UCLA Luskin Center for Innovation
UCLA Sustainable LA Grand Challenge
UNIVERSITY OF CALIFORNIA Agriculture and Natural Resources

Water Systems' Wildfire Fighting Capacities and Expectations

WORKSHOP SYNTHESIS REPORT

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REPORT

UCLA Luskin Center for Innovation

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Cover photo: Water Systems’ Wildfire Fighting Capacities and Expectations Workshop (August 18, 2025). Edith de Guzman

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CONTENTS

EXECUTIVE SUMMARY

Wildfires are becoming more frequent, intense, and destructive across the western United States, sharpening public attention on the performance and responsibilities of urban water systems during major fire events. Although water distribution systems are designed primarily to provide drinking water, domestic supply, and support for routine structure fires, recent disasters—most notably the January 2025 Los Angeles fires—have fueled unprecedented expectations for their role in fighting large urban wildfires. This report synthesizes insights from the first workshop in the UCLA and the UC Agriculture and Natural Resources' Water Supply + Wildfire Research and Policy Coordination Network, which convened 42 experts representing water agencies, fire services, regulators, researchers, and technical assistance providers.

Participants reached a strong consensus that water systems have a limited and inherently constrained role in wildfire suppression. Hydrants, storage, and pipe networks are neither required nor engineered to deliver the sustained flows and pressures required to stop fast-moving, multi-block fires. Yet public perception, misinformation, and fragmented communication have created unrealistic expectations and, at times, misplaced blame. Workshop discussions emphasized the need for clearer communication with policymakers and the public; improved coordination among water systems, fire agencies, and emergency response entities; and careful evaluation of trade-offs in proposed infrastructure or operational interventions.

The workshop surfaced opportunities, such as regional mutual aid, backup power enhancements, infrastructure hardening, and planning exercises, alongside uncertainties about statewide standards, liability, and funding. Participants also highlighted gaps in evidence, including the absence of cost-benefit analyses of interventions, limited cross-case data on system performance, and a lack of systematic frameworks to guide decision-making.

This report summarizes key themes, outlines categories of potential interventions, and highlights illustrative case studies from across California and beyond. It concludes by identifying research and policy priorities for strengthening water system preparedness, response, and recovery in a fire-prone future.

1. INTRODUCTION

The intrinsic human understanding that water can help put out fires has been around since time immemorial. As populations have grown and development has altered landscapes, the human relationship with water as a natural resource, too, has changed. The United States has some 50,000 community water systems—used interchangeably with water supply systems for the purposes of this report—many of which were initially formed to provide water for routine firefighting in addition to providing water for domestic use and outdoor watering (National Research Council, 2006). However, the specific obligation of water supply systems in helping to put out major conflagrations or wildfires has only more recently received attention in scholarly research and in policy and public discourse.

Within water supply systems, water distribution systems or networks (WDSs) are the vast majority of the physical infrastructure and are designed to provide end users with drinking water and ensure appropriate quantity and quality. Typical urban water supply systems consist of conveyance infrastructure, water treatment facilities, distribution networks, local storage facilities, pressure regulation and pumping systems, and network segmentation devices such as valves. Following treatment, water is moved through a branching pressurized pipe network that is designed specifically to meet the needs of the local topography, end users, and demands.

For many decades, communities and local governments have designed and relied upon water supply and distribution systems to help fight localized structure fires. Guidelines for system design account for the water needed to fight such fires. For example, the American Water Works Association (AWWA) Manual M31 provides methods for pipe and storage sizing to accommodate the combined demand of the peak-daily demand plus necessary fire flows. However, this capacity falls short when wildfires occur because they demand greater volumes and sustained pressure beyond system design requirements. Fire hydrants—generally spaced at 500-ft to 800-ft intervals to meet state and national standards such as those set by the National Fire Protection Association—are primarily optimized to fight structural fires and cannot deliver the sustained flows and coverage required to manage large-scale fire events.

In the past decade, the importance of the wildfire-water supply system relationship has grown as wildfires across the nation—including in Colorado, Oregon, Hawaii, Arizona and, most recently, California—have revealed the extent to which fire can disrupt water supply and distribution systems, and foreshadowed an era of changing expectations of those systems in suppression of larger, more destructive fires. The UCLA Luskin Center for Innovation and UC Agriculture and Natural Resources (UC ANR) began to address early questions related to water system preparedness for increasingly catastrophic wildfires in urban areas in 2021, holding an in-person workshop and authoring a report, *Wildfire and Water Supply in California.*

In the wake of the January 2025 Los Angeles fires, a dramatic shift in rhetoric related to water systems occurred. Although water supply is only one element of wildfire fighting, and may not be the highest priority for investment from a cost-benefit perspective, heightened policy and public discourse around water supply systems' operations during wildfires raised new and unprecedented expectations for water systems. With little research conducted in this space, the

Luskin Center for Innovation and UC ANR have begun studying these issues extensively and initiated the Water Supply + Wildfire Research and Policy Coordination Network (Network) to facilitate collaboration and discourse. The Network, primarily funded and supported by UCLA's Climate and Wildfire Research Initiative, was launched in March 2025 and aims to strengthen preparedness and recovery at the water-fire nexus.

Our Network has previously documented that misinformation and a fractured media environment has fueled the interest, outrage and raised expectations for water supply systems to fight wildfires. At the same time, a lack of clear communication by the water sector on urban water systems' function and inherent limitations—a long-standing, recognized problem—has further fed the confusion. It is widely understood in the water and disaster response sectors that no water system can reasonably be expected to "stop" large urban wildfires. While this reality has yet to be fully understood publicly, the recent state agency investigations and Fire Safety Research Institute reports independently came to similar conclusions as our work has in the context of the Los Angeles fires: Water distribution systems in cities cannot be sized and maintained to deliver water of sufficient quantity to meet demands during a catastrophic urban wildfire event (California State Agencies, 2025; Kerber et al., 2025).

Our Network's research and related activities include a series of workshops to investigate both challenges and potential solutions in this space. This report covers the first of these workshops, held in Sacramento, CA, in August 2025. Participants in the workshop agreed that water system infrastructure improvements must be coupled with "soft" solutions for land-use planning, managerial innovations, and emergency response and preparedness. This points to the need for a holistic approach, considering an integrated system analysis for design and management where both hard and soft interventions work together to increase resilience to wildfires.

Yet, a challenge remains: While standards for water supply availability to combat structure fires are codified in housing codes, there are no standards for urban water systems to fight large urban wildfires. Additionally, water supply systems have only been expected or required to fight more modest urban structure fires. Given the mix of expectations, constraints, and unanswered questions in this space, this first workshop focused on the capacity of and expectations for water systems to improve wildfire mitigation and resilience. This was the first in a series of four workshops, which will be held through fall 2026, described further below.

The goal of the August 2025 workshop was to examine the feasibility and wisdom of further investing in various centralized and decentralized water distribution system infrastructure and technology interventions. However, our intent with this workshop was not simply to discuss these categories or specific parameters; rather, we used the workshop to facilitate three higher-level discussions which are necessary to help contextualize debates regarding the merits of specific wildfire-fighting interventions that are more technical in nature.

These discussions begin to answer the following questions to inform policy and planning efforts:

- How can individual systems help evaluate and implement investments from an extensive list of potential interventions?

- What key considerations do water systems need to keep in mind when evaluating investment trade-offs for firefighting versus other critical needs?
- What is the role for statewide guidance, standards, and frameworks related to water supply and wildfire fighting?

This report summarizes themes and insights from the workshop and workshop-related activities, and articulates remaining gaps in understanding. In addition to this report, the workshop had four other outputs:

- The workshop **facilitated conversations and collaborations** among individuals and entities working on the water supply-wildfire fighting issue.
- It formed the basis of **a blog we published** in September with early insights from the workshop (Pierce, Porse, et al., 2025).
- It produced a **system-level intervention evaluation worksheet** for potential broad public use and iteration, which we first tested during the workshop, and which forms an Appendix A to this report.
- Finally, we are working on a **peer-reviewed paper** focused on the topic of state oversight of water systems discussed in the workshop and summarized in the Cross-Cutting Takeaways section below.

We aimed to invite and capture wide representation and participation in the workshop from relevant experts and interested parties, but we also acknowledge that the perspectives and insights contained in this report reflect the views of the authors and those of the workshop participants, as synthesized by the authors.

We recognize that this field remains highly dynamic, with topics of interest and incremental findings continuing to emerge, and that this effort contributes to a changing landscape of research, policy, and practice. Given the scope of this workshop and report, we were unable to conduct a systematic comparison of approaches or conduct cost-benefit analyses of specific water supply enhancements for firefighting, much less across broader wildfire mitigation strategies. Additionally, there are examples of cities in California that have procured dedicated systems to manage large urban fire events resulting from disasters such as earthquakes and wildfires, but the workshop did not discuss detailed case studies of the benefits and costs of building or maintaining these systems. As a result, it remains difficult—and was beyond the scope of our effort—to narrow down recommendations for industry- or system-level application without further study.

Given the interdisciplinary and intransigent nature of many of the problems that are facing water supply systems as they engage in wildfire fighting efforts, we welcome further focus and engaged research efforts in this space by other scholars.

2. STRUCTURE OF WORKSHOP, SUPPORTIVE RESEARCH ACTIVITIES, AND REPORT

This report summarizes an in-person, full-day workshop entitled “Water Systems’ Wildfire Fighting Capacities and Expectations.” We held the workshop in downtown Sacramento at the UC Sacramento Center on August 18, 2025. We had 42 participants (see Figure 1) representing water systems, water industry associations, nonprofit organizations, regulators and legislators, technical assistance providers, fire protection experts, engineering consultants, and researchers from across California and beyond.

FIGURE 1

Workshop 1 Participants

Faith Kearns Arizona State University	**Robert B. Sowby** Brigham Young University	**Ope Oyewole** California Council on Science and Technology	**Julie Ekstrom** California Department of Water Resources	**Darrin Polhemus** California State Water Resources Control Board	**Laura Fisher** California State Water Resources Control Board	**Jason Spotts** California State Water Resources Control Board	**Yuji Marsh** California State Water Resources Control Board
Sarah Musiker California Water Association	**Jennifer Capitolo** California Water Association	**Philip Bogdanoff** City of Anaheim - Public Utilities	**Chad Seidel** Corona Environmental Consulting, LLC	**Terre Logsdon** County of Lake	**Maureen Kerner** EPA R9 Environmental Finance Center at Sac State	**Kyle Shimabuku** Gonzaga University	**Willie Sapeta** Lake County Fire Protection District
Newsha Ajami Lawrence Berkeley National Laboratory	**Michelle Newcomer** Lawrence Berkeley National Laboratory	**Evelyn Cortez - Davis** Los Angeles Department of Water & Power	**Steven Cole** Los Angeles Department of Water & Power	**Morgan Shimabuku** Pacific Institute	**Alix Stayton** Public Water Agencies Group	**Lisa Yamashita - Lopez** Rubio Canon Land & Water Association (PWAG member)	**Darcy Bostic** Rural Community Assistance Corporation
Adam Cooper Senator Ben Allen	**Tori Klug** Stantec Consulting Services	**Kim Boyd** Tahoe City Public Utility District	**Sean Barclay** Tahoe City Public Utility District	**Hope Hauptman** UC ANR	**Camilo Salcedo** UC ANR - California Institute for Water Resources	**Kristin Dobbin** UC Berkeley/UC ANR	**Ariana Hernandez** UCLA Luskin Center for Innovation
Greg Pierce UCLA Luskin Center for Innovation	**Edith de Guzman** UCLA Luskin Center for Innovation/UC ANR	**Jason Islas** UCLA Sustainable LA Grand Challenge	**Sophie Katz** UCLA Sustainable LA Grand Challenge	**Amanda Fencl** Union of Concerned Scientists	**Esther Lofton** University of California Cooperative Extension	**Alesandra Najera** Water Foundation	

Before the workshop, we sent participants a pre-workshop packet of background materials that included a draft agenda and objectives for the workshop process. We used participants’ feedback to help refine discussion considerations before the workshop. Our detailed day-of workshop agenda is posted on the website of UCLA’s Sustainable LA Grand Challenge. The workshop included panels with experts, collaborative activities, and open discussion.

Our working group committee of experts from UCLA, UC ANR, and Arizona State University facilitated the workshop. Erik Porse and Gregory Pierce began the event by framing the day’s focus. In the morning, Camilo Salcedo led a panel discussion of experts on how to think comprehensively, but realistically, about water distribution systems. Pierce then kicked off a focused discussion, informed by four expert lightning talks, on potential options for state-level best practices and standards to assess water systems’ wildfire fighting capacities.

In the afternoon, Edith de Guzman and Faith Kearns led a guided exercise for small, rotating participant groups, using a worksheet focused on specific water system priorities and constraints for enhancing their wildfire fighting capacity. Kearns then led an open reflection on themes of the day, and Porse closed the day with reflections.

Although the list of participants in the workshop is public, the workshop employed the Chatham House Rule to encourage frank conversation during the discussions—that is, the workshop conversation was confidential with respect to individual statements by participants. Accordingly, no statements at the workshop are publicly attributed by name or organization. The UCLA–UC ANR research team took detailed notes, and the recording of themes and insights in this report attempts to remain as true to participants' original statements as possible, even without specific attribution. In addition, some workshop participants are directly collaborating in follow-on research from the workshop, including a peer-reviewed paper on statewide oversight of water systems for future wildfire preparedness and fighting.

As described above, this workshop is the first in a series co-facilitated by the UCLA Luskin Center for Innovation and the California Institute for Water Resources at UC ANR, as part of the Urban Water Supply + Fire Research and Policy Coordination Network. The remaining workshops in the initial series will be structured similarly, and have a similar mix of participants, although invited participants are not identical across all workshops. The topic and timing of all workshops is outlined in Figure 2.

Credit: Edith B. de Guzman

FIGURE 2

Workshop Series Topics and Timeline

01
WORKSHOP 1
Water Systems' Wildfire Fighting Capacities and Expectations (August 18, 2025)

02
WORKSHOP 2
The Economics & Affordability of Water System Firefighting (January 23, 2026)

03
WORKSHOP 3
Drinking Water Quality, Trust, & Communications (April 24, 2026)

04
WORKSHOP 4
Water, Urban Vegetation, & Wildfire (September 2026)

The remainder of this report is structured as follows: Section 3 summarizes major themes emerging from the workshop, especially the opening panel and lightning discussions, which cut across water supply system intervention categories to potentially fight wildfires. We categorize these themes using a simple Consensus ↔ Disagreement spectrum to characterize themes. Section 4 analyzes insights on the five intervention categories from the system-intervention focused worksheet utilized for discussion in the second half of the day. Section 5 discusses the implications and limitations of our approach and the insights yielded from this workshop process. Finally, Section 6 concludes with brief, forward-looking remarks.

3. CROSS-CUTTING TAKEAWAYS

3.1. Consensus: Water Systems' Limited Role in Wildfire Fighting

Of all points discussed during the workshop, participants reached strongest consensus that water supply systems should have a very limited role in fighting wildfires—and likely could not have a significantly larger role, even with substantial investment. Given this common understanding, workshop participants expressed surprise at the scale and level of public and policymaker reaction to water systems' role in the January 2025 wildfires, and specifically the impression that water supply systems had somehow underperformed.

No workshop participant supported the notion that water systems are currently equipped to fight wildfires, or that the water systems involved in the January 2025 wildfires had failed to carry out core responsibilities. Again, these findings are directly echoed in the recently released state's investigative and the Fire Safety Research Institute reports on the Los Angeles wildfires (California State Agencies, 2025; Kerber et al., 2025). Participants drew on their expertise and experience to emphasize that water systems—even "super-sized" ones—cannot extinguish very large, fast-moving fires. As is widely understood in the water and disaster response sectors, participants at the workshop unanimously echoed the idea that no water system can reasonably be expected to "stop" large urban wildfires.

Some workshop participants repeatedly pointed out that fire hydrants are not designed to meet the demand of fighting large-scale wildfires involving entire blocks or neighborhoods. The water system industry standard is that a system can only accommodate a handful of fire

Credit: Faith Kearns

hydrants in use at one time. Thus, during a large urban wildfire event, it is not surprising that fire hydrants will temporarily lose pressure or “run out of water” as reported by media outlets like the Los Angeles Times (e.g., Hamilton et al., 2025). Although reporting generally explained that hydrant pressure losses during the fire were predictable given high demand, depleted storage, and topographic limitations, public discourse frequently highlighted the issue as alarming or unacceptable, as reflected in social media and other modes of commentary. Given the demands that systems face during urban wildfires—the scale and speeds of which have been increasing—this phenomenon is far from unusual; it is to be expected. In the case of the Los Angeles fires, it did not reflect a shortage of water in the system or region. Instead, it relates to the timely availability of water that can be delivered to areas of need. Within water distribution systems designed to manage both quality and quantity, peak flows are regulated by the size of pipes, which cannot be easily scaled up during disaster events when demands increase and pressure often decreases.

It may not be surprising that the workshop participants, many of whom represented water systems, unanimously held these opinions. However, participants from other sectors—who often disagree among themselves and with water systems on various policy and planning topics—also endorsed this view. This demonstrated significant agreement regarding systems’ limited role in fighting wildfires.

This prevailing sentiment was by no means a call to inaction, but rather, to a proper focus on where the most effective action could take place. Participants generally agreed that wildfire prevention should be the biggest focus but that it is also a significant challenge, pointing to a need for water systems to undertake further concerted efforts with land managers, conservancies, and other actors to collaborate on mitigation efforts. Ultimately, participants thought that the majority of preparedness actions—especially regarding fire prevention—are not the responsibility of water systems.

Participants expressed a high degree of interest in and potential support for specific wildfire mitigation and fighting interventions to improve water supply systems’ ability to fight wildfires, which are discussed below in detail. However, they generally concluded that water system interventions are not the most cost-effective approach and would require further evidence before being invested in at scale. There was broad agreement that systematic cost-benefit and trade-off analyses—both for water supply enhancements for firefighting and other wildfire mitigation techniques—have not been rigorously conducted and that developing industry-wide recommendations would require further study.

3.2. Near Consensus: The Role of Communication to Influence Perceptions on Water Systems’ Responsibilities

Throughout the workshop, communication to the public and policymakers emerged as a central recurring theme that participants saw as both a key vulnerability and a major opportunity for improving fire and water system resilience. Participants described challenges that ranged from internal coordination to public understanding to policy awareness; however, they often disagreed on how and whether to act in response.

Many participants highlighted the need to strengthen both internal and interagency communication, noting that relationships between fire services and water agencies are often *ad hoc* and inconsistent. Several proposed strengthening working relationships and real-time communication in an effort to improve preparedness and response speed.

Others focused on communication with the public, expressing frustration about gaps in awareness. “[I am] constantly surprised by the lack of knowledge from community members around water systems and wildfire. People don’t understand that drinking water systems are not actually legally required to provide water for firefighting,” one participant said, reflecting on how limited public understanding of system functions and legal mandates can create unrealistic expectations and strain relationships during crises.

Keeping expectations realistic about the abilities of water distribution systems to fight wildfires requires educating residents and communities on what systems can and cannot do. The lack of knowledge about the operation and capabilities of water systems has generally created a sense of suspicion and loss of trust from the public. To address this issue, suppliers have implemented various initiatives, such as “Water Wednesdays,” to educate people and share relevant information about the capabilities of water infrastructure.

Participants also described a parallel challenge with policymakers and legislators, who often do not have direct technical experience but whose decisions shape water system operations. One participant observed that “someone is writing policies on environmental legislation without any background in these topics.” The frustration was clear: Effective policy communication is necessary but time-consuming and has uncertain results. One respondent questioned, “How much time should we allocate to trying?”

While communication was consistently named as a need, some participants also acknowledged its limitations. They cautioned that public communication is frequently treated as a universal remedy and something that can fully prevent or address misinformation or systemic failures, but that in practice, communication is not a silver bullet and cannot substitute for other resources.

Participants also recognized that effective communication is a relational endeavor that requires sustained funding and structure. Today’s communication landscape is more complex and fragmented than ever and requires expertise and dedication. Even well-planned outreach efforts falter when under-resourced. And, as one person noted, there is rarely a “champion organization that can support outreach, messaging, and coordination.” Some suggested creative partnerships with media to help bridge limited institutional capacity, but others noted that the media are also severely under-resourced.

In sum, communication was described as both indispensable and insufficient. It is essential for preparedness and coordination, yet not a substitute for the material investments that make systems operational and resilient. Our third workshop in this series of four will further explore the possibilities and limitations in approaches to improve communications related to trust around water quality and during fire-event behavior.

3.3. Near Consensus: Water Systems' Physical Limitations and Trade-Offs in Wildfire Fighting

Public expectations for water system infrastructure to support wildfire fighting have grown. But there are many limitations and trade-offs that affect systems' ability to provide this support while fulfilling their other core responsibilities, as participants discussed throughout the workshop. For example, in recent events, the public raised concerns that hydrants ran out of water, rendering them incapable of stopping wildfires. However, because hydrants are placed at most 800 ft apart from each other, they are only capable of fighting local fires at a block level. Opening a hydrant creates large localized demands in the water network. Thus, when multiple are open simultaneously, water demands may reach system design limits. In addition, increased flow reduces water pressure in the pipes, which can trigger major pressure drops that could take some areas of the system below the minimum service pressure. In the aftermath, when multiple hydrants are opened simultaneously and without coordination during a wildfire event, the system's capacity is consequently depleted dramatically (see our FAQ for more information; Pierce, Kearns, et al., 2025). This example and other limitations and trade-offs explain why water systems have not been optimized to fight wildfires.

Urban water distribution system infrastructure is built to meet a particular demand through a unique and fairly rigid configuration of pipes, storage tanks, and other components, paralleling the footprint of the city. It is more costly to modify existing infrastructure in major ways than to add to it. Thus, increasing the resilience and capacity of water systems for wildfire response requires a careful cost-benefit analysis, considering multiple factors and trade-offs. For example, the added capacity can increase the time that water is stored and thereby degrade water quality because these new volumes may never be used.

Participants discussed not only which wildfire fighting solutions are most efficient, but also when these solutions should be implemented. Panelists in the workshop's morning session expressed that the most effort should be put into the weakest and most challenging component to address, which is in the preparedness of the systems prior to the wildfire. Participants also highlighted the importance of interventions supporting a quick recovery of the water system, instead of just prevention or in the moment of response. Once the wildfire is overcome, it is essential that the system works promptly to meet its most important task: to deliver safe water to consumers. Preparedness and recovery can be symbiotic. For example, installing smart and fire-resistant shut-off valves can prevent the suction of gases and melted pipes into the water system, also allowing for a quicker recovery post-fire.

The morning panelists also discussed potential interventions to prepare for wildfires, such as clearing defensible space around relevant infrastructure, improving components in the water system, and the role of private property owners. In the latter realm, a trade-off between local and regional solutions surfaced. For example, when comparing the efficiency of household sprinklers and expanding the storage capacity of the network, sprinklers would use supply capacity required at the regional level to fight a wildfire. As a result, participants seemed to prefer the prioritization of regional solutions over local alternatives because of urban wildfires' ability to quickly move beyond local and city jurisdictions, requiring regional collaboration to proactively plan for wildfires.

Another important trade-off emerged as well: the cost of potentially massive new investments that may be used very infrequently, which could result in stranded assets and public dissatisfaction in picking up the tab. Participants pointed out that resources used for construction of a new but infrequently used firefighting component may, in some cases, be more effectively invested to address other community needs that might receive broader support. On the other hand, failing to prepare for wildfires could result in massive economic and human losses. Ultimately, the decision to enhance water systems' infrastructure to fight wildfires includes multiple trade-offs, where costs, effectiveness, and impacts over the network (e.g., water quality) are relevant. Workshops 2 and 3 in the series will address economic and drinking water quality considerations related to wildfire resilience, respectively.

3.4. Disagreement: Need for Statewide Standards for Water Supply Infrastructure and Wildfires

There are currently no standard requirements or formalized best practices for water supply systems to fight wildfires in the United States. The Safe Drinking Water Act, as implemented by the California State Water Resources Control Board, and the U.S. Environmental Protection Agency both offer some best practices and system support materials on wildfire impacts to community water systems. However, based on our review of existing resources, oversight agencies have historically provided little guidance on the wildfire response role of water systems.

The most relevant requirement under the America's Water Infrastructure Act of 2018 (AWIA)—which only applies to large water systems—is to have updated Emergency Response Plans and Risk and Resilience Assessments. But in their current form, these plans and assessments are inadequate for a focus on wildfire fighting, much less a detailed concept of operations (Sun et al., 2025, Chapter 2). This is not a criticism of these efforts per se; they were simply designed to cover hazards and crises more broadly, and in some cases focus more on impacts to systems rather than the use of systems to mitigate hazards.

In the workshop, participants explored whether statewide guidance, standards, and frameworks could play a role in outlining expectations for water supply systems regarding wildfire fighting. This topic yielded the most disagreement and a mix of divergent viewpoints. Some participants were against any further concept development while others were keen to implement specific ideas. Thus, this topic clearly necessitates further discussion and dialogue before advancing any specific recommendations.

Given these diverging viewpoints, we started our workshop discussion by asking whether the state should provide oversight in this realm. The workshop participants who were opposed to or concerned about the state setting standards put forth several concerns and arguments. First and foremost, they expressed that wildfire fighting should not be thought of as part of the basic service mandate of water supply systems—in fact, they noted that the task conflicts with core mandates. Second, poorly designed standards could create new legal liabilities and increase the number of unmet and unattainable public expectations. New standards for water systems, or even data collection and best practice compilations, could imply a shift in responsibility for firefighting from local fire agencies to water systems. Workshop participants stressed that any guidance developed or provided to water systems would need to account for clear distinctions in roles and responsibilities between water systems and fire agencies. Finally, participants expressed that any new guidance or standard lacking financial support—either externally or through agency rates and charges—is an unhelpful unfunded mandate. Passing laws without funding implementation was judged as potentially worse than not passing them at all. Workshop participants expressed particular concern regarding the feasibility of implementation of A.B. 367 (2025), given some water systems had estimated compliance costs as extremely high without a clear cost-benefit payoff.

Some participants posited that it is important for subject matter experts to proactively develop standards that could be implemented by state bodies. They noted that if subject-matter experts are passive and avoid providing recommendations, the state might set ill-fitting standards. Additionally, legal proceedings against water systems can occur post-wildfires, such as in Yorba Linda and in the City of Los Angeles, on the basis of inverse condemnation arguments (Itani v. Yorba Linda Water District, 2012; Arshad, 2025). These proceedings can be unpredictable and hinge on judgment of the performance of unregulated and above industry-standard water system infrastructure specifics by nonexperts.

Many participants also voiced that it would be helpful, at a minimum, to have better cross-case information on water system efforts, which could be most effectively gathered by the state. There is no systematic understanding of cross-system practices, much less exemplary cost-benefit assessments to build on. Finally, some (but not a majority of) participants said it would be helpful to have more direct guidance or event standards from the state for wildfire fighting efforts for water systems in high wildfire-risk areas.

We also discussed seven potential statewide oversight and guidance options, which we sought feedback on before and during the workshop. These are not fully realized concepts, and we are not making any recommendation regarding them in this report.

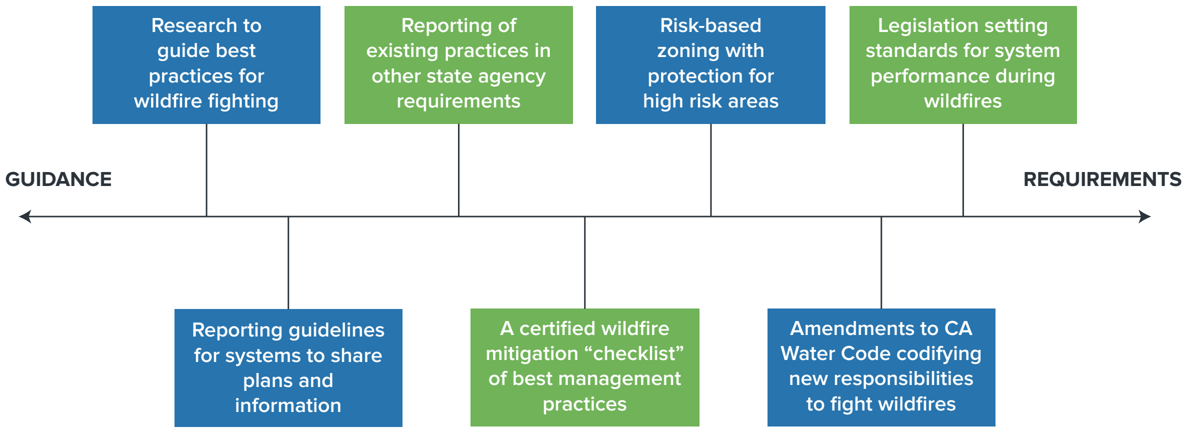
We outlined these seven concepts along a spectrum between **guidance** (providing supportive information) and **requirements** (setting performance standards) for water systems, as outlined in Figure 3 and listed below:

- Legislative-, agency-, or state-commissioned research to provide guidance on comprehensive best practices for wildfire fighting
- Reporting guidelines for water systems to share wildfire plans and other information, potentially incorporated into existing requirements, such as Emergency Response Plans, Emergency Notification Plans, Urban Water Management Plans, or Consumer Confidence Reporting preparation processes

- Collection or self-reporting of existing practices in other state agency requirements, such as sanitary inspection cycles or self-reporting of data (i.e., the Electronic Annual Report, or eAR)
- A wildfire mitigation "checklist" of best management practices certified and inspected to protect against legal liability (i.e., California Wildfire Fund)
- Risk-based zoning approaches, such as a "100-Year Wildfire Zone," with associated protection standards for systems or portions of systems in very high fire hazard severity zone (FHSZ) areas
- Amendments to the California Water Code codifying new system responsibilities in fighting wildfires
- Legislation, such as A.B. 367 (2025), that sets firm standards for system performance during wildfire events

FIGURE 3

Options for Statewide Oversight and Guidance on Water Systems' Role in Wildfire Fighting



Again, participant interest in and opinions on each of these concepts were quite mixed. Among workshop participants who thought specific concepts should be further explored and potentially implemented, the 100-year wildfire zone concept was of interest, along with a liability-limiting checklist, with broader-based support for a state agency gathering more information on existing and best practices by water systems through existing statewide data collection standards. At the same time, a concern was raised with simply collecting data on existing practices because this may not lead to any change in local capacity or action. Keeping system capacity in mind, as well as broader views on water system performance, some participants were interested in standards only if they applied to larger systems, as well as if they could serve as potential triggers for unlocking water system consolidation funding or lead to lower insurance premiums for water systems.

Regarding implementation of potential new guidance or requirements, participants noted the importance of a long implementation timeline, depending on the level of state oversight or guidance advanced. They also called for any such guidance to be differentiated by system size and wildfire risk profile. We expect lively policy and scholarly conversations in this space going forward, and we plan to complete a full-length study on this topic in 2026.

4. INTERVENTION APPROACHES AND LIMITATIONS

Moving beyond major cross-cutting themes, we turn to what can be done by systems to fight wildfires. We present our worksheet and system evaluation exercise, followed by several examples of system interventions that we collected through the workshop and subsequent discussions, representing approaches that may have varied degrees of relevance depending on system resources, configurations, and needs.

4.1. Water System Fire Intervention Evaluation Exercise

In the months leading up to the workshop, we iteratively developed a water system-level fire intervention evaluation exercise based on a fivefold categorization of potential interventions (see Figure 4 and Appendix A). We piloted this worksheet with participants during an interactive 90-minute session at the workshop (described in detail in Appendix B). We do not hold our categorization or worksheet as definitive or a finished product; we developed each in the absence of other resources. Below, we present the results.

The exercise was successful in encouraging initial thinking and planning around practical, actionable considerations to boost firefighting capacity and response among participants. Attendees engaged in very active discussion throughout the exercise and reflected that both the individual and group components were helpful in revealing commonly held questions, concerns, and challenges. This enabled identification of several overarching themes.

Credit: Jason Islas

For the purposes of providing a structure to enable discussion and initiate first steps toward system-level planning, we organized the workshop and related deliverables around five categories of firefighting considerations for water systems. These span both "hard" infrastructure interventions and "soft" management and coordination actions that can promote improved firefighting capacity and resilience. While this is likely a partial list and could be categorized differently, this framework provided a productive starting point during the workshop. We believe it can be useful for prioritizing preparedness and resilience actions at the system, intersystem, and regional level.

FIGURE 4

Categories of Firefighting Considerations for Water Systems

INTERVENTION CATEGORIES	INTERVENTION EXAMPLES	
Category 1: Emergency response resilience improvements	More/enhanced interties between systems	Strengthen/add to existing mutual aid agreement
Category 2: System water supply	Prioritization of existing hyper-local surface storage levels	Additional hyper-local surface storage reservoirs or above-ground tanks
Category 3: Other hyper-local water infrastructure	Defensible space around key water infrastructure	Automated/more robust pumping infrastructure
Category 4: System power supply	More cleaner, safe generators for backup power	Strengthen relationships & real-time communications with power utilities
Category 5: Private property water supply	Below-ground cisterns collecting rainwater on public property	Requirements for on-site, pre-filled tanks or pools

TYPES OF INTERVENTIONS*

HARD INTERVENTIONS (infrastructure, technology, equipment)

SOFT INTERVENTIONS (management, communication, coordination)

*These are not mutually exclusive and can overlap. Hard interventions will require coordination and management to succeed.

The broad results summarized below reflect selective qualitative input from participants. We provide anonymized quotations from participants for added color and context. This was not a formal survey. Participants contributed open-ended responses based on their own experience and local system context, and not every question received a response from every participant. Even so, consistent themes emerged across both sections of the exercise.

4.1.1. Risk, Hazards, and Other Considerations

How has fire historically posed a risk to your system, and how is that risk changing?

Most participants indicated that wildfire risk has become an increasing concern over time. Several noted that their systems have not historically experienced major fire impacts but still recognize rising exposure due to climate change and hotter and faster-moving fires. Others described their systems as already at high risk, particularly those near wildland-urban interfaces where vegetation on steep terrain and limited firefighting access compound vulnerability. A few participants reported that system damages from past fires have been limited, but there is growing worry about a range of issues including power loss and emergency water supply reliability.

REPRESENTATIVE QUOTES

> “Huge risk and increasing, major cause of worry every summer.”
>
> “Fire has changed—bigger, faster, harder to control; we’ve added backup [generators] at all facilities.”

What other risks or hazards does your system face?

Participants cited multiple concurrent hazards, with drought and related water scarcity most frequently mentioned. Drought affects both water supply and firefighting capacity, forcing trade-offs between conservation and emergency storage. Earthquakes were another common concern, alongside power outages and flooding. Aging infrastructure and cybersecurity vulnerabilities were also described as risks. Several participants identified secondary post-fire hazards including sedimentation and erosion that threaten water quality.

REPRESENTATIVE QUOTES

> “Drought, earthquake, power loss—those hit us hardest.”
>
> “Earthquakes and drought are the big ones.”
>
> “Lack of revenue for flood infrastructure; hazards just keep stacking up.”

What resource pressures does your system face?

Many water systems struggle with limited funding and staffing shortages, noting an inability to recruit or retain qualified operators. Smaller systems especially lack dedicated full-time personnel, relying on volunteers or part-time staff. Participants mentioned insufficient capital for infrastructure replacement and difficulty maintaining emergency reserves while meeting water quality regulations. Several also cited administrative burdens like complex grant applications and reporting requirements that strain small agencies' limited capacities.

REPRESENTATIVE QUOTES

> "No staff operator, no money for improvements."
>
> "Continuity of management, hard to keep people or momentum."
>
> "Capital and operations and maintenance costs are the biggest barrier to resilience."

How scalable are water system interventions?

Some participants reported that coordination and adoption of new practices were relatively easy in systems serving smaller communities, where relationships and communication are strong. Others, particularly from urban areas with larger or more complex systems, said that scaling interventions across jurisdictions or agencies remains difficult. Participants noted that technical solutions like interties and generators are often straightforward in concept but constrained by cost and permitting. Several emphasized the importance of regional collaboration to make localized improvements more broadly applicable. Peer learning and shared projects were seen as most promising for broader impact.

REPRESENTATIVE QUOTES

> "Coordination and adoption are easy—we're a small, close-knit system."
>
> "Difficult to make improvements that benefit large areas—too costly."

What internal and intra-agency operations opportunities, challenges, and capabilities exist?

Coordination and communication surfaced as the dominant issues. Participants described fragmented responsibilities between fire and water agencies, leading to inefficiencies or confusion during incidents. Some systems have benefited from close-knit relationships and regular interagency meetings, while others lack formal and informal coordination altogether. A few participants highlighted training opportunities and knowledge exchange as major enablers of operational improvement, especially for smaller systems that depend on neighboring agencies during emergencies.

REPRESENTATIVE QUOTES

> “Close-knit community; we learn from each other.”
>
> “Interties and shared groundwater quality data have helped coordination.”
>
> “Communications and rebate programs are good, but we need more consistency.”

What other types of challenges does your system face?

Responses revealed a mix of institutional, financial, and social challenges. Participants cited legal liability concerns, public resistance to rate increases, as well as land-use restrictions as barriers to instituting more robust resilience measures. Leadership turnover and loss of institutional knowledge also hinder long-term planning, especially in small or rural systems. Participants also mentioned competing priorities—such as water quality compliance versus resilience investment—and uncertainty about new technologies’ relevance to local needs.

REPRESENTATIVE QUOTES

> “Liability concerns and the need to prioritize regulatory requirements.”
>
> “NIMBY attitudes, water rates, and limited public understanding.”
>
> “Lack of continuity in management—every change sets us back.”

4.2. Intervention Priorities by Category

Again, the second part of the discussion focused on a worksheet of five categories (plus an open response category) of firefighting considerations introduced earlier in the day (see Appendices for full details). Because no framework existed for these considerations, we created this categorization and summarized below which specific strategies and categories workshop participants emphasized.

Emergency response resilience improvements

Most participants emphasized the importance of existing mutual aid networks between water systems and their activation during recent fire events in Colorado and Los Angeles. They also stressed the importance of strengthening relationships, communication, coordination, and mutual aid especially with fire agencies and Emergency Operations Centers (EOCs) during emergencies. Participants agreed that emergency response coordination remains a top priority.

They discussed coordination and communication upgrades, real-time data sharing and cross-agency exercises, and the need for formal mutual-aid agreements to supplement informal relationships.

REPRESENTATIVE QUOTES

> “Strengthening working relationships and real-time data exchange would make the biggest difference.”
>
> “Coordination during events is mostly informal—depends on who’s available.”

System water supply

Participants noted that aggregate water supply in the region of a wildfire is often not a major constraint, although it is often perceived to be by the public and policymakers. Still, several participants described interties as an effective way to enhance redundancy and resilience, especially for smaller systems. Interties were considered a high priority but often limited by cost or geography. Cost and permitting remain the main barriers to implementation. Additionally, some systems have interconnections but lack formal agreements for emergency use.

REPRESENTATIVE QUOTES

> “Addition or enhancement of water-supply interties could help both drought and fire response.”
>
> “Geography limits our options; we’d need long runs to reach neighbors.”

Other hyperlocal water infrastructure

Only a few participants provided details on specific infrastructure components (pipes, valves, tanks, hydrants, pumps, etc.), but most recognized the need for physical upgrades to reduce vulnerability. Infrastructure hardening focused on protecting tanks and pump stations from heat and power failure. Backup power and smart and less-burn resistant upgrades to specific components were frequently mentioned. However, cost continues to limit the scope and pace of improvements.

REPRESENTATIVE QUOTES

> “Backup generators at all facilities have been a big step forward.”
>
> “Hardening older systems is expensive; no low-hanging fruit left.”

System power supply

Power reliability emerged as one of the most cross-cutting concerns. Participants consistently tied backup power needs to both fire and drought preparedness, yet Public Safety Power Shutoffs (PSPS) were cited as a growing operational risk. Backup generators or alternative power sources are often viewed as critical infrastructure, yet each have their own limitations, including public funding, fuel supply constraints, and their effect on sustainability.

REPRESENTATIVE QUOTES

> “PSPS events cut our pumping capacity—backup power is now essential.”
>
> “We’re adding generators but can’t cover every site yet.”

Private property water supply

Although fewer systems provided detailed entries under this category, responses revealed ongoing challenges tied to aging private property infrastructure and unclear responsibilities between property owners and utilities. Participants discussed the condition of private pumping and hydrant systems, the need for dedicated funding and insurance coverage, and post-fire water-loss management on private connections. The interconnection between public systems and private infrastructure and related decision-making was recognized as a gap area needing future collaboration.

REPRESENTATIVE QUOTES

> “Lots of money lost from broken lines and unauthorized use.”
>
> “Aged pumps need reconditioning.”
>
> “Water loss because people hooked up to fire hydrants but they weren’t metered.”

Other interventions (blank category filled in by participants)

Open entries filled by participants usually reflected deeper concerns about institutional coordination, communication, and post-disaster recovery logistics. Participants proposed improving cross-agency planning and ensuring long-term support mechanisms for recovery. Suggestions included the following: enhance regional support and information flow through mutual aid and coordination, conduct regional tabletop exercises, involve press/media to improve communication, address post-fire recovery issues such as bottled water provision, provide gap insurance, and establish re-entry protocols.

REPRESENTATIVE QUOTES

> “Housing code and water code mismatch.”
>
> “Invite press/media because they’ve been instrumental in getting the word out.”
>
> “Need participants to prioritize time and leadership … take advantage of existing regional venues.”

4.3. Case Studies of Firefighting Interventions in Practice

Workshop participants offered detailed intervention concepts and examples that they had either experience with or knowledge about. In this section we present some of these examples, including additional information from our follow-up research. The relevance for broader application and deployment of each concept discussed below will vary based on location, fire risk, development and population patterns, system capacity, and much more. As mentioned previously, it would be useful to develop a defined typology of interventions that builds on the worksheet in Appendix A, considers case-by-case factors, and guides users to assess intervention relevance and priority.

4.3.1. Building an Alternate Water Supply Plan for Fire Suppression: Example from Lake County

During the workshop, some participants expressed concerns that water systems do not always receive sufficient access to fire areas to carry out fire suppression and infrastructure protection activities during fire events. They also noted that systems could benefit from more integration and preplanning with fire agencies and emergency operation centers to act more effectively during fires.

A positive example was shared from Lake County, California, located north of the Bay Area, which has experienced some of the state’s most destructive wildfires over the past decade. Fire Chief Willie Sapeta, a 45-year veteran of the region’s emergency services, has led an effort that redefines how small, rural jurisdictions can ensure water supply for fire suppression. Sapeta provided insights at the workshop, which we followed up on through an interview.

Sapeta's approach combines pragmatic planning and equipment sharing, as well as strong personal relationships, to create a flexible, deployable alternate water supply system. The initiative provides a blueprint for other counties confronting the dual challenges of extreme fire behavior and vulnerable water infrastructure.

Lake County has endured repeated, large wildfires across the last four decades. In fact, between 2012 and 2024, over 65% of the county land mass and roughly 3,200 structures were lost to major incidents such as the Valley, Clayton, and Sulfur fires, the Mendocino and LNU Complexes, and the more recent Boyles Fire. By 2010, larger and faster fires were overwhelming local resources. Sapeta's department began informal coordination meetings with nearby water companies to discuss fire flows and infrastructure vulnerabilities.

"For us, collaboration wasn't theoretical; it came out of necessity," Sapeta says. "We had fires where systems hemorrhaged water, resulting in a loss of a complete water system. We realized we had to plan together." In 2021, these conversations formalized into a working group, eventually evolving into the Lake County Water Association (LCWA), a coalition of 40 member agencies and utilities representing most of the county's systems.

LCWA now meets monthly with the Lake County Fire Chiefs Association to review vulnerabilities and plan joint projects. The group also created an emergency guidebook, standardized communication channels, and designated three regional liaisons to coordinate water logistics during major incidents. A formal framework Sapeta developed translates the formal and informal relationships that have been vital to Lake County becoming a leader in water and wildfire into clear, actionable procedures for every incident.

For example, activation of the alternate water supply plan occurs when:

- A fire exceeds local water purveyor capacity within the first operational hour.
- Hydrant flow tests show system failure or diminished pressure.
- Multiple-structure or large commercial/industrial fires occur.
- Drought, mechanical, or electrical issues reduce supply.

The framework also makes roles and responsibilities clear. For example, a water supply officer is a liaison between the fire department and LCWA. They will have access to hydrant testing, flow analysis, and deployment coordination. An LCWA liaison maintains contact with Incident Command, coordinates alternate pump deployment, identifies raw-water sources, and helps isolate damaged infrastructure to preserve system integrity.

By late 2025, the Lake County Fire District and LCWA had operationalized key elements of the plan. Interties among four primary water systems now allow movement of millions of gallons throughout the Lake County Fire Protection District. Each entity has the ability for 24/7 contact with Sapeta and is incorporated into the county's unified command framework.

Sapeta emphasizes that technical infrastructure alone is insufficient; relationships and protocols matter equally. For other communities looking to strengthen their water and fire agency relationships, Sapeta has advice: When it comes to fire departments, there are a number of key steps to take including: knowing your water systems, creating regular communication loops, designating water liaisons within command structure and practice activation early, investing in deployable equipment, and planning for post-fire recovery. For water agencies, Sapeta recommends taking the first step, clarifying operational expectations, sharing cost and maintenance responsibilities, and participating in exercises.

By embedding operational clarity into a culture of personal trust and relationship, Lake County has turned lessons from catastrophe into a potentially reproducible framework. “You don’t know your firefighting capabilities until you know your water company’s capabilities,” Sapeta says. “The rest is about working together before the next big one.”

4.3.2. Auxiliary Water Supply Systems: Examples from San Francisco and Other Bay Area Systems

In 1906, San Francisco was struck by a major earthquake that affected large portions of Northern California. Soon after the shaking stopped, fires ravaged the city. A water system deeply damaged by the earthquake retained very little pressure, with broken water mains and a distribution infrastructure that was effectively offline, hampering firefighting ability. By the time the earthquake and ensuing fires were over, some 80 percent of the city had burned. The event still ranks as one of the most destructive earthquakes in California and serves as a reminder of the potential for cascading disasters to greatly accelerate and magnify the toll of any one event.

In the years following the earthquake and subsequent fires, San Francisco built a dedicated water system for firefighting purposes separate from the drinking water system: the Auxiliary Water Supply System (AWSS), now called the Emergency Firefighting Water System. More than 100 years after it was completed, it is still in operation today. This high-pressure system delivers water from a reservoir and two high-elevation tanks to 1,889 fire hydrants via 135 miles of pipelines (San Francisco Fire Department, n.d.; San Francisco Public Utilities Commission, n.d.). The San Francisco Fire Department operated and maintained the system until 2010, when ownership transferred to the San Francisco Public Utilities Commission amid more than $100 million upgrades (San Francisco Public Works).

The system relies primarily on freshwater via gravity-fed components that operate independently of the electrical grid. The system was built to operate under a variety of conditions and includes pumping stations in the event that the gravity-fed supply is depleted or compromised. Given the city’s proximity to the ocean, the Emergency Firefighting Water System can optionally pump salt water from the bay, though that option is a last resort due to corrosion damage from saltwater (Van Dyke, n.d.). Additionally, 172 cisterns serve as backup water sources; they are not connected to the emergency system or the public water system. San Francisco Fire Department’s Bureau of Engineering and Water Supply inspects and maintains the cisterns (San Francisco Fire Department, n.d.).

The Emergency Firefighting Water System is partitioned into zones with varying elevation and pressures, which enable system components to be isolated and shut off as needed without affecting other parts of the system. The highest-elevation zone includes the 10.5-million-gallon Twin Peaks Reservoir and two large-capacity tanks at lower elevations. Beyond these, at elevations below these three water storage locations, is a series of pump stations that activate when the gravity-fed upper zones are depleted or fail (Van Dyke, n.d.).

San Francisco completed the system in 1913 with funding from a $5.2 million voter-approved bond. In the decades since its completion, the Emergency Firefighting Water System has undergone several phases to augment and improve service, most recently through the City and County of San Francisco's $628.5 million Earthquake Safety and Emergency Response bond, passed in 2020. The bond includes a suite of preparedness and response measures, including some $150 million to renovate, expand, and seismically upgrade the Emergency Firefighting Water System (OneSF, 2020).

Similar, albeit more modular, systems operate in other parts of the Bay Area. The City of Berkeley maintains an emergency system that can pump water from local fresh or saltwater sources through temporary water pipes laid over streets, delivering 6,000 gpm to 12,000 gpm from water and power sources distant from the disaster zone. Berkeley's highest wildfire risk areas are uphill, several miles from the sources of water. Oakland also maintains modular pumping systems for delivering lake or bay water to high-fire risk areas.

4.3.3. Private Property Water Requirements for Firefighting: Examples from Australia and California

In recent decades, devastating wildfires have swept many parts of Australia, including areas surrounding its largest population centers in the southeast. These fires have often occurred in wildland-urban and rural areas. Events such as the Black Saturday Bushfires, which burned across the state of Victoria and killed over 170 people, prompted regulations requiring property owners in wildfire-prone areas to have a dedicated water supply, with varying requirements for firefighting authorities to connect to parcel-level supply. In Victoria, for example, new developments must incorporate a static water supply for firefighting, with a minimum volume of 10,000 liters stored above ground in a concrete or metal tank (see Victoria County Fire Authority, 2024; Victoria Department of Transportation and Planning, 2021).

In California, the state fire and building codes (California Code of Regulations, Titles 14 and 24, respectively) govern fire protection-required water supply and, in combination, require a supply of water with adequate fire-flow for buildings and facilities (as defined by the building code). Where larger water systems do not provide such supply, supplemental tanks, ponds, or other natural or human-made water sources must be present.

In addition, some counties explicitly set forth specific requirements. In general, counties mandate an extra 2,500-gallon tank or other source for properties lacking access to a larger water supply system. This requirement sometimes applies specifically to the State

Responsibility Area (SRA) and sometimes follows other parameters. Examples include, but are not limited to, the following counties:

- Humboldt County requires a 2,500-gallon reserve for SRA properties, in addition to the domestic water supply (2025).
- Sonoma County requires a 2,500-gallon emergency supply for nonurban parcels on private wells (2025).
- Mono County requires a 2,500-gallon supply for SRA parcels (2010).
- San Luis Obispo County requires a "2,500 gallon minimum dedicated fire water reserve," in addition to typical domestic water supply (which, the County notes, would usually imply a 5,000-gallon supply in total; n.d.).

4.3.4. Lake Tahoe Region: Adopting Hard and Soft Infrastructure Measures to Boost Wildfire Resilience

Finally, we present the example featured in the workshop from the Lake Tahoe area. We note that this is a particularly novel situation given the fire risk areas span multiple states, and thus require special coordination. A unique level of coordination is demonstrated in the Tahoe Water for Fire Suppression Partnership, a bistate collaboration of Lake Tahoe Basin water agencies formed in response to the 2007 Angora Fire.

Within the region, the Tahoe City Public Utility District (TCPUD), which participated in the workshop, has a strong history of collaboration with land managers, conservancies, water agencies and other water systems on wildfire mitigation efforts and response. The district has taken an array of management and investment actions geared toward boosting water resilience for firefighting in their communities, many located in high fire hazard areas adjacent to forestlands. System improvement projects have included upsizing waterlines, installing fire hydrants, and increasing water storage capacity.

TCPUD has grown through acquiring smaller systems. In certain cases, increasing fire flow significantly motivated residents to support consolidation into TCPUD. These consolidations enabled the district to establish new emergency interconnections, augment waterlines, and install new hydrants (Gardiner & Dobbin, 2025).

The district has also been active in agency coordination, legislation, and funding spaces. TCPUD participated in a National Special Districts Coalition working group that explored challenges and pathways to ensuring sufficient fire suppression capacity, delivering recommendations for policymaking. The district also worked to support the Lake Tahoe Restoration Act and S.B. 470, which include federal and state grant funding for water system fire suppression improvement projects (Withrow, 2024). That work continues via participation in the Wildfire Solutions Coalition, which works to secure long-term funding for wildfire resilience throughout the state.

5. FUTURE RESEARCH AND IMPLEMENTATION DIRECTIONS

Though the need is urgent and growing, few studies have investigated the resilience of water systems to wildfires, even in terms of the type of case study approaches we presented above. Many different solutions can be implemented to prepare for wildfires before they happen (e.g., increasing a system's capacity), during wildfire events (e.g., coordinating and assisting across agencies), or in the aftermath of the emergency (e.g., plans to restore a system's functionality).

A full assessment and comparison of all potential interventions and investments—their relative contribution to increased wildfire fighting capacity, and the estimated benefits and costs of each—will require integrated systems analysis that incorporates risk-based design. This approach examines interrelated system elements holistically rather in isolation and can clarify complex problems. Multidisciplinary systems analysis approaches simulate and model potential designs, benefits, and costs in meeting operational and socioeconomic goals. To date, no peer-reviewed literature has used such approaches to evaluate the managerial and infrastructure solutions that could improve water system performance during wildfires. Moreover, literature has not addressed potential trade-offs in performance outcomes, such as maintaining basic water system functions in undamaged parts of a system versus segmenting systems to increase firefighting capacity in areas of need. Trade-offs are important to evaluate, as participants highlighted throughout this workshop.

While participants discussed many of these interventions, the workshop did not yield a consensus on which solutions to implement during each phase. This lack of clear-cut agreement highlights areas where additional research is needed to better inform policy, engineering, and risk management actions that help cities manage long-term wildfire risk. This section suggests more in-depth analysis and direction for future study on two of these areas of research.

Pending funding, bandwidth, and collaborative interest, we hope to carry out a more technical and systematic analysis in 2026 and beyond using the evaluation typology to fully evaluate a wide range of specific fire resilience measures, such as those outlined in the Appendix.

5.1. Water Distribution System Design, Operation, and Constraints Under Extreme Conditions

In designing and managing a water distribution system, water agencies typically use a hydraulic model of the system to simulate key performance metrics of pressure, flow, water quality, capacity to meet peak demands, and capacity to maintain functions during periods of low demand. In recent decades, resilience assessments for water distribution systems have evaluated how they can best maintain functioning and reduce risk during contamination events.

Some studies have investigated methods to increase water distribution system resilience during catastrophic events, such as earthquakes (Klise et al., 2017). For instance, a water system can systematically assess vulnerabilities through data collection, disaster modeling, vulnerability analysis of system segments or components, failure mode analysis of these components, and development of mitigation strategies with benefits and costs (Qi et al., 2025). This is a challenging empirical task, with hundreds of potential scenarios.

A massive wildfire in an urbanized area is a catastrophic scenario for a water distribution system. Workshop participants identified several constraints on water distribution system functionality during extreme conditions, including rapid reductions in water pressure due to increased use by residents and broken lines at burned properties. In considering viable solutions given these constraints, participants pointed to the need for a holistic integrated system approach for design and management, in which both hard and soft implementations work together to improve the water system resilience to wildfires. As noted above, each water system has unique infrastructure. The layout of each network highly depends on the topography and street configuration of the city, traditionally designed as a combination between branched and looped topologies. One of the important constraints that water distribution system design must consider is the required fire-flow requirements; read more about this constraint in the callout box below.

While there is not a single solution that fits all water distribution systems, a risk-engineering approach may help to identify the best combination of solutions by minimizing the related costs and the risk of the system. The framework mentioned above can be developed using an approach of simulation-optimization, where multiple fire scenarios are considered.

Modular systems in particular may offer cost-effective solutions that agencies can share regionally in an area of wildfire risk. Following severe urban wildfire events in 1989 and 1991, the City of Berkeley passed several multimillion-dollar bond measures through 2000 to fund water systems improvements to improve firefighting capacity during disasters. As a city in the San Francisco Bay Area, Berkeley faces disaster risk from both earthquakes and wildfire. Original plans for water system improvements included construction of an auxiliary water supply system—a hard pipe system capable of delivering 30,000 gpm of sea water for firefighting capacity. Ultimately, the city invested in a modular solution (Orth, 2011).

Risk, however, is not the only performance metric to consider. From an operational standpoint, redundancy in the network incentivizes that water constantly moves throughout the system, reducing stagnation that could lead to water quality issues (National Research Council, 2006). A 2025 Water Research Foundation request for proposals (namely WRF 5358: Balancing Water Distribution System Flow Capacity and Water Quality for Fire and Natural Disasters) underlines the need for further research in this space. In addition, choosing solutions requires balancing the cost to implement against the expected use of that infrastructure; otherwise, infrastructure can quickly become a stranded asset.

FIRE-FLOW REQUIREMENTS: A KEY CONSTRAINT IN EXTREME CONDITIONS

In their design, water distribution systems must balance the volume of water needed to meet demands, the pressure needed to deliver that water to end uses at a given flow rate, and the quality of the water when delivered. System designs incorporate pressure and demand requirements to supply typical firefighting volumes, which represent important capacity but are only a small percentage of the annual delivery volumes in the system across all routine uses. For instance, studies show that 75% of the storage capacity within a water distribution system may be dedicated to meeting peak volume needs for firefighting. Local water storage tanks and reservoirs help to maintain sufficient capacity for this volume, which can create water quality challenges if the water remains in storage for too long.

To deliver this water to areas of need, systems must maintain sufficient pressure and flow in pipes. Fire-flow requirements significantly drive system designs. While minimum pressure requirements for flow to fire hydrants (20 pounds per square inch, or psi) are lower than typical pressure levels in a water distribution system (40-50 psi), firefighting requires much higher flow rates. Routine demands for a home can range up to 20 gallons per minute (gpm) depending on the household size, but fire-flow requirements for that home are over 1,000 gpm (National Research Council, 2006). Thus, for a structure fire during normal water system operations, nearly 50 times the typical flow rate of water must be available through one or more hydrants. A typical water distribution system is designed to provide no less than 1,000 gallons per minute (gpm) of fire flow for a home via one or more fire hydrants (more for larger buildings), but hydrants are rarely used.

Fire-flow requirements vary based on land use and density, with typical requirements ranging from 1,000 gpm for houses to 5,000 gpm or more for apartments or warehouses. Under this configuration, the set of solutions to increase the ability of water distribution systems to fight wildfires is highly constrained. Thus, firefighting is a critical contributor to the system's design and management but constitutes a small percentage of end uses while also introducing significant maintenance requirements to maintain functioning hydrants and water quality challenges for storage volumes.

5.2. Ongoing Need for In-Depth Physical Intervention Typology Using Hydraulic Models

In terms of infrastructure, proposed solutions ideally are tested thoroughly and implemented before wildfires happen. Thus, water systems need approaches such as hydraulic modeling using risk analysis frameworks, following proper cost estimates of the potential interventions and using computational simulation tools that support decision-making processes (e.g., Water Network Tool for Resilience; Klise, 2017).

We have discussed different infrastructure intervention alternatives in this report. To develop a more robust decision-support framework to select which interventions work best to increase the resilience of water systems to wildfires, it is important to consider the following key aspects:

1. **Each water system is unique:** The connectivity between the elements of the system (pipes, valves, pumps, tanks) determines the impact of topological changes (e.g., interventions) on the system. For example, when a network is divided into sectors, the topology and hydraulic connectivity among these units significantly affect the criticality and recovery capabilities of each segment (Liu & Kang, 2021). Furthermore, knowing the dynamics of the system helps to identify areas where these changes would be more effective than others.
2. **Reliability assessment in water systems:** Topological changes (e.g., closing valves) will impact system hydraulics. This will reduce leaks, but also limit water deliveries in certain areas of the network. The use of global and local reliability indicators should be defined to balance potential trade-offs derived from the solutions relative to other purposes of the water system (e.g., unsupplied demands vs. agility to restore the service; Berardi et al., 2021).
3. **Wildfires may cause cascading failures, yet water systems are locally connected:** Water infrastructure is vulnerable to cascading disruptions due to its interconnection with other grids such as electricity and other components of the drinking water system such as treatment plants. However, utilities typically isolate water infrastructure from neighboring systems (Verschuur et al., 2024). Thus, when designing interventions to make the water system more robust to wildfires, planners should use an integrative framework that evaluates multiple systems and addresses the suitability to connect with surrounding systems (e.g., water networks, or water bodies).
4. **Uncertain occurrence, robust frameworks**: Given uncertainty regarding the occurrence of a wildfire impacting a water system during its life cycle, risk-assessment frameworks should incorporate large ensembles of scenarios (Verschuur et al., 2024). These analyses help to identify critical response patterns in the system and evaluate different intervention strategies, so the most robust approach is selected.
5. **Develop multidisciplinary and risk-based systems approaches to assess technical feasibility:** Systems analysis and planning tools can assist in methodically assessing potential options by incorporating metrics of performance, costs, benefits, feasibility, and frequency of use. Studies that couple hydraulic modeling with updated assessments of wildfire risk, adaptation options, and benefits and costs can provide more guidance for utilities and regulators facing difficult questions about the level of interventions that can be reasonably accepted for managing wildfire risk in urban and peri-urban areas.

6. CONCLUSION

The UCLA and the UC Agriculture and Natural Resources' Water Supply + Wildfire Research and Policy Coordination Network launched in response to the unprecedented spotlight on the relationships between water systems and wildfires in the Southwest United States and beyond. While critics have, in some ways, misdirected this spotlight due to a misunderstanding and mischaracterization of the responsibilities of water systems in fighting wildfires, exploring these relationships remains critical, especially as wildfires become more frequent and increasingly intense.

Amid ongoing and steady scientific research progress to assess how wildfires can damage a water system and the ways that contamination spreads in a system, there is an urgent need for support and actionable guidance. Cities across California and the Western United States, as well as climactically similar regions globally, face immediate, high-stakes decisions regarding emergency response strategies, infrastructure investments, and long-term planning for system resilience. Through this workshop series and our broader portfolio of ongoing work, this Network aims to fill immediate gaps in knowledge and provide guidance. This effort brings together expertise from the water sector, firefighters, water supply and quality researchers, policymakers, and affected communities to help address the most pressing questions faced raised by the need to adapt to 21st-century wildfires.

This report presents some of the first products of this endeavor, sharing insights and questions from the first Network workshop, held in August 2025. Forty-two participants, alongside the organizers, explored whether, where, and which wildfire fighting interventions make most sense to pursue further for water supply systems. While this field remains highly dynamic, with topics of interest and incremental findings continuing to emerge, this report captures key opportunities, constraints, and illustrative examples to guide future work.

Looking ahead, the Network will continue to explore critical questions to strengthen our understanding of water systems' role in fighting wildfires. We plan to convene additional discussions and produce several more research products, including a peer-reviewed paper analyzing statewide guidance options, as described in section 3. Over 2026, three more workshops are planned and will focus on remaining, pressing issues at the water supply-wildfire nexus.

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APPENDIX A. WATER SYSTEM FIRE INTERVENTION EVALUATION WORKSHEET

WATER SYSTEM FIRE INTERVENTION EVALUATION **PART 1**

Your Name:

System Location:

System Name:

ANSWER THESE QUESTIONS ON YOUR OWN, THEN BREAK INTO SMALL GROUPS TO DISCUSS. YOUR ANSWERS WILL INFORM PART 2.

Risks, hazards and other considerations

1. How has fire historically posed a risk to your system, and how is that risk changing?
2. What other risks or hazards does your system face (drought, earthquake, vector control, etc.)?
3. What resource pressures does your system face (e.g., capital and O&M costs, labor concerns, capacity, tradeoffs with drinking water regulation)?

Firefighting effectiveness considerations

4. How scalable are water system interventions (consider parcel-level to system-level)?
5. What internal and intra-agency operational opportunities, challenges and capabilities exist?
6. What other types of challenges (e.g., NIMBY opposition, aesthetics) does your system face?

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1

WATER SYSTEM FIRE INTERVENTION EVALUATION EXERCISE **PART 2**

1. With your tablemates, **choose 3 Categories** that are most relevant to you.
2. **Choose one Intervention for the first Category** that is a priority or of interest for you.
3. **Circle it and fill out the Priority and Resources** fields individually (5 minutes)
4. **Discuss** as a group (10 minutes).
5. **Repeat steps 2-4 for the remaining 2 Categories**.

DEFINITION KEY

Category = *Firefighting considerations for water systems*

Intervention = *Potential actions to increase firefighting resilience*
These are possible interventions. You are not limited to this set if you have others to suggest.

Priority = *How you assess the relative importance of the intervention*
Factors to consider:
- Is this intervention a short-term or a low-hanging priority?
- Is it a medium-term or a larger investment?
- Is it long-term, a moonshot, or requires significant investment or regulatory overhaul?
- Is it an emerging or a high-urgency need?

Resources = How you assess the availability of resources your system has or needs
Questions to consider:
- What resources does your system have available?
- What are your system's strengths and needs?
    - Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

2

This worksheet is available for download here

Category 1: Emergency response resilience improvements

INTERVENTION (circle one)	**PRIORITY** (How you assess the relative importance of the intervention)	**RESOURCES** (How you assess the availability of resources your system has or needs)
Addition or enhancement of water supply interties between systems Strengthening or adding to existing mutual aid agreement Strengthening working relationships and real-time communications with emergency operations center Strengthening working relationships and real-time communications with fire departments Early fire detection and prediction software systems Other:	Factors to consider: • Is this intervention a short-term or a low-hanging priority? • Is it a medium-term or a larger investment? • Is it long-term, a moonshot, or requires significant investment or regulatory overhaul? • Is it an emerging or a high-urgency need?	Questions to consider: • What resources does your system have available? • What are your system's strengths and needs? ◦ Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

3

Category 2: System water supply

INTERVENTION (circle one)	**PRIORITY** (How you assess the relative importance of the intervention)	**RESOURCES** (How you assess the availability of resources your system has or needs)
Prioritization of existing hyper-local surface storage levels Additional hyper-local surface storage reservoirs or above-ground tanks Additional regional storage strategically placed and managed for firefighting (county or DWR) Driveable tankers at the ready managed by own system, neighboring systems or regional partner New and enhanced helicopter support approaches, such as "Heli-Hydrants" At certain coastal access points, potential pumping of ocean water Other:	Factors to consider: • Is this intervention a short-term or a low-hanging priority? • Is it a medium-term or a larger investment? • Is it long-term, a moonshot, or requires significant investment or regulatory overhaul? • Is it an emerging or a high-urgency need?	Questions to consider: • What resources does your system have available? • What are your system's strengths and needs? ◦ Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

4

This worksheet is available for download here

Category 3: Other hyper-local water infrastructure

INTERVENTION (circle one)

Defensible space around key water infrastructure

Automated shutoff / control valves to isolate (pressure-lowering) parts of the system

Automated/more robust pumping infrastructure

Hardening certain distribution system components to avoid burning (including meters)

Distributed above-ground tanks, including potentially unconventional designs (e.g., Water Tree)

More robust public hydrants that are regularly inspected

Other:

PRIORITY (How you assess the relative importance of the intervention)

Factors to consider:
- Is this intervention a short-term or a low-hanging priority?
- Is it a medium-term or a larger investment?
- Is it long-term, a moonshot, or requires significant investment or regulatory overhaul?
- Is it an emerging or a high-urgency need?

RESOURCES (How you assess the availability of resources your system has or needs)

Questions to consider:
- What resources does your system have available?
- What are your system's strengths and needs?
  - Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

5

Category 4: System power supply

INTERVENTION (circle one)

Strengthening working relationships and real time communications with power utilities, incl. PSPS

More, cleaner, and safe to operate (automated) generators for backup power supply

Consideration of safe to operate, non-fire triggering battery storage for backup power supply

Other innovations in demand-responsiveness of distribution system and associated power support

Other:

PRIORITY (How you assess the relative importance of the intervention)

Factors to consider:
- Is this intervention a short-term or a low-hanging priority?
- Is it a medium-term or a larger investment?
- Is it long-term, a moonshot, or requires significant investment or regulatory overhaul?
- Is it an emerging or a high-urgency need?

RESOURCES (How you assess the availability of resources your system has or needs)

Questions to consider:
- What resources does your system have available?
- What are your system's strengths and needs?
  - Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

6

This worksheet is available for download here

Category 5: Private property water supply

INTERVENTION (circle one)

School or other public property below-ground cisterns collecting rainwater

On-site, residential greywater and rainwater harvesting requirements or support

Requirements that residential property have on-site, pre-filled tanks or pools precedent

Requirements that residential property with private hydrants have pre-filled tanks or pools

Other:

PRIORITY (How you assess the relative importance of the intervention)

Factors to consider:
- Is this intervention a short-term or a low-hanging priority?
- Is it a medium-term or a larger investment?
- Is it long-term, a moonshot, or requires significant investment or regulatory overhaul?
- Is it an emerging or a high-urgency need?

RESOURCES
(How you assess the availability of resources your system has or needs)

Questions to consider:
- What resources does your system have available?
- What are your system's strengths and needs?
  - Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

7

Category 6 (add your own):

INTERVENTION

PRIORITY (How you assess the relative importance of the intervention)

Factors to consider:
- Is this intervention a short-term or a low-hanging priority?
- Is it a medium-term or a larger investment?
- Is it long-term, a moonshot, or requires significant investment or regulatory overhaul?
- Is it an emerging or a high-urgency need?

RESOURCES
(How you assess the availability of resources your system has or needs)

Questions to consider:
- What resources does your system have available?
- What are your system's strengths and needs?
  - Consider factors such as: structural, technical, financial, material, personnel, mutual aid opportunities, etc.

8

This worksheet is available for download here

APPENDIX B. WORKSHOP ACTIVITY ON RISKS AND INTERVENTIONS

We piloted the worksheet in Appendix A with participants during an interactive, 90-minute session at the workshop. Here, we describe how we organized and ran the session.

We designed the exercise in two parts, with the first part prompting participants to spend a few minutes filling out the worksheet on their own to note the major risks, hazards, and other considerations their system faces—including related to fire, drought, or earthquakes; capacity pressures; and capital, operational, and maintenance costs. In this first part of the exercise, we asked attendees to briefly consider the scalability, capabilities, opportunities, and challenges broadly related to deploying firefighting interventions within their system.

The second part of the exercise consisted of interactive discussions with other participants sitting at the same table. Using the five categories of firefighting considerations which we introduced earlier in the day (see the Appendix worksheet), each table was asked to select up to three categories to explore. We defined categories as bins of "firefighting considerations for water systems." In addition to the five predefined categories, we included a sixth sheet for participants to add their own category, if desired.

The worksheet included one page per category, with several possible interventions (or "potential actions to increase firefighting resilience") listed under each. After each table selected a category, participants spent a few minutes individually exploring an intervention under that category, including considerations such as priority (or "how you assess the relative importance of the intervention") and resources (or "how you assess the availability of resources your system has or needs").

Each table then discussed interventions under each category. The intent of the discussion was to make the strengths, weaknesses, opportunities, and next steps of potential interventions more tangible while learning and receiving feedback from others. Following the table-level discussion, we facilitated a plenary discussion with highlights from participants at each table. We invited participants to keep their worksheets or photograph them for future reference. We collected either the hard copy or photos from participants and then created a spreadsheet combining all responses.

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