockwell, *Philadelphia Water Department*
Kavita Heyn, *Portland Water Bureau, WUCA Vice Chair*
Seevani Bista and Goldamer Herbon, *San Diego County Water Authority*
David Behar, *San Francisco Public Utilities Commission*
Danielle Purnell and Ann Grodnik-Nagle, *Seattle Public Utilities*
Keely Brooks, *Southern Nevada Water Authority*
Tirusew Asefa, *Tampa Bay Water*

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executive summary

While water utilities are highly adept at understanding and mitigating uncertainty, climate change enhances current challenges and adds new risks to already complex utility practices. Climate adaptation requires working across business functions and organizational silos, necessitating more integration and new tools. It benefits from collaboration across sectors, including businesses and suppliers, and among the utility, the city, and the region. Developing new approaches is not easy—nor is the work straightforward—yet **there is an incredible power in learning from and with each other**.

For more than 10 years, the Water Utility Climate Alliance (WUCA) has been at the forefront of strengthening the field of climate adaptation. WUCA members have uncovered ways to build adaptive capacity and incorporate new climate science into water management, planning, investments, and actions. To share what worked, WUCA has compiled climate adaptation practices that have been tested, leveraging WUCA members' experiences to build a shared knowledge base and illustrate not-always-clear directions forward. The goal is to make approaches for successful climate change adaptation easier to discover, understand, and navigate, and to help other utilities avoid having to recreate the wheel or invest in unnecessary efforts, thus saving time and money.

This collection of **leading practices in climate adaptation** covers a suite of climate adaptation actions and is intended to broadly promote collaborative learning. Each practice in the collection is explained and supported by concrete examples. These practices are drawn from WUCA work products and WUCA members' experiences, and, when possible, connected to relevant resources and related efforts. Most of these practices are appropriate for water utilities of any size, as well as other sectors interested in climate adaptation.

The five essential climate adaptation actions that underpin the leading practices

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Many participants at WUCA utilities also engaged in conversations that helped WUCA's Leading Practices Committee form the foundation of this report and added important details. We are grateful for their contributions.

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introduction


SOURCE: WUCA

This report shares leading practices in water utility climate adaptation based on practical experience from Water Utility Climate Alliance (WUCA) members.

For more than 10 years, WUCA has been at the forefront of strengthening the field of climate adaptation. WUCA members have uncovered ways to build adaptive capacity and incorporate new climate science into water management, planning, investments, and actions. WUCA's experience comes from the cutting-edge activities and products developed by the Alliance's 12 utility members from across the United States, who represent a range of decision-making processes, risk profiles, utility sizes, and geographical contexts, as well as from WUCA's collaborative action as an alliance. WUCA members' experiences are deeply rooted in a willingness to innovate and learn from what works and, importantly, what does not. Through sustained effort and supportive peer learning, the collective experiences of WUCA members offer practical paths forward to develop and implement climate change adaptation actions more effectively.

This report describes a two-year effort to compile tested climate adaptation practices that leverage WUCA members' experiences, building a shared knowledge base and illustrating not-always-clear directions forward. The goal is to make approaches for successful climate change adaptation easier to discover, understand, and navigate, and to help other utilities avoid having to recreate the wheel or invest in unnecessary efforts, thus saving time and money.

This collection includes examples from each WUCA member utility, highlighting what worked for them and providing others an opportunity to learn from and build on the Alliance's in-the-field experiences. Many current leading practices were tried after other ideas and approaches did not work. When possible, the examples in this collection provide information about how these approaches have evolved to date, with an expectation that they will continue to evolve with time.

Location of WUCA member utilities. All 12 participated in the Leading Practices in Climate Adaptation Project.

Five essential climate adaptation action areas. Actions complement each other and can be done in any order, or simultaneously, depending on your needs and resources.

CLIMATE ADAPTATION ACTIONS

From its inception, WUCA has sought to advance water utility adaptation through projects that employ or develop the best available science, both to understand how climate change will impact water utilities in the future and develop water system strategies to prepare for these impacts. Through this process, WUCA's understanding of meaningful climate adaptation has been transformed over the last decade. Specifically, a deeper, more nuanced understanding of how to successfully achieve comprehensive adaptation has emerged.

WUCA's broader and more comprehensive understanding of adaptation was sparked by years of experience gained by:

- Projects and risk assessments (e.g., WUCA's Piloting Utility Modeling Applications (PUMA) projects);
- Information sharing with peers and partners (e.g., WUCA's Climate Resilience training);
- General advances in climate science and climate resiliency approaches;
- Embracing climate change as a deep uncertainty, (e.g., WUCA white papers: Embracing Uncertainty and Decision Support Planning Methods); and
- Work with key partners in the adaptation field.

For WUCA, climate adaptation now includes a full suite of actions that involve building institutional capacity, assessing climate vulnerability and risks, planning for multiple futures, communicating effectively, making investments, financing and sustaining new organizational initiatives or programs, and more. To establish a common understanding of the range of what climate adaptation entails, WUCA's Leading Practices Committee developed five essential climate adaptation actions (above), the foundation upon which individual leading practices are built and organized.

If progress is slow in some action areas, it may be useful to think more broadly and find support and potential for progress elsewhere, which may break gridlock in unexpected ways.

These five essential climate change action areas can help utilities effectively navigate to practices most relevant to where they are and prioritize their next steps, whether engaging people, understanding climate science and the utility system, planning for future change, acting by implementing changes, or sustaining adaptation efforts. The actions are illustrated as a wheel as there is no beginning or end, and all actions are connected. Typically, efforts move clockwise, although the Alliance does not intend to portray this as an ordered cycle and encourages thinking about all five action areas simultaneously. Certain actions may be more relevant than others at a given time, depending on utility-specific circumstances. If progress is slow in some action areas, it may be useful to think more broadly and find support and potential for progress elsewhere, which may break gridlock in unexpected ways.

How to start?

Climate change actions are iterative, yet some sequencing is important if you are just beginning. To get started, consider the following three steps:

1. Focus on UNDERSTAND Leading Practices. Understanding is foundational to all climate adaptation work, specifically:
   - Know your water system,
   - Foster sustained relationships with the climate science community, and
   - Know your past climate conditions.
2. Explore your system's vulnerability to a warming climate by asking, "What does warming mean to supply, demand, quality, assets, and key utility functions?" This simple, yet scientifically robust question begins an informative dialogue, creates a critical understanding of system vulnerabilities, helps prioritize initial work, and avoids an often expensive and debilitating assessment rabbit hole.
3. Develop and document a common understanding of your organization's needs, priorities, and vision regarding climate adaptation. This can then be connected to strategic goals and plans (see examples in PLAN: Connect with ongoing or upcoming planning processes).

See WUCA webpages for more, e.g., practical considerations shared during a WUCA Climate Resilience training.

LIVING, LEARNING, LEADING PRACTICES

The term "leading practices" recognizes that climate adaptation is a learning process. Over time, the Alliance expects new practices will emerge and move to the forefront, while some previously leading practices will fall away or change. Leading practices are designed to be:

Living: This work exists as a living document, to be revised as knowledge of climate adaptation, decision science, and climate science evolves. The Leading Practices Collection is housed on an easy-to-navigate website: www.wucaonline.org/adaptation-in-practice/leading-practices and will be periodically updated. To do this effectively, the leading practices are modular and can be easily amended (or removed).

Learning: The Alliance shares these practices to facilitate greater discussion and to provide a structure and platform to encourage other utilities and adaptation professionals to share what has worked well (see learning-sharing worksheet). The Alliance invites feedback and additions from its members and from the broader adaptation community.

Terminology

action areas: WUCA's leading practices are organized into the following categories, called "action areas": ENGAGE, UNDERSTAND, PLAN, IMPLEMENT, and SUSTAIN

adaptive capacity: The ability of a system or organization to adjust to change effectively, taking advantage of potential opportunities and moderating negative impacts

climate adaptation: Preparatory actions taken to reduce anticipated negative impacts of climate change like temperature increases, reduced snowpack, and sea level rise

climate resilience: The capacity to anticipate, prepare for, respond to, and recover from harmful events caused by disturbances related to climate change

deep uncertainty: Deep uncertainty occurs when the parties to a decision do not know or do not agree on the likelihood of alternative futures or how actions are related to consequences. Learn more: www.deepuncertainty.org

leading practice: A practice (there are currently 39) endorsed by WUCA member utilities, defined by short statements (page 9), and supported by examples and resources in the online collection

One Water: An approach that encourages more holistic management of water within a specific region, including drinking water, wastewater, stormwater, and greywater

mainstreaming: Incorporating climate adaptation and climate resilience thinking into regular organizational activities

risk: Exposure to danger, harm, or loss that involves threat to life, health, safety, the environment, and/or system operations

the leading practices collection

The Leading Practices Collection is introduced below as 39 leading practices. Each practice is placed within the five essential climate adaptation action areas. Several practices fit under two actions and are noted as such. More details and related resources for each practice are available at www.wucaonline.org/adaptation-in-practice/leading-practices, a platform designed for easy navigation and updating.

Action areas and leading practices are not prioritized. Instead, the most useful practices depend on the individual organization's needs and priorities.

ENGAGE

- Recognize many ways to motivate climate adaptation action
- Seek out and support climate champions throughout your utility
- Consult expertise throughout your utility regularly and with purpose
- Tailor the climate adaptation message for the intended audience
- Develop a climate communications plan
- Include equity from the beginning
- Make the business case for climate adaptation

UNDERSTAND

- Invest in understanding climate science
- Explore how extremes might change in the future
- Value simple vulnerability assessments
- Foster sustained relationships with the climate science community
- Know your water system
- Think broadly about climate impacts
- Be a savvy consumer: recognize values and limits of climate science in practice
- Know your past climate conditions
- Recognize the value of long-term monitoring

PLAN

- Connect with ongoing or upcoming planning processes
- Leverage the power of well-placed climate change screening questions
- Be prepared to be changed by the process
- Learn from earlier climate change planning efforts
- Develop tools that allow information customization
- Leverage existing funding mechanisms
- Take on climate change as another component of risk management
- Plan for a range of futures, not a single future
- Employ decision-making science and deep uncertainty concepts
- Build and maintain in-house capacity

IMPLEMENT

- Be prepared to act when opportunities arise
- Find co-benefits and no- and low-regret adaptation strategies
- Recognize some adaptations can be employed quickly
- Recognize smaller changes can lead to bigger ones
- Focus on your organization's core responsibilities first
- Enact incentives or policies that change behavior
- Enact changes in infrastructure and operations

SUSTAIN

- Make the business case for climate adaptation
- Leverage existing funding mechanisms
- Monitor and evaluate current conditions
- Approach climate adaptation through mainstreaming
- Avoid new climate science whiplash
- Keep moving forward, even if it feels slow
- Value climate adaptation as more than a plan
- Establish a community of practice to integrate climate change adaptation
- Build and maintain in-house capacity
- Seek out and support climate champions throughout your utility

COMPOSITION OF PRACTICES

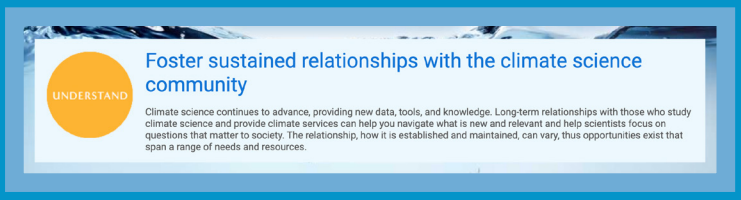
By design, these practices are short and modular so they can be easily sorted and added to (or removed) as understanding of climate science, decision science, and climate adaptation within utility practices grows and evolves.

The leading practice collection is designed to serve as a platform for effective, solution- and action-based knowledge exchange and refinement as experience teaches us what is—and what is not—effective.

Each leading practice is defined by a 1-3 sentence description. These short statements articulate recommended practices common across utilities and reflect WUCA utilities' ongoing experiences. These practices generally fall under a particular action area within the collection of climate adaptation. However, several fit in multiple action areas (e.g., *Make the business case for climate adaptation* is under **ENGAGE** and **SUSTAIN**).

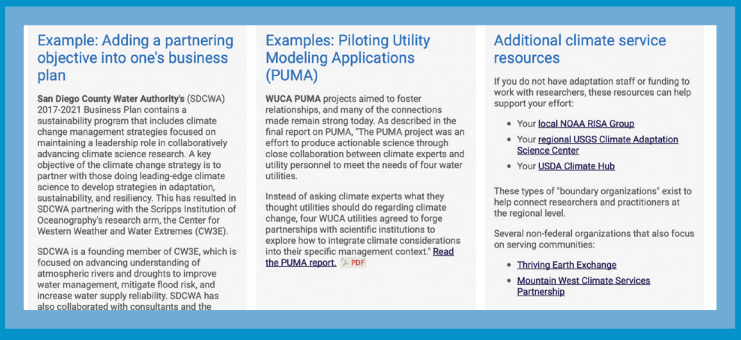
Each leading practice is supported by short utility-based examples; most include pointers (usually links) to additional information and resources that support the work. Most utility-specific examples support a particular leading practice, although some examples support more than one practice, and are linked accordingly. With time, more examples and resource links can be added. This design allows those seeking information to more easily identify adaptation actions they want to explore and find relevant examples more quickly. It also provides a structure to organize diverse actions that could help a utility track its collective efforts over time (e.g., in one year, a utility's actions could be focused in **UNDERSTAND**, in the next year, new efforts could be focused in **ENGAGE**).

Composition of a Leading Practice



Circle and color indicate the action area the leading practice fits within

1–3 sentence description of leading practice, common across utilities



EXAMPLES: Examples from individual utilities, 1–2 paragraph explanation and links to additional information, the number of examples vary between practices

ADDITIONAL RESOURCES: Related leading practices, links to similar efforts or educational materials, and contact information (not included for all practices)

SOURCE: www.wucaonline.org/adaptation-in-practice/leading-practices

TYPES OF PRACTICES

Two types of practices can support adaptation: (1) adaptation-specific practices and (2) useful business practices. Many things necessary for successful adaptation are also useful business practices that are, hopefully, already encouraged or in place in your organization. To date, this collection largely focuses on adaptation-specific practices, though some align closely with best business practices. For example, making the business case for future investments and having a communications plan are examples of best business practices that should be used to support climate adaptation, while understanding and recognizing the limits of climate science in practice are specific to climate adaptation. This difference, while acknowledged, is not yet distinguished in the leading practice descriptions.

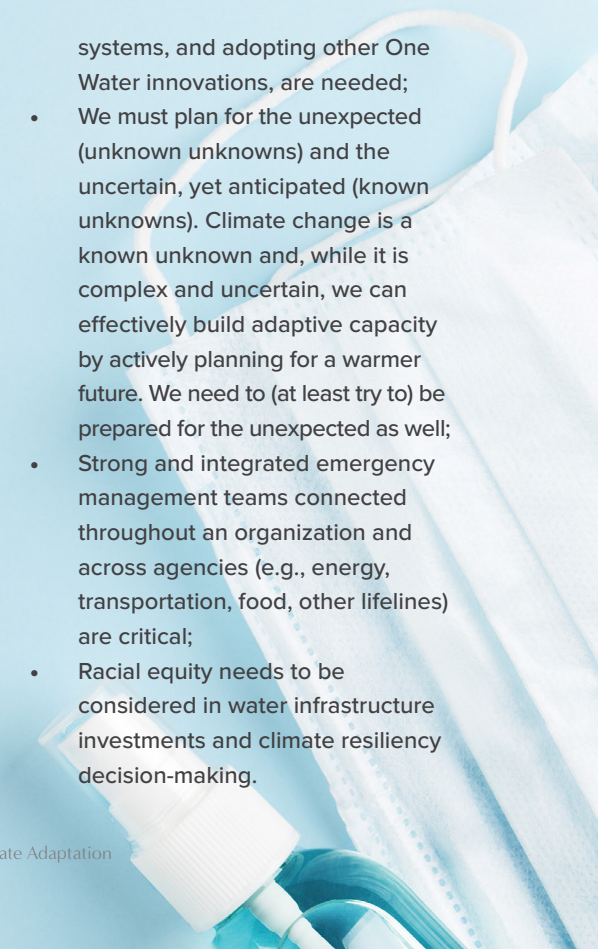
Through experience, WUCA members have also increasingly seen how climate change work can inform existing business practices. This includes opportunities to mainstream climate change work, including it within existing business functions; see PLAN: Take on climate change as another component of risk management for examples. WUCA members have also found that grappling with climate change can inspire new ways of thinking about how your organization plans; see PLAN: Be prepared to be changed by the process.

Most leading practices to date are focused on climate change adaptation, but conversations about climate change emissions are becoming more common. In some cases, climate change adaptation can be energy intensive, negatively impacting mitigation. However, there are possible synergies between adaptation and mitigation as well. Future leading practices will likely include considerations of both climate adaptation and mitigation.

Leading practices in the context of 2020–2021 events

Marked by social unrest, wildfires and storms, and COVID-19, the past year has been a time of uncertainty like no other. The current public health crisis provides an analogy for climate uncertainty, in that it demonstrates the challenges of planning for an unpredictable future. In this past year, WUCA members have recognized and continue to learn many climate adaptation-related lessons, including elevated awareness that:

- We will not go back to "normal";
- We must prepare for new and ongoing emergencies; there is no "one and done";
- We must prepare for compound events (e.g., multiple stressors or events occurring simultaneously, like a pandemic and wildfires or droughts);
- Climate change will manifest in many different ways and is a threat multiplier;
- Understanding and accepting facts and science can guide effective actions – but, as seen with both COVID and climate change, there may be resistance;
- New and resilient solutions, such as adding decentralized portable and wastewater systems to centralized systems, and adopting other One Water innovations, are needed;
- We must plan for the unexpected (unknown unknowns) and the uncertain, yet anticipated (known unknowns). Climate change is a known unknown and, while it is complex and uncertain, we can effectively build adaptive capacity by actively planning for a warmer future. We need to (at least try to) be prepared for the unexpected as well;
- Strong and integrated emergency management teams connected throughout an organization and across agencies (e.g., energy, transportation, food, other lifelines) are critical;
- Racial equity needs to be considered in water infrastructure investments and climate resiliency decision-making.



This section introduces all the leading practices to date. The examples that follow were selected to illustrate the diversity of climate adaptation opportunities, not to prioritize them. Browse this list and use the links (if viewing online) to go directly to the practices. You can also easily navigate to any practice at www.wucaonline.org/adaptation-in-practice/leading-practices. The online Leading Practices Collection provides over 70 examples along with a wealth of resources that allow you to learn from and leverage others' work.

ENGAGE

Well-thought-out communication and engagement plans result in more effective, successful, and supported adaptation. Climate adaptation often requires field building and change management. As such, engaging internal and external stakeholders (two-way communication, listening and sharing) to motivate action, connect with and support others, and develop climate messages can go a long way toward making your adaptation efforts successful.

ENGAGE: Recognize many ways to motivate climate adaptation action. Many things can motivate investment in climate adaptation, including climate champions, natural disasters or crises, peer and public pressure, personnel changes, personal observations of change, and access to new knowledge. Leverage the motivational opportunities that fit your circumstances. Learn more how natural disasters changed how Denver and Austin now plan, and how a climate summit motivated WUCA's formation.

Important lessons for effective engagement:

- Have well-organized information for people to react to.
- However, do not wait for the analysis to be perfect—share what you have along the way.
- Strike the right balance between reaching out to staff and respecting their time.

ENGAGE: Consult expertise throughout your utility regularly and with purpose. Adapting to climate change requires diverse expertise and broad participation, both of which can be gained by consulting others throughout your organization. The type of engagement that works best varies depending on an organization's culture, but a little forethought and some regularity can go a long way (e.g., begin with listening and ask what matters). See how Southern Nevada and Philadelphia learned how to do this better.

ENGAGE | SUSTAIN: Seek out and support climate champions throughout your utility. Progress happens more quickly with the support of motivated individuals who value and prioritize climate adaptation work, including executive-level leaders. It is therefore important to build relationships with and educate champions who can influence climate adaptation actions, then help sustain and strengthen those efforts. Having champions across an organization (in planning, engineering, finance, public relations, and other roles) can contribute diverse expertise and resources and help provide institutional memory as individuals' roles change. Learn more about how Austin, Central Arizona (below), Denver, and Philadelphia identified, educated, and supported their climate champions.

One key to successful communication is knowing your audience(s) and framing your message so it has meaning and value to them.

SOURCE: CAP

EXAMPLE: Building a cross-functional team of champions

The Central Arizona Project (CAP) climate adaptation plan was developed with an education and engagement mindset, which elevated existing and promoted future climate champions throughout the organization. Key to the development of the plan was the active participation of a cross-functional team of internal experts comprising all of CAP's climate-sensitive functions, including water policy, operations and engineering, maintenance, public affairs, technology, legal services, finance and administration, and employee services. The team collaboratively identified implications of climate change for CAP's functions as well as all components of the CAP climate adaptation plan. This approach helped foster climate champions in each of CAP's organizational functions by actively educating and engaging them in the climate adaptation process. It also gave members of the CAP team ownership in addressing CAP's climate challenges.

ENGAGE: Tailor the climate adaptation message for the intended audience. One key to successful communication is knowing your audience(s) and framing your message so it has meaning and value to them. A climate adaptation message that resonates with one individual or group might not "land" with others. Identifying which messages work best is time well spent. Learn more online about simple, clear messages that have worked well for WUCA, including Philadelphia's messages for engineers (page 15) and Portland's and Central Arizona's focus on climate impacts. Also online is an abundance of resources for how to improve your utility's climate change communication.

ENGAGE: Develop a climate communications plan. Taking time to consider how climate change information and adaptations strategies are communicated both internally and externally can help motivate action and avoid conflict or confusion. Learn more about Philadelphia's internal and external climate communication plans.

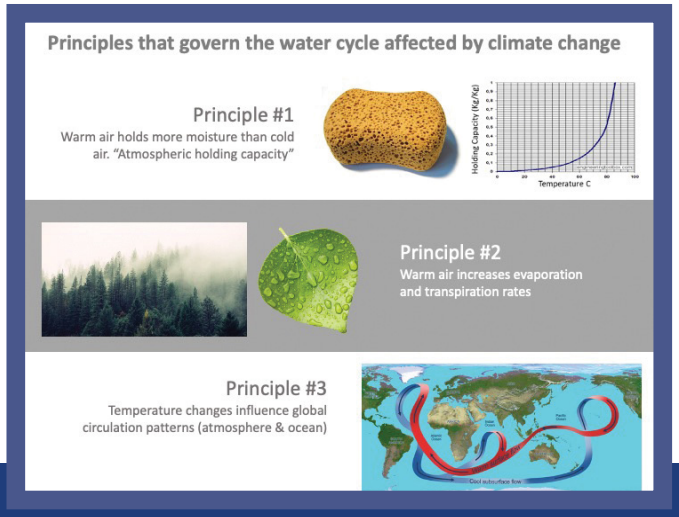
ENGAGE | SUSTAIN: Make the business case for climate adaptation. Improving resiliency takes time and resources but can also save time and resources. Transparency about financial elements, including tradeoffs in costs and other triple-bottom-line benefits — social, environmental, and financial — can motivate action and demonstrate how adaptation investments can save money in the long run. This helps engage people from the beginning and sustain the effort. Learn how New York City (page 29) and San Diego have made the business case for climate adaptation.

MESSAGES THAT RESONATE:

ENGAGE: Include equity from the beginning. Effective solutions to climate change challenges depend on many factors, all of which might not be clear at the onset. Engaging and focusing on the needs of communities, particularly those most vulnerable to disruptions caused by climate impacts, is best done at the beginning and throughout a project. By improving conditions for the most vulnerable in your community, you also improve conditions for everyone. Learn more how Seattle and Portland elevated communities and equity in their planning efforts.

"It was important to engage with champions throughout the organization to understand their day-to-day challenges, what regulations or departmental objectives drive their work, and what is valued within their program or unit."

– Julia Rockwell, *Climate Change Adaptation Program Manager Philadelphia Water Department*



An example slide used to communicate to engineers the ways climate change is impacting the water cycle. SOURCE: *Water Research Foundation*

EXAMPLE: Messages that resonate with engineers

When the Philadelphia Water Department (PWD) Climate Change Adaptation Program (CCAP) was ready to share information and results from risk assessments internally, success—i.e., whether climate information would eventually be adopted within existing planning, design, and asset management processes —hinged on good communication. For example, when sharing information with engineers who work on long-term infrastructure plans, CCAP first explained how climate change is altering the water cycle and how climate non-stationarity might challenge standard engineering practices, procedures, and tools. Engineers are used to working with return intervals and other statistical tools to inform infrastructure plans and designs, so it was essential to explain that climate change means that the tools typically relied on may not be the best approach moving forward. It was also essential to convey that the CCAP team is available to help PWD staff tackle these challenges.

UNDERSTAND

Understanding is continuous and foundational to climate adaptation work. Knowing more about climate change science, how your system functions along with its underlying conditions and key vulnerabilities, provides valuable context to assess future risks and opportunities for adaptation actions. Leading practices in the UNDERSTAND action area, introduced below, illustrate ways to facilitate better understanding. Find more examples and supporting resources: www.wucaonline.org/adaptation-in-practice/leading-practices/understand.html or links below.

UNDERSTAND: Invest in understanding climate science. Climate change impacts to a water system vary considerably depending on where the system is located, how it is built and operated, and how far into the future impacts are considered. Investing the time and resources to understand the capabilities and limitations of climate science yields insights into how science should be applied and how climate change will impact your utility and provides a foundation for planning and preparing for those impacts. Learn from examples from New York City and San Diego and about Climate Resilience trainings WUCA offers.

UNDERSTAND: Explore how extremes might change in the future. Annual and long-term (e.g., 30-year) averages and trends are common in climate change impact assessments, while extremes like hurricanes and rapid-onset droughts, which are more challenging to simulate and less certain, are under-reported in assessments and reports because extremes are difficult to model. Considering how extremes could change gets people thinking outside of what is "normal" and helps them think through what-if scenarios. Learn how Tampa Bay is thinking about weather whiplash.

UNDERSTAND: Value simple vulnerability assessments. Exploring how a simple change in temperature and precipitation impacts water utility resources and functions offers a low-cost, quick, and informative mechanism to better understand system vulnerability. Simple assessments provide knowledge and help utilities gain insights necessary to build adaptive capacity. Learn about the assessment Denver and other communities on the Front Range did, and how it changed their thinking.

UNDERSTAND: Foster sustained relationships with the climate science community. Climate science continues to advance, providing new data, tools, and knowledge. Long-term relationships with those who study climate science and provide climate services can help you navigate what is new and relevant and help scientists focus on questions that matter to society. The relationship, how it is established and maintained, can vary; learn more from examples from Tampa Bay (below), San Diego, and others and about opportunities that span a range of needs and resources.

UNDERSTAND: Think broadly about climate impacts. Climate change is a risk multiplier that will create new, unexpected challenges. Utilities often focus on water quantity, but many other factors can affect water supply and public safety, including how extreme storms, flooding, sea level rise, extreme heat, extreme drought, low snowpack, fire, smoke, and wind might impact water quantity, water quality, health and safety, risks to assets and built infrastructure, treatment processes, financial risks, etc. These can also cause other cascading impacts. Learn about how Southern Nevada, New York City, Philadelphia, and Portland have rethought workforce health, power loss, wastewater treatment, and more.

End-to-end system knowledge lets you more effectively identify and evaluate climate risks and cascading implications as well as identify adaptation solutions that are informed and scientifically based.

EXAMPLE: A student program

For almost a decade, Tampa Bay Water has sponsored Ph.D. students to work for the utility, where they are oriented to the utility's tools and attend regular meetings. The student program allows for continuous connections with the university community, supports the growth of a workforce savvy in both utility needs and applied climate change science, and helps transfer knowledge from research to applications and build tools that are operated in-house.

UTILITY-UNIVERSITY TEAM MEMBERS

Tirusew Asefa, Ph.D., P.E., D.WRE
Planning & System Decision Support, Tampa Bay Water

David Gold
Ph.D. Student, Cornell University

David Gorelick
Ph.D. Student, UNC-Chapel Hill

This team is working on a collaborative project that explores water supply and financial impacts of water supply infrastructure expansion for Tampa Bay Water over the next 20 years.

UNDERSTAND: Know your water system. To better understand how your utility will be impacted by climate change, it is important to know your system: Where does your water come from? How does it move throughout the collection system? How is it stored? What are your utility's key operations? What are its current underlying vulnerabilities? What interdependencies exist with other systems and across sectors (e.g., energy, transportation)? Knowing your system allows for a deep understanding of the factors that influence a system's vulnerabilities and risks, including but not limited to climate change, and can help direct resources and inquiries more effectively. Learn more about vulnerability studies and risk analysis from Denver (page 19), Metropolitan Water District, and Southern Nevada.

UNDERSTAND: Be a savvy consumer: recognize values and limits of climate science in practice. Climate science helps us better understand what we might expect from a warmer world (e.g., changes in temperature, precipitation, snowpack), but there are limits to what models can simulate and intrinsic uncertainties in future projections. Climate change information is created using models and methods that are more appropriate for certain questions than others. Use science to inform the process, but do not wait for nor expect climate change science to provide precise predictions. Learn more about the value and limitations of climate science shared at WUCA's Climate Resilience trainings and how Metropolitan Water District and San Francisco make decisions amid climate change uncertainty.

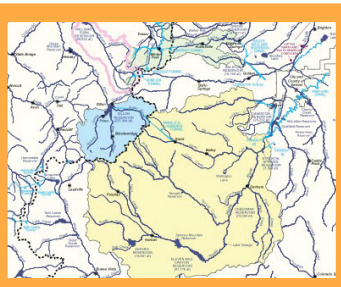
UNDERSTAND: Know your past climate conditions. Understanding the past is crucial to better understanding the future. Even though climate is changing (stationarity is no longer an appropriate assumption), information about past climate conditions is essential to understanding the range of natural variability and how your system's baseline is changing relative to what you have already experienced. Learn how Central Arizona and Philadelphia used the past as a guide to manage future change.

Long-term records can help an organization understand where trends are occurring and whether and when to make climate change-related investments.

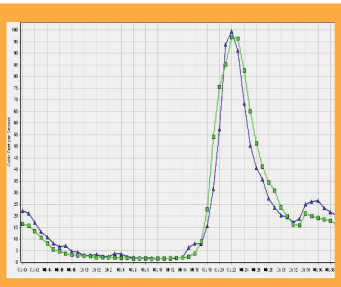
UNDERSTAND: Recognize the value of long-term monitoring. Long-term records can help an organization understand where trends are occurring and whether and when to make climate change-related investments. Becoming familiar with what data have been collected already and what environmental conditions and operational procedures should be monitored is time well spent. A defined baseline, in the context of other information, can help determine (1) what climate change information is appropriate for the region of interest, (2) if changes are occurring, and (3) what changes are significant enough to pass a threshold that requires action. Learn about the importance of environmental and operational baselines from Philadelphia and Portland.

SEE IT.

MAP IT.



MODEL IT.



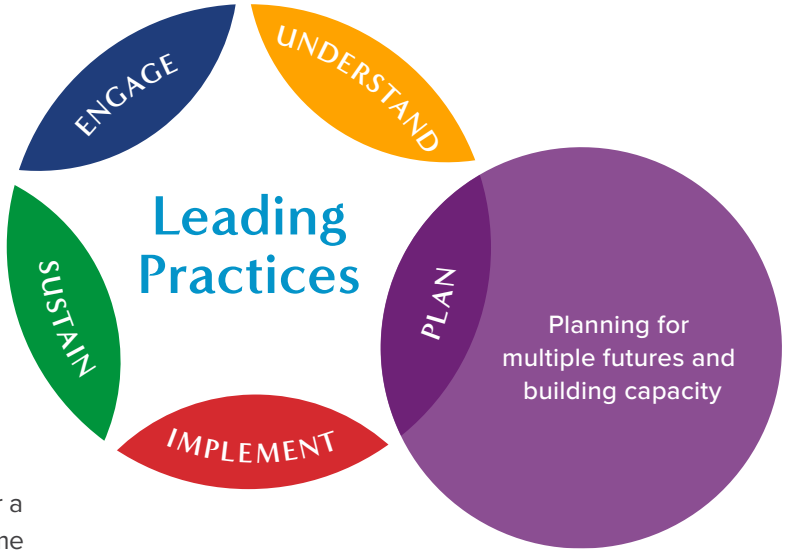
SOURCE: Denver Water

DENVER WATER

EXAMPLE: Understanding the managed raw water system

While understanding the natural system is fundamental to evaluating and estimating water supply and watershed health, it must go hand-in-hand with a nuanced knowledge of system operations, asset management, treatment and distribution, and customer water use. Denver Water approaches this in three parts: *See it. Map it. Model it.* Shadowing staff and taking system tours to learn the ins and outs of system management and functions, as well as to discuss the potential implications of climate change, allows for a more thorough system understanding while building important relationships with people throughout the organization (read more online).

PLAN



Unfortunately, science will not "solve" climate change in the way we traditionally expect science to solve our challenges. The range of climate projections will stay large and may even grow as more detail and complexity are added to the models used to understand past and future conditions of a naturally chaotic system. **As with planning for retirement, practitioners benefit from embracing uncertainty.** Faced with unknowns, it is better to move forward with different decision-making techniques and plan for a range of future conditions than spend time and money waiting for the science to become more predictive. Seeking robust, no-regret and low-regret investments that work across a range of future conditions and identifying solutions for future use helps build adaptive capacity within a utility's operations and investments to prepare for whatever the future may bring.

Navigating the planning process in the midst of uncertainty is fundamental to climate adaptation success. The leading practices in the PLAN action area, introduced below, highlight how WUCA members are learning to better assess how changes in underlying conditions impact their systems (e.g., infrastructure, financial, ecosystems, and human resources) and how to plan in a climate change context. Find more examples and supporting resources: www.wucaonline.org/adaptation-in-practice/leading-practices/plan.html or links throughout.

"The challenge of climate is so big, in grappling with it, you can't help but be changed by the process."

— Edward Campbell, *Portland Water Bureau*

PLAN: Be prepared to be changed by the process. Grappling with climate change and planning for adaptations can inspire new ways of thinking that could alter how you plan within your organization, whether for climate, land use, population, or other significant future changes. Learn how Portland's climate adaptation planning has been game changing.

PLAN: Connect with ongoing or upcoming planning processes. Climate adaptation can be most effective when worked into ongoing or upcoming planning within a utility, as opposed to creating a separate, standalone document like a climate adaptation plan. Examples of integrating climate adaptation into existing or planned efforts could include:

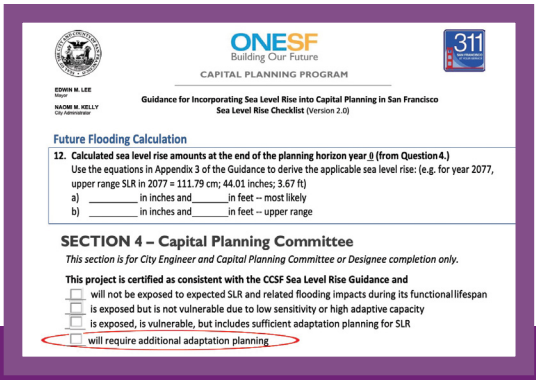
- Making strategic suggestions when planning documents are revised;
- Adding "consider climate change" to planning checklists;
- Adding language about exploring/evaluating climate adaptations in RFPs and consultant scoping documents; and
- Providing new data sets/analysis by which planning options can be evaluated.

Learn how Austin, Portland, and Southern Nevada have integrated climate change into their planning processes.

PLAN: Develop tools that allow information customization. Climate information is rarely ready to use directly. Instead, climate planning requires preparing tools to translate existing information into locally relevant and decision-appropriate knowledge through interpretation, synthesis, and model development. Customizing tools to help others incorporate climate change information can make adoption easier. Learn about Seattle's and Tampa Bay's utility-focused information.

PLAN: Learn from earlier climate change planning efforts. Over the past 10+ years, many utilities have started planning for climate change. Their efforts have resulted in both missteps and innovations worth learning about through attending trainings, reading case studies, and exploring these leading practices. Learn more through WUCA's peer-learning-focused Climate Resilience training and Tampa Bay's experiences.

PLAN: Leverage the power of well-placed climate change screening questions. One of the first steps to successful climate adaptation is building awareness that future conditions (e.g., weather, sea levels) will be different. While there is often not a clear answer to how big changes will be, a lot can be done by getting decision makers to pause and consider how they might adjust. This could be as basic as inserting climate change screening questions into key planning processes. Learn more from San Francisco (below), Southern Nevada, and others about their screening tools.



ONESF
Building Our Future
CAPITAL PLANNING PROGRAM

EDWIN M. LEE
Mayor
NAOMI M. KELLY
City Administrator

Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco
Sea Level Rise Checklist (Version 2.0)

Future Flooding Calculation

12. Calculated sea level rise amounts at the end of the planning horizon year 0 (from Question 4.)
Use the equations in Appendix 3 of the Guidance to derive the applicable sea level rise: (e.g. for year 2077, upper range SLR in 2077 = 111.79 cm; 44.01 inches; 3.67 ft)
a) _____ in inches and _____ in feet -- most likely
b) _____ in inches and _____ in feet -- upper range

SECTION 4 – Capital Planning Committee
This section is for City Engineer and Capital Planning Committee or Designee completion only.

This project is certified as consistent with the CCSF Sea Level Rise Guidance and
- ☐ will not be exposed to expected SLR and related flooding impacts during its functional lifespan
- ☐ is exposed but is not vulnerable due to low sensitivity or high adaptive capacity
- ☐ is exposed, is vulnerable, but includes sufficient adaptation planning for SLR
- ☐ will require additional adaptation planning

An excerpt from San Francisco's Guidance, including an influential checklist.

SOURCE: https://onesanfrancisco.org

San Francisco Water Power Sewer
Services of the San Francisco Public Utilities Commission

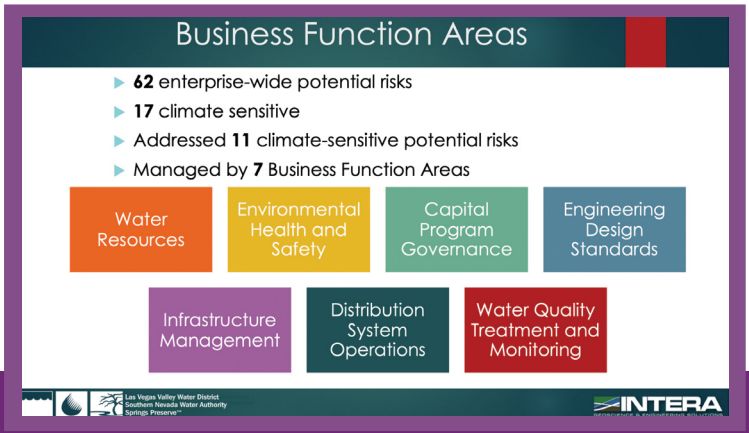
EXAMPLE: Translating uncertainty and developing guidance for sea level rise

To help City engineers work through anticipated sea level rise (SLR) impacts on future infrastructure, San Francisco adopted "Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco" in 2014. The Guidance instructs City engineers, planners, and architects managing capital projects to identify their projects' vulnerability to future scenarios throughout their asset's identified life cycle, including vulnerability to water-level elevation caused by an historic 100-year storm surge (which would average 42 inches across the San Francisco Bay shoreline). The Guidance provides consensus *median* projections identified as the "most likely" level of SLR expected from authoritative documents. The Guidance also presents "unlikely but possible" *high end* projections based on best available science. These terms were deliberately nonquantitative and intended to be interpreted according to their meaning in plain English. This Guidance, including the checklist in the figure above, has helped promote science-based planning.

SUSTAIN | PLAN: Leverage existing funding mechanisms. Work to engage, understand, plan, and implement climate change adaptation requires financial resources. Funding is also needed to sustain efforts. State or federal government funding possibilities may exist; they just need to be discovered and leveraged, sometimes creatively. Learn about how Austin (page 30) has leveraged funding for green projects and explore resources on where to look for funds.

PLAN: Take on climate change as another component of risk management. Infrastructure design and operations have always been carried out under conditions of uncertainty. While climate change adds new elements and challenges, utilities usually have tools already available to help manage uncertainty and leverage risks. Incorporating climate change as a component of an organization's overall risk management strategy is also useful in mainstreaming climate change actions. Learn what Southern Nevada has done to look at enterprise risk management (below).

Planning efforts should focus on understanding a range rather than a single "most likely" future.



A slide from SNWA that highlights how risks are already managed.

SOURCE: Southern Nevada Water Authority

SOUTHERN NEVADA WATER AUTHORITY

EXAMPLE: Enterprise risk management

Southern Nevada Water Authority (SNWA) conducted an enterprise risk management (ERM) initiative to document the breadth of future risks the organization could be exposed to, from unplanned increased spending due to asset failure to natural disasters halting water delivery. The organization is now completing a secondary assessment to evaluate how the risks identified in the ERM process may be exacerbated by climate change. The climate change assessment acknowledges both the department within SNWA currently managing those risks and the actions already in place to manage them, then recommends enhanced actions to account for the increased risk with climate change. One recommended approach, to "consider future climate conditions or scenarios in planning," has the added benefit of mainstreaming climate change considerations across the organization as part of staff's daily work activities to mitigate risks.

PLAN: Plan for a range of futures, not a single future. While climate change projections indicate clear trends (e.g., increasing temperatures, declining snowpack), specifics will always be uncertain. Planning efforts should focus on understanding a range rather than a single "most likely" future. Hear how San Francisco deals with a range of sea level rise projections, Austin with wide-ranging droughts and floods, San Diego with climate-impacted demand forecasts, and Metropolitan Water District with climate and demographic uncertainties (below).

PLAN: Employ decision-making science and deep uncertainty concepts. Decision-making science provides tools to help navigate and plan for multiple futures that include climate change alongside other unknown and surprising future changes. Making decisions in the midst of uncertainty is not new, but climate change adds an additional layer of complexity. A diversity of climate change assessment approaches incorporates this new deep uncertainty to allow utilities to make robust decisions and avoid being paralyzed by the unknown. View additional resources used by WUCA utilities, including Denver, Portland, and others, to better plan amid climate uncertainty.

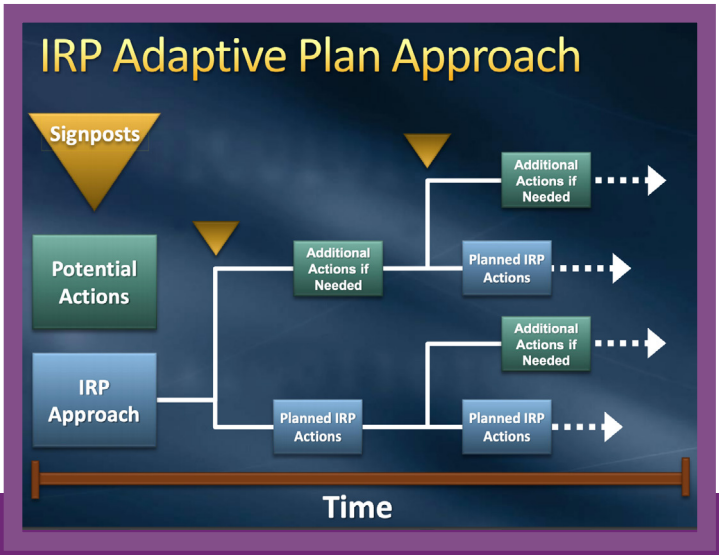


Figure used to explain signposting to WUCA Climate Resilience training in Austin, Texas, December 2019.

SOURCE: Metropolitan Water District

EXAMPLE: Robust Decision Making

Metropolitan Water District of Southern California (Metropolitan) worked with RAND to conduct a Robust Decision Making analysis of its 2010 and 2015 Integrated Resource Plans (IRPs). The analysis examined how the IRPs perform across a range of plausible climate and demographic futures and identified future scenarios under which the IRPs are vulnerable (i.e., when the IRP doesn't meet its reliability goals). By identifying these vulnerabilities, Metropolitan can use signposting (monitoring of relevant conditions) to determine when a specific variable (e.g., temperature, demographics) exceeds an identified threshold, then take appropriate management action. Eliminating uncertainty of future projections is unnecessary.

PLAN | SUSTAIN: Build and maintain in-house capacity. Climate adaptation work can be done both within and outside of an organization, though action ultimately requires work within. It can be a significant undertaking, requiring hiring or redirecting staff time. It is better to not assume people can incorporate climate adaptation work into their existing responsibilities. Learn how Portland increased its capacity with a climate program manager and an in-house hydrology model (below).

By hiring staff to focus on modeling and climate change, Portland Water Bureau substantially increased its institutional knowledge and technical capacity over time.

Portland Water Bureau climate change research meeting with external partners.

SOURCE: Portland Water Bureau

EXAMPLE: An in-house hydrology model

The Portland Water Bureau (PWB) developed internal modeling capacity for climate adaptation through the WUCA Piloting Utility Modeling Applications (PUMA) project (2012–2014). During this project, the utility asked scientists to train staff in the use of a newly developed hydrologic watershed model and downscaled climate data. The ultimate goal was for utility staff to lead future efforts to use these tools, since they are most familiar with system planning and needs. Following the PUMA project, the utility hired a full-time Water Resource Modeler in 2015 to operate and manage the modeling tools that were brought in-house. The modeler position adds value to water supply analysis, demand modeling, water quality modeling, and other efforts where climate and hydrologic data are used systematically for planning purposes. By hiring staff to focus on modeling and climate change, PWB substantially increased its institutional knowledge and technical capacity over time.

IMPLEMENT

The goal of climate adaptation is to change an organization's actions and assets, thus improving its ability to adjust appropriately to future change. There are many ways to implement effective actions, though there are strategic approaches WUCA members have found particularly useful.

Leading practices in the IMPLEMENT action area, introduced below, illustrate ways WUCA members have taken action on climate adaptation. More examples and resources are at www.wucaonline.org/adaptation-in-practice/leading-practices/implement.html or links below.

IMPLEMENT: Be prepared to act when opportunities arise. Being able to act often requires having information, ideas, and strategies ready for when the time is right to introduce them. When possible, work with others in your organization to identify when opportunities for creating change might arise and what information would be most useful in those situations. Opportunities might include pointing to an event (e.g., water shortage) to emphasize what likely future conditions will be or making strategic suggestions when planning documents are revised. Learn more about how New York City made adjustments after Superstorm Sandy and Austin connected adaptation planning to land development code revisions.

IMPLEMENT: Find co-benefits and no- and low-regret adaptation strategies. Preparing for climate change often requires making tradeoffs or selecting the "least-bad" option, yet this need not always be the case. When possible, find climate adaptation actions that have no or low regrets or even result in positive impacts. Win-wins can build overall resilience. See how WUCA cities, including New York City, Philadelphia, Austin, and others have found green infrastructure win-wins and how Central Arizona prioritizes its no-and low-regret evaluations.

IMPLEMENT: Recognize some adaptations can be employed quickly. Not all climate adaptation actions have to involve a long planning process and lots of preparation. Many adaptations can be implemented quickly when appropriate information is provided to decision makers. Learn how Central Arizona evaluates strategies based on ease of implementation (and regrets, as noted on left) and how Southern Nevada quickly reduced extreme heat impacts.

IMPLEMENT: Recognize smaller changes can lead to bigger ones. When confronted with barriers to tackling high-priority risks, seek out smaller, more tractable changes that can build momentum, engage champions, and give existing efforts new energy. Smaller changes and pilot studies may open up opportunities and provide needed inspiration. Check out how Southern Nevada used a landscape assessment to build collaboration and momentum.

IMPLEMENT: Focus on your organization's core responsibilities first. Prioritize progress in your utility's core services and lines of business. Demonstrating how adaptation is good for your organization—particularly how it helps fulfill responsibilities and could benefit the bottom line—can build support and help transition adaptation from a feel-good pursuit to a responsible business practice. See how WUCA members have mapped business functions at Southern Nevada, San Diego, Tampa Bay, and the City of Fort Collins Utilities, and how San Diego (below) has investigated its water supply resiliency.

IMPLEMENT: Enact incentives or policies that change behavior. Behavior change can be an effective climate adaptation measure. Behavior change may include residents landscaping with more drought-tolerant plants, customers using less water because of modified rate structures, or water utility staff working new hours to avoid excessive heat. Behavior changes are adaptations in and of themselves and can build awareness and momentum for additional adaptation action. Read about Austin's water conservation programs.

Building the Carlsbad Desalination Plant, raising San Vicente Dam, and implementing water conservation measures have helped drought-proof San Diego's water supply.

SOURCE: San Diego County Water Authority

San Diego County Water Authority
Our Region's Trusted Water Leader

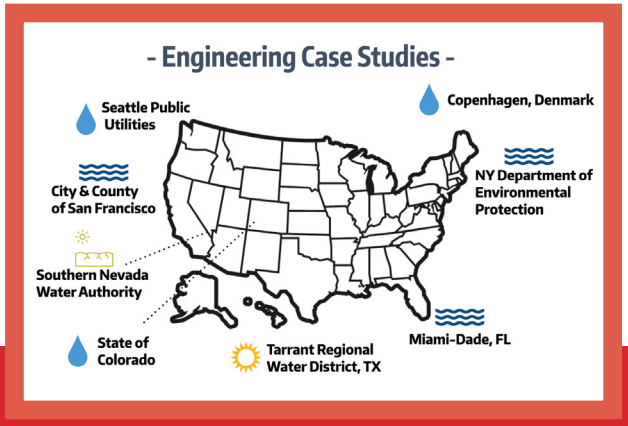
EXAMPLE: Supply resiliency

Supply resiliency is a high priority for the San Diego region. Many of the climate change adaptations made by the San Diego County Water Authority (SDCWA) are intended to support supply resiliency. SDCWA updated its Regional Water Facilities Master Plan in 2013 to serve as a roadmap for the major capital improvements needed to ensure the region's supply reliability under changing demand and supply conditions. The 2013 planning efforts also included SDCWA's first Climate Action Plan, which was updated in 2020. These plans resulted in the development of facilities that significantly improved overall water supply reliability, including the Carlsbad Desalination Plant. These actions are part of an innovative plan to ensure water supply reliability for the San Diego region by providing SDCWA with a highly reliable, locally controlled water supply. The new, drought-proof supply reduces the region's dependence on water from the Colorado River and the Bay-Delta, both of which are vulnerable to droughts, natural disasters, and regulatory restrictions.

IMPLEMENT: Enact changes in infrastructure and operations. Climate adaptation often requires changing the way facilities and other infrastructure are planned, designed, and operated. Strategies include diversifying water supply sources, expanding local surface water reservoir storage, modifying pumping stations, and changing pipe materials. A WUCA effort to identify facility- and infrastructure-based adaptation strategies that incorporate climate information is highlighted below.

Locations of current case studies shared as eight 2-page overviews.

SOURCE: Roop and Heyn 2019



EXAMPLE: Engineering case studies

WUCA efforts have sought to understand how the water sector incorporates climate change information into the design, redesign, construction, and maintenance of assets and infrastructure exposed to a range of climate threats and hazards. One such effort was a survey and report carried out by the Portland Water Bureau to assess how WUCA utilities and other national and international utilities are planning for a range of climate risks to built infrastructure.

Through this process, WUCA, in partnership with the University of Washington Climate Impacts Group, solicited information from water utility engineers to understand the barriers they face using climate change data and information and modifying facility operations to make assets more adaptive to changing conditions. Engineers asked for practical examples of how climate information is used at the project level by other peer water utilities, so the team developed a suite of case studies that demonstrate how peer water managers have changed facility designs and operations, including:

- Designing new cooling systems at pump stations to reduce vulnerability to extreme heat waves;
- Incorporating standard operating procedures in engineering capital project delivery processes to assess project climate change risks during project planning and design;
- Raising the elevation of new or existing assets above the standard design flood elevation to accommodate higher sea levels and increased flood risk (based on the design-life of the asset);
- Designing for a higher level of extreme precipitation in dam safety; and
- Building lower-level reservoir intakes to respond to decreasing lake levels.

Key lessons learned from these examples are that both management-level and project staff-level support is instrumental in changing facility design construction and operations, and how individuals involved greatly influence if and how climate change information is used. WUCA's engineering case studies were developed in collaboration with the utilities and operators profiled, and project contacts are provided in each case study to facilitate follow-up and enable interested readers to learn more about implementing similar measures or approaches. Current case studies include examples related to extreme rainfall, sea level rise, extreme heat, and drought and are available at www.wucaonline.org/adaptation-in-practice/engineering-case-studies.

SUSTAIN

Work to engage, understand, plan, and implement climate change adaptation requires energy and resources, now and into the future. You must continuously make the business case for this work, monitor and assess conditions, sustain connections with partners, and learn how new information fits into what is already known. This work also requires an abundance of patience and perseverance.

Leading practices in the SUSTAIN action area illustrate ways WUCA members have initiated climate adaptation work and kept it going. More examples and resources are at www.wucaonline.org/adaptation-in-practice/leading-practices/sustain.html or links below.

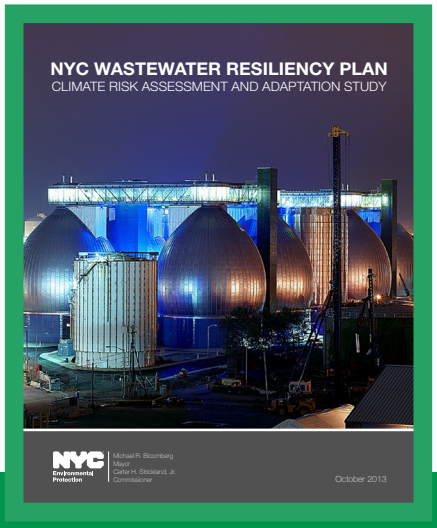
SUSTAIN: Approach climate adaptation through mainstreaming. Creating utility-wide climate resilience can be achieved by examining climate change impacts and implementing adaptation solutions throughout organizational activities. Coined "mainstreaming," this approach allows utility subject matter experts to work with their climate leads or champions to co-produce relevant and timely adaptation solutions. By understanding risks and identifying solutions with staff, mainstreaming builds the adaptive capacity needed to ensure water systems, operations, resources, and investments are diversified, flexible, redundant, and resilient. Learn more about Denver's pilot to mainstream climate adaptation using a new Risk and Opportunity Framework with four utility business functions: finance, water treatment, water distribution/hydraulics, and watershed management.

SOURCE: WUCA

SUSTAIN: Monitor and evaluate current conditions. Knowing current climate conditions and tracking how they change is important. Monitoring programs can allow for incremental adaptations that employ resources as needed, based on if and when important thresholds are exceeded. Then, pairing monitoring with evaluation can help you understand whether your implemented processes and actions actually achieve targets and goals. Learn more about Philadelphia's sea level rise monitoring and federal long-term monitoring efforts.

SUSTAIN | ENGAGE: Make the business case for climate adaptation. Improving resiliency takes time and resources but can also save time and resources. Transparency about financial elements, including tradeoffs in costs and other triple-bottom-line benefits — social, environmental, and financial — can motivate action and demonstrate how adaptation investments can save money in the long run. This helps engage people from the beginning and sustain the effort. Learn how New York City (below) and San Diego have made the business case for climate adaptation.

Understanding the natural system over time and having long data sets available to look for trends has been vital to Philadelphia Water Department's climate adaptation efforts.



Study highlights costs and benefits of climate adaptation for New York City.

SOURCE: NYC DEP

EXAMPLE: Flood protection benefits in New York City

In 2011, New York City (NYC) Department of Environmental Protection (DEP) initiated an internally funded pilot study of climate change impacts on its drainage system and wastewater treatment, looking at potential risks based on projected temperature, precipitation, and sea level rise. When Superstorm Sandy hit New York in 2012, DEP expanded the assessment to all vulnerable treatment facilities and pumping stations to consider risks from future storm surge events with sea level rise. The result of the study is a portfolio of adaptive approaches described in the 2013 NYC Wastewater Resiliency Plan, including elevating and flood-proofing critical equipment. The plan showed that by investing in flood protection, NYC could avoid over $2 billion in estimated damages to waterfront facilities from 50+ years of flooding. This business case was helpful in securing over $160 million in federal funding for retrofits at DEP wastewater treatment facilities and pumping stations.

SUSTAIN: Avoid new climate science whiplash. New science is not necessarily better or more predictive. Climate science moves forward in an iterative fashion. Usually, through these iterations, a common understanding develops—though consensus and synthesis take time and don't often make headlines. Put another way, flashy new findings and scientific debate may cause whiplash, whereas scientific assessments synthesize and report new knowledge in a more deliberative way. See how San Francisco and Portland have managed new science.

SUSTAIN: Keep moving forward, even if it feels slow. Change is rarely easy, especially when building institutional capacity to adapt to climate change; it can feel slow. It is important to keep at it and move forward carefully. In some situations, being too forceful or alarmist could unintentionally create more barriers. Learn how Central Arizona has navigated this challenge.

SUSTAIN | PLAN: Leverage existing funding mechanisms. Work to engage, understand, plan, and implement climate change adaptation requires financial resources. Funding is also needed to sustain efforts. State or federal government funding possibilities may exist; they just need to be discovered and leveraged, sometimes creatively. Learn about how Austin (below) has leveraged funding for green projects and explore resources on where to look for funds.

Hornsby Bend Biosolids Management Plant.

SOURCE: Ash Bledsoe

EXAMPLE: State and federal loans

Innovation is essential when thinking about ways that funding from established programs could be used to implement climate-related projects. Austin Water (AW) received funding from state and federal loan programs for green projects. Through the Texas SWIFT loan program, AW expanded its reclaimed water infrastructure ($65 million) and began initiation of an advanced metering infrastructure program ($81 million). In 2010, AW received a zero-interest, 30-year loan through the federal Clean Water State Revolving Fund green reserve program. This allowed AW to reduce methane leakage and expand the biosolids compost facilities as well as get a biogas generator that produces most of the electricity used at the Hornsby Bend biosolids plant ($32 million). These loan programs helped AW reduce the debt for these projects. With SWIFT, AW received a 35 percent interest rate discount for a 20-year loan term, saving the utility $10 to $17 million for every $100 million loan. While the zero interest was unique to the American Recovery and Reinvestment Act federal stimulus, the Clean Water and Drinking Water State Revolving Funds are still available for utilities across the country with significant interest rate discounts. Green reserve components can result in a portion of principal forgiveness or further interest rate discounts depending on the individual state. While these programs were focused on greenhouse gas mitigation and not specifically identified as climate adaptation projects, they proved to be cost-effective tools in helping AW make infrastructure investments to prepare for a changing climate.

SUSTAIN: Value climate adaptation as more than a plan. While the focus is often on the resulting plan, it is the process of planning that is most important. Creating and reinforcing the connections and processes required to adapt to climate change builds valuable institutional capacity that will serve the utility even if the plan itself is not used. View an example from Portland.

SUSTAIN: Establish a community of practice to integrate climate change. Climate change adaptation and mitigation are organization-wide endeavors that impact planning, policy, operations, and investments. Because this work is cross-cutting, it benefits from a clear agenda and shared, collaborative leadership. Establishing a community of practice, within an organization or through shared impact focus areas across organizations, can provide a supportive forum in which to investigate ideas, define focus, share knowledge, and communally advance and celebrate progress. Activities can be initiated by a single person or group, or a collection of people from different groups—ideally with support distributed so responsibilities can be shared. Learn what Seattle (below) and Denver did within their utilities and how WUCA members are connected to regional communities fostered by Climate Resilience trainings (page 32).

SUSTAIN | PLAN: Build and maintain in-house capacity. Climate adaptation work can be done both within and outside of an organization, though action ultimately requires work within. It can be a significant undertaking, requiring hiring or redirecting staff time. It is better to not assume people can incorporate climate adaptation work into their existing responsibilities. Learn how Portland increased its capacity (page 24).

SUSTAIN | ENGAGE: Seek out and support climate champions throughout your utility. Progress happens more quickly with the support of motivated individuals who value and prioritize climate adaptation work, including executive-level leaders. It is therefore important to build relationships with and educate champions who can influence climate adaptation actions, then help sustain and strengthen those efforts. Having champions across an organization (in planning, engineering, finance, public relations, and other roles) can contribute diverse expertise and resources and help provide institutional memory as individuals' roles change. Learn how WUCA members identified, educated, and supported their climate champions.

Community of practice members tour the utility's transfer facilities.

SOURCE: Seattle Public Utilities

Seattle Public Utilities

EXAMPLE: A community of climate champions in Seattle

To bring greater clarity and cohesion to its climate work, Seattle Public Utilities established a community of practice that brings together climate practitioners, utility (and outside) subject matter experts, and climate enthusiasts from across the organization. The community of practice convenes quarterly to share broadly about climate-related information, impacts, initiatives, concerns, and innovations and to develop a shared climate agenda to structure and align the utilities' climate work and commitments in all areas.

Each training is hosted in a different region by a WUCA member and helps to create and inform a regional climate adaptation community, with case studies that highlight lessons learned.

SOURCE: Tampa Bay

EXAMPLE: Learning together

In 2017, WUCA developed and hosted its first technical climate science and adaptation training in collaboration with EPA's Creating Resilient Water Utilities (CRWU) program and other partners. *"Building Resilience to a Changing Climate: A Technical Training in Water Sector Utility Decision Support"* focuses on the practical use of climate science [UNDERSTAND: EXAMPLE: Learning about climate change science] in adaptation planning, decision making under conditions of uncertainty [PLAN: EXAMPLE: Planning amid uncertainty training], generating buy-in for resilience investments, and addressing communications barriers [ENGAGE: EXAMPLE: Communication training]. Each training is hosted in a different region by a WUCA member and helps to create and inform a regional climate adaptation community, with case studies that highlight lessons learned [PLAN: EXAMPLE: WUCA Climate Resilience Training peer learning].

Following each training, participants are encouraged to maintain engagement, continue learning, and begin work together to address the challenges of a changing climate [SUSTAIN: Establish a community of practice to integrate climate change].

WUCA's collaborative has successfully planned and held two trainings per year (excluding 2020) following the initial development and kickoff in Boulder, Colorado. While in-person events in 2020 were postponed due to COVID, WUCA worked with the EPA and NOAA to begin transitioning training materials to a virtual platform hosted on NOAA's climate toolkit website to allow for broader access to the training. When complete, WUCA's virtual training will lay the foundation for a future water utility climate adaptation certification program. See materials and information on future trainings at: www.wucaonline.org/training/index.html.

connections to complementary efforts

In recent years, the amount of climate change knowledge available and efforts to support adaptation have grown. Guidance is available from federal agencies (e.g., reports from the US Army Corps of Engineers, Bureau of Reclamation, NOAA Regional Integrated Sciences and Assessments (RISA) program), professional organizations (e.g., manuals of practice from American Water Works Association, American Society of Civil Engineers), and in the scientific literature and online information portals (e.g., www.weadapt.org, https://resiliencemetrics.org, https://global-change.github.io/dos_and_donts). Through this process, WUCA has come across similar efforts (https://nca2018.global-change.gov/chapter/28) that serve the same adaptation goals and are worth sharing.

To promote knowledge exchange and connect WUCA's leading practices with water management peers, scientists, and the broader adaptation community, WUCA regularly connects with complementary efforts. The goal is to collectively promote greater awareness of existing resources and ensure WUCA's efforts add to and do not duplicate other efforts, while highlighting possible partners and peer networks. If you would like to learn more or make a connection, please reach out to WUCA at www.wucaonline.org/contact/index.cfml.

By fostering a deeper understanding of ongoing climate adaptation work, WUCA members hope to identify innovations and strategic partnerships in the water management and climate science communities that can help elevate, expand, and share this increasingly critical knowledge.

valuable lessons

In compiling these leading practices, WUCA learned several lessons that may help support climate adaptation practices within other organizations:

The process is often more important than the resulting plan. In this and other WUCA projects (e.g., engineering case studies, WUCA's *Building Resilience to a Changing Climate* technical training), the opportunity to encourage conversations (two-way, both listening and sharing) about climate adaptation within and across utilities was valuable. WUCA hopes this report's living-document design will continue to facilitate these types of conversations within and across water utilities and in other sectors as well.

Climate adaptation champions are integral to the success of most leading practices.

Utilities are seeking ways to improve their ability to mainstream climate change information into existing business functions.

Mainstreaming simultaneously allows for the identification of practical, relevant, and achievable adaptation solutions while also fostering internal champions.

The science will never be perfect, so learning about strategies for making decisions in the face of deep uncertainty is key to taking climate adaptation action.

The perfect can be the enemy of the good. Developing perfect climate adaptation actions may slow progress and prevent necessary learning. It is important to try different things to learn and adapt. The climate change adaptation landscape is also rapidly changing, so what gets developed may need to be revised sooner than anticipated.

Adaptation is an iterative process. Essential climate adaptation actions and leading practices need to be re-visited over time as they continue to inform and support each other.

www.wucaonline.org