Executive Summary

Long Term Vulnerability Assessment and Adaptation Plan for the San Francisco Public Utilities Commission Water Enterprise - Phase I (4703)

ES.1 Key Findings

Overall, the study found that:

- Climate change exacerbates impacts from other external drivers of change and is not the single most important driver of vulnerability for the San Francisco Public Utilities Commission's (SFPUC's) Regional Water System (RWS).
- The RWS at a baseline demand of 227 mgd is resilient to changes in climate and other external drivers.
- The RWS water supply performance declines with reductions in mean precipitation, but is mostly insensitive to increases in temperature.
- The RWS is more vulnerable to changes in demand and instream flow requirements than changes in mean annual temperature and precipitation.
- The RWS is vulnerable to changes to mean climate when demand or instream flow requirements increase.

ES.2 Background and Objectives

To help better understand the potential vulnerability of the SFPUC RWS to uncertain future conditions, SFPUC partnered with The Water Research Foundation to develop a long-term vulnerability assessment (LTVA) of the RWS. The study was conducted by University of Massachusetts Hydrosystems Research Group (HRG) with input from National Center for Atmospheric Research (NCAR), other climate scientists, and Deltares.

The goal of the LTVA is to help quantitatively and qualitatively assess to what extent climate change will be a threat to the RWS in comparison to, or in combination with, other external drivers of change over the next 50 years (2020-2070). More specifically, the assessment aims to answer the following questions:

- Under what conditions and when will the RWS no longer meet system performance criteria?
- Is climate change the most important driver of vulnerability for the RWS and if not, what is?

While climate change is the driver of change that triggered this study, the intent is to understand the effects of climate change in the context of effects from other drivers of change on the RWS.

ES.3 Project Approach

The LTVA was performed using the decision scaling approach whereby vulnerabilities are first identified and used as a basis for assessing risks. The analysis includes a multi-dimensional quantitative stress test and qualitative scenarios in which sources of vulnerability are revealed through testing against changing conditions. A suite of computer models of the RWS was created, calibrated, and used to estimate the system performance under a range of future and/or unexpected conditions. Models were developed to simulate changes in climate and weather, hydrology of each of the contributing watersheds, operations of the RWS, long-term demand, raw water quality, and finance. Narratives or qualitative scenarios were designed to investigate the effects of instream flow requirements and failures of key infrastructure components. A series of performance metrics and targets was used to reveal vulnerabilities of the RWS water supply.

Boundaries of temperature and precipitation changes were set for the stress test from reviewing climate projections and findings from an elicitation workshop of climate science experts organized by SFPUC. Temperature changes of up to +7 °C above historical baseline (1986-2005) and precipitation changes from -40% to +40% of historical baseline were examined. A range of demand changes above baseline was evaluated. The narratives developed included five new instream flow requirements (IFR) and four critical infrastructure outages across different parts of the RWS.

ES.4 Results

- According to climate projections and expert elicitations, there is a central tendency of warming of +2°C and +4°C by 2040 and 2070 (Representative Concentration Pathway [RCP] 8.5), respectively, with no clear direction of change in mean annual precipitation over the planning horizon.
- In the Upcountry region, by 2040, most projections and elicitations of warming estimate between +1°C and +4°C, and precipitation changes between -5% and +5% compared to historical baseline; and by 2070 estimates of warming range between +3°C and +6°C, and precipitation changes range between -15% and +15% (RCP8.5).
- Changes in hydrology due to climate change affect the RWS's ability to meet water supply targets[1]. At 227 mgd baseline demand, the RWS can sustain up to +4°C and -5% precipitation change before failing to meet targets for delivery reliability, frequency of 20% rationing, storage reliability, and duration of rationing.
- Precipitation change is an important driver for RWS performance. A decrease by 10% or more will cause RWS targets to be missed. The climate projections and expert elicitations show that such a change in precipitation is possible by 2040, although unlikely. The likelihood of this change increases toward 2070.
- The RWS shows minor sensitivity to temperature change for the metrics evaluated in this study. Most metrics stay above target under warming conditions. However, warming conditions often magnify the loss in system performance if precipitation or demand change.
- Demand change appears to be a major driver of future RWS performance. An increase in demand by 15% (265 mgd) will lead to failure to meet rationing frequency targets under current climate conditions. At 265 mgd demand, the rationing frequency targets would be met if there is an increase in precipitation of 10%. If demand increases by 30%, the rationing target cannot be met even when precipitation increases by 40%, which is believed plausible but unlikely over the planning horizon.
- The RWS is particularly vulnerable to the state-adopted new IFR below Don Pedro Dam (State WQCP), which represents a significant reduction in water available. At a demand of 227 mgd, the effect of state-amended WQCP under current conditions is equivalent to a reduction in mean annual precipitation of about 15% in terms of the water delivery reliability (reliability around 85%, rationing in 1 out of 6.5 years on average).

ES.5 Benefits

There is great concern among the public and water professionals regarding the potential implications of a changing climate on the future of water supply. Yet, the water supply industry is currently struggling to characterize the effects of future climate change on systems and to incorporate climate change considerations

[1] Due to the limitations of the models, these results are likely understating the impact of climate change. Next steps will include improvements on these models to address the bias in the current versions.

into their long-term planning. This report provides a detailed case study of the decision scaling methodology, which provides a systematic approach for addressing climate change concerns while also incorporating non-climate considerations. The case study illustrates the application to the SFPUC RWS, a large, complex water supply system spanning the width of California. The result is a vulnerability assessment that reveals clear thresholds of climate change that are problematic while using climate projections to inform rather than drive the analysis. The report demonstrates methods for using climate stress testing and qualitative scenarios of demand change, new regulation, and infrastructure failure to reveal vulnerabilities singly and in combination. The report shows how climate change projections and expert elicitation from climate experts can be used to assess a level of concern associated with vulnerabilities. The analysis reveals the vulnerability of the system to specific climate changes and shows the relative effect of climate change versus other uncertain factors. The result for SFPUC is a clear vision of priority considerations for long-term planning.

Related WRF Research

Project Title	Research Focus
An Integrated Modeling and Decision Framework to Evaluate Adaptation Strategies for Sustainable Drinking Water Utility Management Under Drought and Climate Change (4636)	This project developed an integrated framework to assess water quality and availability impacts for a suite of climate and natural hazards in the water supply watershed, along with evaluation of decision options.
Impacts of Climate Change on Honolulu Water Supplies and Planning Strategies for Mitigation (4637)	This project evaluated climate change impacts on the Honolulu Board of Water Supply and its assets, and developed a suite of management and treatment strategies to address the anticipated changes. This project delivered an adaptive management plan for Honolulu based on climatic and hydrologic modeling, scenario modeling, and evaluation of adaptive management strategies.
Improving Tradeoff Understanding in Water Resource Planning Using Multi-Objective Search (4941)	Water utilities commonly use simulation models to inform decision making, with time frames ranging from long-term planning to near-term system operations. Those models can be complex, and identifying the preferred decisions or options among many alternatives is challenging. Multi-objective evolutionary algorithms (MOEAs) are complementary tools used to generate alternatives for such planning problems by linking with existing simulations models. This project conducted four utility case studies to demonstrate how MOEAs can be set up and used to extract greater system insights and also whether alternative problem formulations result in similar, worse, or better system performance with regard to decision-making processes. This collection of case studies describes different drinking water supply systems and planning challenges, and how the MOEA tools were used to help analyze tradeoffs.
Mapping Climate Exposure and Climate Information Needs to Water Utility Business Functions (4729)	This project developed a comprehensive, enterprise-level framework and a guidebook for understanding the exposure and sensitivities of water utility business functions to a changing climate. The water utility business risk and opportunity framework is applicable to a range of utility sizes, impacts, and functions. Though this framework

Related WRF Research	
Project Title	**Research Focus**
	specifically focuses on drinking water utilities, its approach has broader applicability across a variety of utility types. The application of the framework and guidebook can accelerate the incorporation of climate considerations into everyday utility management.
Water Utility Planning Strategies to Mitigate Impacts of Climate Change in Central Ohio (4585)	This project produced a suite of management and treatment strategies that water suppliers can apply to address anticipated changes in source water quantity and quality due to climate change. The project focused on climate change impacts in central Ohio and the eastern portion of the Midwest, but the approach and considerations from this project have broad applications throughout the region and the country.

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Project 4703 **December 2021**