May, 2016

Toward a More Resilient Water and Wastewater Infrastructure in the Pacific Region

Acknowledgements

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Recent press reports and technical articles detail significant changes impacting the West Coast's water-related infrastructure – i.e., its drinking water, wastewater and stormwater systems. There are increasingly frequent reports of record temperature highs, record drought, record storms and record forest fires in the region.[1] It does not appear that this trend will abate and, to the contrary, many experts predict the challenges will only increase and become more severe in the coming years. Changes will impact the region in differing ways, and "one size fits all" response measures will not adequately address the disparate impacts. For instance, while some Pacific regions will suffer increasing drought and water availability shortages, others will experience more significant storm events and additional stormwater impacts.

In response to these growing impacts and predictions of even greater ones in the future, there has been no shortage of assessments and protocols for how water-related utilities can become more climate resilient and better prepared for the predicted changes.[2] However, most of the attention and resources from government agencies and water-related associations tend to focus on large water-related utilities. These large water utilities have larger customer bases and hence more access to resources and staffing to focus on climate resilience issues. Many large water utilities have dedicated resilience or climate change staff and resources to focus on integrated planning and carry out complex modeling of location-specific climate models. For example, the cities of Portland, Seattle, San Francisco and Los Angeles each have full-time water agency climate change staff positions.

Rather than focusing on the big water utilities, this report is intended to be a resource for medium to small utilities, especially those that cannot afford full-time staff devoted solely to planning for climate change. It offers tools and information that may assist those utilities in starting to integrate longer term resilience issues into planning and asset management. The issues can appear daunting to tackle but, as discussed in Section III, there are discrete steps that can be taken to start on this journey.

I. Why Should This Matter?

With all the other short-term pressures confronting small and medium size water-related utility managers, why should a focus on longer-term climate resilience matter? The short answer is that impacts from a changing climate likely will affect utilities' budgets and bottom lines soon, if not already. At the very least, these issues should be assessed and acted on before undertaking any new large capital expenditures or expansion projects. As discussed in Section III, there are strategies that also can save utilities money in addressing capital expenditures.[3]

[1] See e.g. Gillis, J. (2015, August 20). California Drought Is Made Worse by Global Warming, Scientists Say. *The New York Times*. Retrieved from http://www.nytimes.com/2015/08/21/science/climate-change-intensifies-california-drought-scientists-say.html?_r=0; Thompson, A. (2015, April 15). Scientists Pore Over Warm West, Cold East Divide. *Climate Central*. Retrieved from http://www.climatecentral.org/news/warm-west-cold-east-weather-divide-18889; Bernton, H. (2016, February 12). Snowpack drought has salmon dying in overheated rivers. *The Seattle Times*. Retrieved from http://www.seattletimes.com/seattle-news/environment/snowpack-drought-has-salmon-dying-in-overheated-rivers/; Hamilton, M. (2015, August 27). Sea levels will rise, experts warn, and 'it's not going to stop.' *Los Angeles Time*s. Retrieved from http://www.latimes.com/science/la-me-0827-oceans-rising-20150827-story.html; Tomlinson, S. (2014, May 6). Global climate change report: Impacts on Oregon, Pacific Northwest. *The Oregonian*. Retrieved from http://www.oregonlive.com/weather/index.ssf/2014/05/global_ climate_change_report_i.html; Graham, D. A. (2015, September 15). Just How Bad Is the 2015 Fire Season? *The Atlantic*. Retrieved from http://www.theatlantic.com/national/archive/2015/09/just-how-bad-is-the-2015-fire-season/405439/

[2] See Section IV for a list of resources.

[3] For example, in 2012 Irvine Ranch Water District (IRWD) worked with its consultant to develop a plan to identify energy saving and greenhouse gas (GHG) reducing projects within their system. The nine recommended projects saved the district an average of $1.4 million per year, nearly $24 million over 20 years, 127 million kWh of electricity and reduced GHG emissions by 53,000 metric tons of CO2.

It also is likely that, over time, states will begin to expressly require integration of climate resilience into the core planning processes and asset management of even smaller water utilities. This may start with conditions to receiving government grant funding for planning. For example, Business Oregon's Safe Drinking Water Revolving Loan Fund supports planning, surveying, technical support and environmental review. While those funds could be used for resilience planning today, future use of such funds may require resilience planning. Such requirements could extend beyond funding to regulations in the future as well. Furthermore, the bond market is beginning to factor climate resilience into a water-related utility's credit ratings. For example, in 2014, Ceres and other partners created the Climate Bonds Initiative to develop standards to assess water utility infrastructure projects that should qualify for climate bond certification.[4] Increasingly, a utility's financing costs may be directly impacted if the utility does not start addressing climate resilience.

The bond market's increasing attention to climate resilience stems from proliferating examples of damages and costs caused by forest fire, flooding and drought. Other budget-based impacts can occur through the permitting and planning process as well. For example:

Forest Fires and Flooding

The Hayman fire in Colorado in 2002 was the largest and costliest wildfire in Colorado's recorded history. The fire, while started by arson, was fueled by record drought and extreme weather conditions. While many of the economic impacts of the fire were felt immediately, two front-range water providers—Denver and Aurora—spent $25 million to remove sediment repeatedly dumped into a reservoir caused by flooding resulting from severe rain events over several years. The sediment accumulation resulted in large part from the ecosystem being less able to act as a sponge due to the death of trees and understory in the forest. The resulting run-off caused erosion which consequently caused the soil to wash into the nearby streams and settle in the reservoir.

Drought

Numerous water providers have had to invest millions of dollars to expand their water storage and/or water supply due to increasing and unprecedented drought. For example, the City of Calgary, Alberta, responded to extreme drought in 2002 by expanding its water storage at the cost of hundreds of millions of dollars. The San Diego County Water Authority (SDCWA) has recognized a long-term water supply challenge due to continued droughts in the Colorado River Basin and Southern California. In response, SDCWA partnered with a private investor-owned company to develop a $1 billion desalination plant in Carlsbad, CA, that came online in December 2015.

Storm Events

Clackamas County Water Environment Services is altering its Hoodland Treatment Plant outfall by switching from piping directly into the Sandy River to a subsurface discharge to allow for groundwater recharging. The change will aid in avoiding the need to repeatedly repair the outfall following damage incurred from large storm events. Capital costs of the new outfall will be greater than $5 million. On a larger scale, governments and nonprofits around San Francisco Bay plan to invest over $1 billion in wetland reclamation to protect against sea level rise and erosion from storm surges projected over the coming decades.

Sea Level Rise

The City of Morro Bay, CA, proposed to replace an old water treatment plant at its existing location near the ocean and within the adjacent creek's 100-year flood zone. The California Coastal Commission, which had jurisdiction because the proposed project was within the coastal zone, denied a permit for the project in January 2013, in part, because of its proximity to the ocean and creek, making it susceptible to flooding and

[4] See, generally *Water*. Retrieved from https://www.climatebonds.net/standards/water

sea level rise caused by climate change and tsunamis. The commission noted that the city's own analysis showed that the site could be inundated by a conservatively estimated 4.5 feet from sea level rise. It was projected that moving the treatment plant to a new location further from the ocean and creek would add $12 million to $20 million to the project cost, which would translate into an additional $12 to $20 a month on the average sewer bill.[5]

II. Checklist for Vulnerability Assessment

The following checklist presents issues that utilities should consider in evaluating their vulnerabilities to climate change impacts. The checklist is not exhaustive, nor is every issue presented relevant to every utility. It is intended to be a starting point in the assessment process, and each West Coast utility's most pressing climate resilience issues will vary depending on geography and customer base. The point is to start honing in on core risks and, where applicable, learn what other utilities in similar situations have done to mitigate them.[6]

A. Water Demand and Supply

- Droughts are expected to become more frequent and more severe in the future. Are you overly reliant on groundwater? If so, do groundwater supplies in your region lack resilience after drought events? Areas with fixed or increasing demand will be particularly vulnerable to droughts and may become more dependent on groundwater pumping.
- Does a portion of the water supply in your region come from snowmelt? Snowmelt is expected to continue to decrease as the climate warms. Water systems supplied by snowmelt are vulnerable to climate change.
- Does your utility rely on coastal aquifers? Has salt intrusion been a problem in the past? Coastal aquifers are susceptible to salt intrusion as sea levels rise, and many areas such as the West Coast Basin in Southern California have already observed salt intrusion due to over-extraction.
- Would your utility have difficulty storing carryover supply surpluses from year to year? Systems that can store more water may be more resilient to droughts.
- Has your region faced a drought in the past during which it failed to meet local water demands? Systems that have already come close to their supply thresholds may be especially vulnerable to droughts in the future.
- Are water conservation and curtailment measures effective in your region? Areas with a fixed or increasing demand may be particularly vulnerable to droughts.
- Are there major industries that require cooling and process water in your planning region? If so, can you identify major industrial water users in your service territory and assess their current and projected needs for cooling and process water? As average temperatures increase, cooling water needs may also increase.
- Are crops grown in your region climate-sensitive? Would shifts in daily heat patterns, such as how long heat lingers before nighttime cooling, be prohibitive for some crops? For example, fruit and nut crops are climate-sensitive and may require additional water as the climate warms.
- Does water use vary significantly by seasons, such as for irrigated agriculture or summer lawn watering? Water demand for these uses is expected to increase as average temperatures increase and droughts become more frequent.

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[5] California Coastal Commission. (2011). F10a:

[6] The checklist is modified from a version presented in the California Department of Water Resources Climate Change Handbook: California Department of Water Resources. (2011). *Climate Change Handbook for Regional Water Planning.*

- Are some instream flow requirements in your region either currently insufficient to support aquatic life or occasionally unmet? Changes in snowmelt patterns in the future may make it difficult to balance demands for water and the environment. Vulnerabilities for ecosystems and municipal/agricultural water demand may be exacerbated by instream flow requirements that are: 1) not quantified, 2) not sufficient for ecosystem needs under multiple environmental stresses including droughts, or 3) not being currently met by regional water managers.

B. Water Quality

- Are increased wildfires a threat in your region? If so, does your utility have reservoirs with wildfire-susceptible vegetation nearby which could pose a water quality concern from increased erosion and run-off? Some areas are expected to become more vulnerable to wildfires over time.
- Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low-dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change? Warming temperatures will result in lower dissolved oxygen levels in water bodies, which are exacerbated by algal blooms and in turn enhance eutrophication. Changes in stream flows may also alter pollutant concentrations in water bodies.
- Are seasonal low flows decreasing for some water bodies in your region? If so, are the reduced low flows limiting the water bodies' assimilative capacity? In the future, low flow conditions are expected to be more extreme and last longer. This may result in higher pollutant concentrations where loadings increase or remain constant.
- Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?
- Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation? While it is unclear how average precipitation will change with temperature, there is general consensus that storm severity will probably increase. More intense, severe storms may lead to increased erosion, which will increase turbidity in surface waters. Areas that already observe water quality responses to rainstorm intensity may be especially vulnerable.

C. Sea Level Rise

- Does your utility have any infrastructure along the coast that could be subject to coastal erosion? Is there other community infrastructure such as sea levees that could impact your infrastructure if breached? Sea level is expected to continue to rise in the future due to climate change.
- Are there coastal structures, such as levees or breakwaters, in your region? Coastal erosion is expected to occur over the coming decades as sea levels rise, and critical infrastructure in the coastal floodplain may be at risk. Digital elevation maps should be compared with locations of coastal infrastructure.
- Are there important climate-sensitive low-lying coastal habitats in your region? Low-lying coastal habitats that are particularly vulnerable to climate change include estuaries and coastal wetlands that rely on a delicate balance of fresh water and salt water.
- Are there areas in your region that currently flood during extreme high tides or storm surges? Areas that are already experiencing flooding during storm surges and very high tides are more likely to experience increased flooding as sea levels rise.
- Is there land subsidence in the coastal areas of your region? Land subsidence may compound the impacts of sea level rise. Do tidal gauges along the coastal parts of your region show an increase over the past several decades? Local sea level rise may be higher or lower than state, national or continental projections.

D. Flooding

- Does critical infrastructure in your region lie within the 200-year floodplain? While it is unclear how average precipitation will change with temperature, there is general agreement that storm severity will probably increase. More intense, severe storms may lead to higher peak flows and more severe floods.
- Does aging critical flood protection infrastructure exist in your region? Levees and other flood protection facilities across the region are aging and in need of repair. Due to their overall lowered resilience, these facilities may be particularly vulnerable to climate change impacts.
- Have flood control facilities (such as impoundment structures) been insufficient in the past? Reservoirs and other facilities with impoundment capacity may be insufficient for severe storms in the future. Facilities that have been insufficient in the past may be particularly vulnerable.

E. Ecosystem and Habitat Vulnerability

- Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues? Erosion is expected to increase with climate change, and sedimentation is expected to shift. Habitats sensitive to these events may be particularly vulnerable to climate change.
- Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas? As invasive species are expected to become more prevalent with climate change, existing invasive species issues may indicate an ecological vulnerability to climate change.
- Does your region include estuarine habitats which rely on seasonal fresh water flow patterns? Seasonal high and low flows, especially those originating from snowmelt, are already shifting in many locations.
- Do climate-sensitive fauna or flora populations live in your region? Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region? Some specific species are more sensitive to climate variations than others. Species that are already threatened or endangered may have a lowered capacity to adapt to climate change.
- Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities? Economic values associated with natural habitat can influence utility decision-making.
- Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life? Constrained water quality and quantity requirements may be difficult to meet in the future.
- Do estuaries, coastal dunes, wetlands, marshes or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region? Storm surges are expected to result in greater damage in the future due to sea level rise, making fragile coastal ecosystems vulnerable.
- Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change?[7] Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? Are there movement corridors for species to naturally migrate? Are there infrastructure projects planned that might preclude species movement?

[7] Endangered Species Coalition. (n.d.). *It's Getting Hot Out There: Top 10 Places to Save for Endangered Species in a Warming World.*

III. Strategies to Move Forward

This section of the report highlights some successful climate resilience strategies, based on interviews with experts at the following organizations:

Interviewees for this Report:

1. California Association of Sanitation Agencies: Adam Link – Director of Governmental Affairs, Sarah Deslauriers – Climate Change Lead, and Greg Kester – Director of Renewable Resource Programs
2. California State Water Resources Control Board: Max Gomberg – Climate and Conservation Manager
3. Ceres: Monika Freyman – Director, Water Program
4. Clean Water Services (OR): Mac Martin – Water Resource Analyst, and Nora Curtis – Conveyance Systems Department Director
5. Denver Water: Laurna Kaatz – Climate Scientist
6. Encina Wastewater Authority (CA): Kevin Hardy – General Manager
7. Geos Institute (OR): Cathy Kellon – Green Infrastructure Program Director
8. Inland Empire Utilities Agency (CA): Joe Grindstaff – General Manager
9. Kitsap Public Utility District (WA): Bob Hunter – General Manager
10. Los Angeles Department of Water and Power: Nancy Sutley – Chief Sustainability and Economic Development Officer
11. Metropolitan Water District of Southern California: Grace Chan – Manager, Resource Planning & Development, and Brandon Goshi – Manager, Water Policy and Strategy
12. Oregon Association of Clean Water Agencies: Janet Gillaspie – Executive Director
13. Portland Water Bureau: Kavita Heyn – Climate Science & Sustainability Coordinator
14. Portland Bureau of Environmental Services: Alice Brawley-Chesworth – Principal Management Analyst, and Jennifer Belknap Williamson – Division Manager, Asset Systems Management
15. City and County of San Francisco: Todd Rystrom – Deputy Controller
16. Santa Ana Watershed Project Authority (CA): Celeste Cantú – General Manager
17. Seattle Public Utilities: Paul Fleming – Manager, Climate Resilience Group
18. Sonoma County Water Agency: Grant Davis – General Manager, Cordell Stillman – Capital Projects Manager, and James Jasperse – Chief Engineer and Director of Groundwater Management
19. City of Vancouver, WA: Eric Schadler – Engineering Manager
20. Washington Public Utility District Association: John Kounts – Water Program Director
21. Washington State Department of Ecology: Dave Christensen – Water Resources Program Development
22. Washington State Department of Health: Linda Kildahl – Technical Advisor, Field Operations Team
23. Yolo County Flood Control and Water Conservation District (CA): Tim O'Halloran – General Manager

Interviewees confirmed that, although many water-related utilities have limited resources to focus on climate resilience, some small to medium size water utilities in the Pacific region have begun to tackle the issue. Some of these strategies may fit a utility's circumstances better than others. Implementing any of them will put an organization on the path to addressing climate resilience.

A. Integrate Climate Resilience into Existing Core Planning Processes

As a starting point, water utilities, whether large or small, should integrate climate resilience assessments into their existing core planning processes.

This is already happening throughout the Pacific region with respect to earthquake resilience and the potential for a major earthquake from the Cascadia Subduction Zone. For example, in 2013 the state of Oregon developed The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami.[8] The plan included extensive findings about antiquated water infrastructure and its vulnerability along the coast and west of the Cascade mountain range. The plan has heightened awareness of the issue with respect to even small water utilities west of the Cascades. As a result, more utilities are integrating seismic assessments of infrastructure into their long-range planning.

However, small to medium sized water-related utilities typically have not yet focused on integrating climate resilience concerns into their planning processes. The reason for this appears to be a combination of factors: climate issues are less pressing to government officials and water-related utility managers than the threat of a magnitude 9.0 earthquake that could happen at any time; the states have not put as much focus and resources on the broader climate change issues in the water-related utility context; and climate issues get caught up in the politicization of climate change. A recent study of six cities conducted by researchers at George Washington University found that "strong political will among local officials to act on climate change was the most important factor that affected a city's ability to" undertake climate change planning.[9]

In addition, smaller utilities typically do not have staff to dedicate to an extensive climate change planning process. Because of this constraint, a more likely way to start resilience planning for climate change is to integrate it into existing planning processes. The sections below describe different planning processes that lend themselves to incorporating climate resilience planning. Using the vulnerability analysis done in Section II, utilities can assess and modify projects to reduce or mitigate the impacts of climate change.

1. Capital Improvement Plan (CIP)

The best opportunity for planning integration is through the Capital Improvement Plan (CIP) planning process. Best practice among water-related utility managers should be to incorporate meaningful long-term planning into the CIP process. For larger utilities, it sometimes is required. In the state of Washington, for example, any water utility with over 1,000 connections, as well as any new or expanding water utility, is required to prepare a CIP.[10] The plan must evaluate, among other things, "how the system will address present and future needs in a manner consistent with other relevant plans and local, state, and federal laws, including applicable land use plans." It must also include a 20-year "water supply reliability analysis."

CIPs often include the replacement of facilities and infrastructure that have reached the end of their useful economic service life due to conditions or age and where routine maintenance is no longer effective. This type of useful-life assessment could be modified to also include analysis of how the infrastructure will hold up to potential climate vulnerabilities. This can be done by staff or included in a Scope of Work (SOW) for a consultant. Projects that have high vulnerability can be modified and/or prioritized within the CIP.

EXAMPLE: **Yolo County Flood Control and Water Conservation District**

Yolo County Flood Control and Water Conservation District in California integrated resilience action items into a Capital Prioritization Worksheet in their CIP.

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[8] Oregon Seismic Safety Policy Advisory Commission. (2013). *The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami*. Salem, OR.

[9] Patterson, B. (2015, November 18). *Politicization of climate change hinders adaptation in cities—report*. Retrieved from http://www.eenews.net/stories/1060028192

[10] Washington Administrative Code WAC 246-290-100.

EXAMPLE: **City of San Francisco**

All capital projects in the city of San Francisco go through its Capital Risk Committee, which assesses seismic and sea level rise risk. An example of a project that went through this process was the Bay Tunnel project. This project included the addition of a fifth tunnel for the Hetch Hetchy Reservoir water supply. In performing the analysis, the city decided to raise the elevation of the shafts at either end of the bay once potential seismic and sea level rise impacts were taken into consideration. While this design change increased the project's initial cost, the additional upfront cost was lower than retrofitting the tunnel later would be.

2. Regional Planning

Small to medium size water utilities are particularly susceptible to adverse climate issues such as drought, forest fire and flooding, because their systems oftentimes lack redundancy. Large utilities more often have multiple water sources, for instance both reservoir and groundwater/wells. If there is a reduction of stream flows to fill a reservoir, the utility can rely more on groundwater to offset the reduction. Or the utility may have reservoirs geographically diverse enough to not be equally impacted by drought or sediment problems caused by flooding.

Small water utilities may be well served to replicate this sort of redundancy and flexibility by developing partnerships within their watershed. Regional watershed approaches are of great interest to state policymakers and many funders, including state revolving funds (SRFs). As a result, a utility may be more competitive in securing funding by participating in a regional approach. Regional approaches also create opportunities to broaden the team of partners, such as by including a nonprofit, which in turn may create additional funding opportunities. Similarly, regional approaches may provide a competitive advantage to one utility over another to the extent they are both seeking limited watershed planning and infrastructure funding.

EXAMPLE: **Kitsap Public Utility District in Washington**

Kitsap PUD is attempting to coordinate and partner with other water providers in their watershed to increase its resilience. It has developed a partnership with the adjacent Silverdale Water District. Each has their own reservoirs in different parts of Kitsap County where rainfall can vary significantly from east to west in the county. The two districts are connecting the reservoirs with a pipeline so that they can access the other's reservoir system when needed.

Kitsap PUD also has a joint application with a neighboring water district for state drought relief funds to drill a new well. The state may be more interested in funding a well project that creates greater resilience in two water utility districts rather than just one.

EXAMPLE: **San Francisco Bay Area IRWMP**

In 2013, the agencies providing water to the seven million people in the nine counties surrounding the San Francisco Bay incorporated climate change impacts for the first time into their Integrated Regional Water Management Plan (IRWMP). Chapter 16 of the plan focuses on assessing the potential climate change vulnerability areas of the region's water resources and identifying climate change adaptation strategies, with the overall goal of making climate change adaptation an overarching theme throughout the plan. The plan prioritized six vulnerability areas in the following order:

- Sea Level Rise
- Flooding
- Water Supply and Hydropower
- Water Quality
- Ecosystem and Habitat
- Water Demand

The potential impacts of each vulnerability area were discussed at the Bay Area level, and at each of the four regional levels (North, East, South and West). Regional adaptation strategies and performance metrics were identified for each vulnerability area. In addition, it was recognized that analysis needs to be done at the project level and include greenhouse gas baseline calculations, adaptation strategies, mitigation strategies and performance metrics.

EXAMPLE: **Santa Ana Watershed Project Authority (SAWPA**)

SAWPA uses a "one watershed approach" to planning. It includes six large water districts with over five million people. SAWPA's "one watershed" regional planning efforts begin at the Santa Ana River's headwaters and end at its Pacific Ocean outfall. The analysis considered the impact of fire on water retention and flooding, rechanneling and flood plain alterations, groundwater recharge and energy use.[11]

3. Asset Management Plans

Asset management plans are used by utilities to manage infrastructure and other assets to deliver a clearly defined standard of service. Typically, these plans will cover more than a single asset and take a system approach.

EXAMPLE: **Encina Wastewater Authority (EWA)**

EWA's Comprehensive Asset Management Plan (CAMP) includes asset-specific assessments that consider remaining useful life, likelihood of failure, consequences of failure, redundancy, replacement cost, risk probabilities and risk consequences. The CAMP includes climate-related risks and determined that EWA's key climate vulnerability was flooding from a river canal that goes through the middle of its plant. To depoliticize this risk assessment, the focus was on the climate risks and impacts rather than their causes.

4. Climate Resilience Plans

In addition to including climate resilience analyses into existing planning efforts, utilities can also create their own climate resilience plans without hiring dedicated staff. There are various types of climate resilience plans that can enable and encourage integration of climate impacts on smaller utility systems.

[11] United States Bureau of Reclamation. (2013, October). *Santa Ana Watershed Basin Study.* Retrieved from http://www.usbr.gov/lc/socal/basinstudies/OWOW.html

EXAMPLE: **Clean Water Services**

Clean Water Services (CWS) staff in Washington County, Oregon, began formulating a climate change adaptation strategy in 2012. First, staff created an interdepartmental working group. Then, this group defined the range of climate changes likely to impact the Tualatin Basin, considered how these changes may influence planning and operations, and generated a suite of responses that would likely allow CWS to maintain or improve its service levels. All this work was captured in a matrix that covered major operational areas and likely climate scenarios.

More recently, the working group surveyed the CWS's partners to ascertain how they are likely to respond to climate change in order to place CWS's needs and responses in a greater operational context. The survey included local, state and federal agencies with interests in the Tualatin Basin or Washington County.

This year, the working group is developing a strategy that focuses on data analysis, risk evaluation and reporting. This strategy will allow CWS to:

- Stay current with climate science and its potential impacts on the Tualatin Basin.
- Establish an operational baseline that allows CWS to formally recognize changes or trends related to climate change that may be significant.
- Observe trends and annually assess vulnerabilities brought on by climate change.
- Analyze the risk of climate change.
- Integrate climate change into high-level strategic planning and budgeting.
- Inform the public how CWS is impacted by and responding to climate change.

The working group came to the conclusion that while CWS is currently subject to extreme weather events driven by climate change, it is not subject to other impacts like sea level rise and diminished snowpack that many other utilities face.

B. Include Climate Resilience in Staff Job Descriptions

In addition to integrating climate resilience into core planning processes, another complementary approach is to begin developing internal staff expertise on climate resilience issues. Many utilities do not have the resources to devote full staff positions to climate resilience. However, for utilities facing this situation, it may be possible to start integrating resilience planning by slowly and incrementally augmenting staff understanding of and responsibility for these issues.

Rather than jumping into full scale planning from day one and needing a dedicated FTE or consultant, utilities can incrementally develop internal climate resilience understanding and expertise by writing aspects of climate resilience analysis into staff job descriptions. Eventually, such efforts can fully integrate climate resilience into a water-related utility's long-term planning, capital improvement strategy and asset management.

As staff builds internal expertise and begins to assess climate risk, accessing existing regional models of future climate scenarios may be beneficial as well. Modeling is becoming a standard practice in large water utility planning. However, location-specific modeling with a high degree of granularity is costly and complex. Typically, it requires the use of outside expert consultants and can cost tens of thousands of dollars. An alternate approach for small utilities is to take advantage of less precise, publicly available regional climate models. Whether such modeling is useful to a utility's particular situation will depend on whether such models address the concerns identified through a climate vulnerability assessment.

In sum, the most important step is to get staff talking about climate resilience through a process that executive management clearly supports. As that process develops, consider using publicly available modeling tools to the extent they are easily accessible and relevant. While models can be useful, they are not a necessary condition for becoming more climate resilient. What matters most is a commitment to exploring these issues and embedding these questions in a utility's decision-making DNA.

C. Make Climate Resilience Planning a Deliverable

Many smaller water-related utilities outsource parts of their planning processes to consultants. In such cases, it is essential to make climate resilience analysis a deliverable in a consultant's scope of work (SOW). For instance, in an SOW for an Integrated Regional Water Management Plan or an Energy and Management Plan, include a separate requirement that the consultant conduct a climate vulnerability and risk assessment of projects in the plan, and use that assessment to modify the character and prioritization of projects. Similarly, in an SOW for a Project Feasibility Analysis, require that an individual stand-alone project be subject to a vulnerability and risk assessment for climate change, and use the results to modify the project as needed.

D. Can the Core Issue Be Addressed through Green Infrastructure?

Green infrastructure projects increasingly are being seen as an attractive solution with respect to cost and climate resilience. The water-related utilities that have been pioneering them are reporting back that the systems typically cost less than the equivalent traditional ("grey") systems and they can perform as well or better. For example, Kitsap PUD in Washington considered the repair and expansion of a greywater treatment facility. However, the utility concluded that an alternative green system (a membrane bioreactor and wetland) would be less costly and more beneficial to the utility and the community. As a result, wastewater and stormwater will be treated through a natural filtration process into a wetland rather than treated with chemicals and discharged into Hood Canal. The District Manager indicated that the cost of the alternative green system was significantly less than a comparative upgrade to the water treatment plant. Also, it can be scaled as needed much easier than continued upgrades to a conventional treatment facility. It also provided other benefits to the local community by improving mollusk proliferation and harvesting in the area.

One disadvantage to green infrastructure is it often requires much more land than grey infrastructure equivalents. However, small water utilities tend to be located in rural geographies with sufficient available land for developing and scaling up green infrastructure projects. Examples of green infrastructure projects include:

- Recycled water irrigation systems
- Tree farms and re-vegetation programs
- Indirect discharge systems (e.g., filtered into the ground and not into a surface water body)
- Wastewater treatment ponds
- Natural treatment systems
- Water quality trading programs

For a short summary of green infrastructure projects in Oregon, see Natural Treatment Systems – A Water Quality Match for Oregon's Cities and Towns.[12]

[12] Oregon Department of Environmental Quality and the Oregon association of Clean Water Agencies. (2014). *Natural Treatment Systems – A Water Quality Match for Oregon's Cities and Towns.*

EXAMPLE: **City of Medford**

Medford, Oregon, is using a water quality trading program rather than conventional chillers to reduce its temperature impacts on the Rogue River. The trading program consists primarily of tree planting along the river and costs approximately $6 million whereas the estimate for chillers would have been almost three times more expensive. Also, scaling up the trading program if needed in the future is much easier (e.g., plant more trees) than expanding a chiller system. This makes the system more climate resilient to conditions such as increased storm events that could lead to greater need for water treatment.

EXAMPLE: **Roseburg Urban Sanitary Authority**

The Roseburg Urban Sanitary Authority in Oregon installed a natural treatment system (i.e., a wetland) at a cost of $9 million as compared to an estimate of $100 million for a conventional treatment system. As discussed in the Kitsap PUD example above, wetlands make the system more climate resilient by providing greater protection from storm surges than a conventional greywater treatment system. They can also be expanded at less cost as greater water treatment needs occur.

EXAMPLE: **Oro Loma**

In Oro Loma, California, a utility irrigated a sloped wetland area with treated, cleaned wastewater. The project has multiple co-benefits including a berm that provides resilience against sea level and storm surge, water use and habitat restoration.

E. Increase Customer Side Resilience

Facing increasing rate pressures from water supply issues, increased treatment costs and necessary infrastructure improvements, many water utilities recognize the need to get their customers to conserve water. Reducing demand is also one of the most cost-effective climate resilience measures available to water utilities. Water conservation programs accompanied with ratepayer education campaigns are an effective resilience measure that can also be ramped up to meet new challenges. For example, in response to record drought in the early 2000's, Denver and other water utilities in the region developed an aggressive education and outreach program for water users that was estimated to reduce per capita water use by over 10 percent.[13] Rate structures that are designed to charge higher rates with increased use also can be an effective water conservation and climate resilience tool. Helping users to understand that their reduced and more efficient use of water can help avoid costly infrastructure investments in the future can be an effective tool for reducing consumer use.

EXAMPLE: **San Diego Water Rate Sliding Scale**

Many large water utilities have developed sliding rate scales based on use. For example, San Diego charges a base rate of $3.896 per hundred cubic feet (HCF) for 0 to 8 HCF and increases in several steps to $6.234 per HCF for use of 25 to 36 HCF.[14]

[13] Lucke, D.F., Morris, J., Rozaklis, L., & Weaver, R. (2003, January). *What the Current Drought Means for the Future of Water Management in Colorado*. Retrieved from https://se.reis.com/learning/ColoradoDrought.pdf

[14] The City of San Diego. *Water Rates*. Retrieved from https://www.sandiego.gov/water/rates/rates/; See also, Las Vegas Valley Water District. *Water Rates*. Retrieved from https://www.lvvwd.com/custserv/billing_rates.html; Denver Water. 2015 *Water Rates*. Retrieved from http://www.denverwater.org/BillingRates/RatesCharges/2015-rates/; Irvine Ranch Water District. *Residential Water Rates*. Retrieved from http://www.irwd.com/services/residential-water-rates

F. Funding

Interviewees repeatedly stated that a lack of funding is one of the primary impediments to increased resilience planning efforts. Nonetheless, efforts should be made to identify potential funding sources. For instance, there may be limited funds available through mechanisms such as regional planning and State Revolving Loan Funds or Community Development Block Grants.

G. Messaging

There are two key messaging junctures to inform people and gain support for resilience planning. The first is garnering support to include resilience planning in existing core planning processes such as the CIP or regional planning process as discussed above. This is a relatively minor request as it will only add a small amount to a planning budget and could potentially be offset by grant funds. The second and more difficult ask is garnering support for actual infrastructure investments in ways that resonate with stakeholders. Strong messaging could highlight the cost of inaction and tie the importance of climate resilience investments to topics important to boards and ratepayers: e.g., improving public health and fostering healthy ecosystems.

> EXAMPLE: **City of San Francisco**
>
> San Francisco was faced with the daunting task of convincing ratepayers to make millions of dollars in investment to better protect infrastructure from earthquakes. The city was able to translate the costs into a tripling of water bills over a 15-year period and drilled down to specific uses of water. They told ratepayers that flushing a toilet would increase from 1 cent to 4 cents per flush – making the information more accessible. With extensive education and outreach, the city was able to garner strong support from the majority of its ratepayers despite the large increase in water bills.

IV. Reference Materials and Tools

Planning Resource Materials:

1. California Natural Resources Agency. (2015). *Safeguarding California: Implementation Action Plans.*

   The California Natural Resources Agency is seeking public comment on a draft plan for how California will prepare for and adapt to the catastrophic effects of climate change, including extended droughts and wildfires, rising sea levels and increasing extreme weather.

2. California Department of Water Resources. (2011). *Climate Change Handbook for Regional Water Planning.*

   Developed cooperatively by DWR, the U.S. Environmental Protection Agency, Resources Legacy Fund, and the U.S. Army Corps of Engineers, the Climate Change Handbook for Regional Water Planning provides a framework for considering climate change in water management planning. Key decision considerations, resources, tools and decision options are presented that guide resource managers and planners as they develop means of adapting their programs to a changing climate.

   The handbook uses DWR's Integrated Regional Water Management (IRWM) planning framework as a model into which analysis of climate change impacts and planning for adaptation and mitigation can be integrated. The handbook includes:

   - The science of climate change, tools and links;

- Evaluating the energy-water connection and greenhouse gas emissions;
- Assessing regional vulnerability to climate change;
- Measuring regional impacts;
- Evaluating projects, resource management strategies, and Integrated Regional Water Management Plans with respect to climate change;
- Implementing and quantifying uncertainty; and
- Case studies illustrating a range of climate change adaptation and mitigation issues within and outside of California.

3. **Water Utility Climate Alliance. (2010).** ***Decision Support Planning Methods: Incorporating Climate Change Uncertainties into Water Planning.***

   This document presents multiple outcome planning techniques to water utilities interested in incorporating climate change into their planning and advises utilities to integrate a four step approach: 1) Understand – understand climate science and climate model projections, 2) Assess – assess water system vulnerabilities to potential climate changes, 3) Plan – incorporate climate change into water utility planning, and 4) Implement – implement adaptation strategies.

4. **United States Environmental Protection Agency and United States Department of Agriculture. (2013).** ***Rural and Small Systems Guidebook to Sustainable Utility Management.***

   While the guidebook is general in nature, there are elements that focus on resilience and how to integrate sustainability/resilience planning into a small water utility.

5. **Water Environment Research Foundation. (2009).** ***Implications of Climate Change for Adaptation by Wastewater and Stormwater Agencies.***

   The report broadly concludes that temperate regions in North America generally should expect the following: winters that are shorter and warmer; summers that are warmer and drier; precipitation that occurs more frequently in high-intensity events; rising sea levels.

6. **The Johnson Foundation at Wingspread. (2014).** ***Navigating to New Shores: Seizing the Future for Sustainable and Resilient U.S. Freshwater Resources.***

   This document recommends that water related utilities: (1) optimize the use of available water supplies, (2) transition to next-generation wastewater systems, (3) integrate the management of water, energy and food production, (4) institutionalize the value of water, and (5) create integrated utilities.

7. **Portland Water Bureau. (2015).** ***Climate Risks to Water Utility Built Assets and Infrastructure: A synthesis of interviews with national and international water utilities.***

   The document provides a recent summary of issues being addressed by numerous large scale utilities in the United States, the United Kingdom and Australia.

8. **State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience. (2014).** ***President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience: Recommendations to the President.***

   This document provides recommendations on how the federal government can respond to the needs of communities nationwide that are dealing with the impacts of climate change by removing barriers to resilient investments, modernizing federal grant and loan programs to better support local efforts and developing the climate change information and tools that local communities need.

9. American Society of Civil Engineers. (2015). *Adapting Infrastructure and Civil Engineering Practice to a Changing Climate.*

   This document provides guidelines for incorporating climate change considerations. It identifies the technical requirements and civil engineering challenges raised by adaptation to a changing climate.

10. Australian Centre of Excellence for Local Government, City of Canada Bay, & RPS Group. (2014). *Climate Adaptation Manual for Local Government – Embedding resilience to climate change.*

    This document contains many links to useful case studies.

11. Kennedy/Jenks Consultants, Environmental Science Associates, Kearns & West, & Zentraal. (2013). *San Francisco Bay Area Integrated Regional Water Management Plan.*

    This document is an example of integrated water resource management planning.

12. Associated Engineering. (2011). *City of Calgary Water Supply Infrastructure: Climate Change Vulnerability Risk Assessment.*

    The Calgary study used a protocol developed by the Public Infrastructure Engineering Vulnerability Committee to guide climate change vulnerability assessments. The protocol is based on standard risk assessment methodologies. It provides a methodology to gather information and data, which are subsequently used to understand relevant climate effects and their predicted interactions with infrastructure.

Planning Tools:

13. United States Environmental Protection Agency. *Climate Resilience Evaluation and Assessment Tool (CREAT).*

    This risk assessment tool created by the EPA allows water utilities to evaluate potential impacts of climate change. Users can also identify adaptation options to address impacts using both traditional risk assessment and scenario-based methods. CREAT provides: lists of drinking water and wastewater utility assets (such as water resources, treatment plants, and pump stations) that climate change could impact; possible climate change-related threats (such as flooding, drought, and water quality); adaptive measures that utilities can implement to reduce potential impacts. It has gone through several iterations and the EPA is completing revisions to version 3.0 this year.

    To use CREAT, utilities must first enter information about their utility into one of five modules in the tool. Based on location, the tool then provides historical and projected climate data (temperature and precipitation) at 32 kilometer resolution. The climate data are used to generate climate scenarios and climate threats (e.g., flooding, drought, number of hot days) in another module. Utilities then specify their main concerns related to climate change or extreme weather (e.g., water quality, reservoir storage, saltwater intrusion) in subsequent modules.

    In order to quantify the risk to assets and infrastructure, the tool then has a module that uses benchmarking data and industry surveys provided by the EPA and the American Water Works Association to determine consequence and risk to assets from climate threats. Each asset has to be manually entered into the tool in order to quantify the risk (a database of assets cannot be uploaded). These data are then used to monetize risks to assets before and after adaptation. In addition to the default climate projections and data on asset replacement values, the tool is completely customizable, so utilities that have downscaled climate data or specific asset data they want to apply can use these instead to quantify risk costs. CREAT is free and data are stored at offsite servers.

14. Cal-Adapt. *Local Climate Snapshots.*

This tool provides resilience modeling for communities in California concerning climate issues such as snowpack changes, wildfire likelihood and temperature and sea level rise.

15. University of California, Davis; California Department of Water Resources; & United States Environmental Protection Agency. (2014). *The California Water Sustainability Indicators Framework.*

This document provides a toolbox, useful templates, and a set of illustrative examples for water utilities and regions to conduct water sustainability analysis for local and regional water management. By utilizing the framework, local and regional water and other agencies will be able to improve their sustainability through an evaluation of condition and trends of relevant indicators reflective of their particular needs.

16. United States Environmental Protection Agency. *Vulnerability Self-Assessment Tool (VSAT) 6.0.*

This tool enables drinking water and wastewater utilities to enhance their security and resilience by identifying the highest risks and the most cost effective measures to reduce those risks.