Drinking Water Emergency Planning and Response in the State of New Hampshire

Megan Cramton[1], Sara Berg[2], Jingyan Huang[3], Taler Bixler[2], Weiwei Mo[2,3,4]

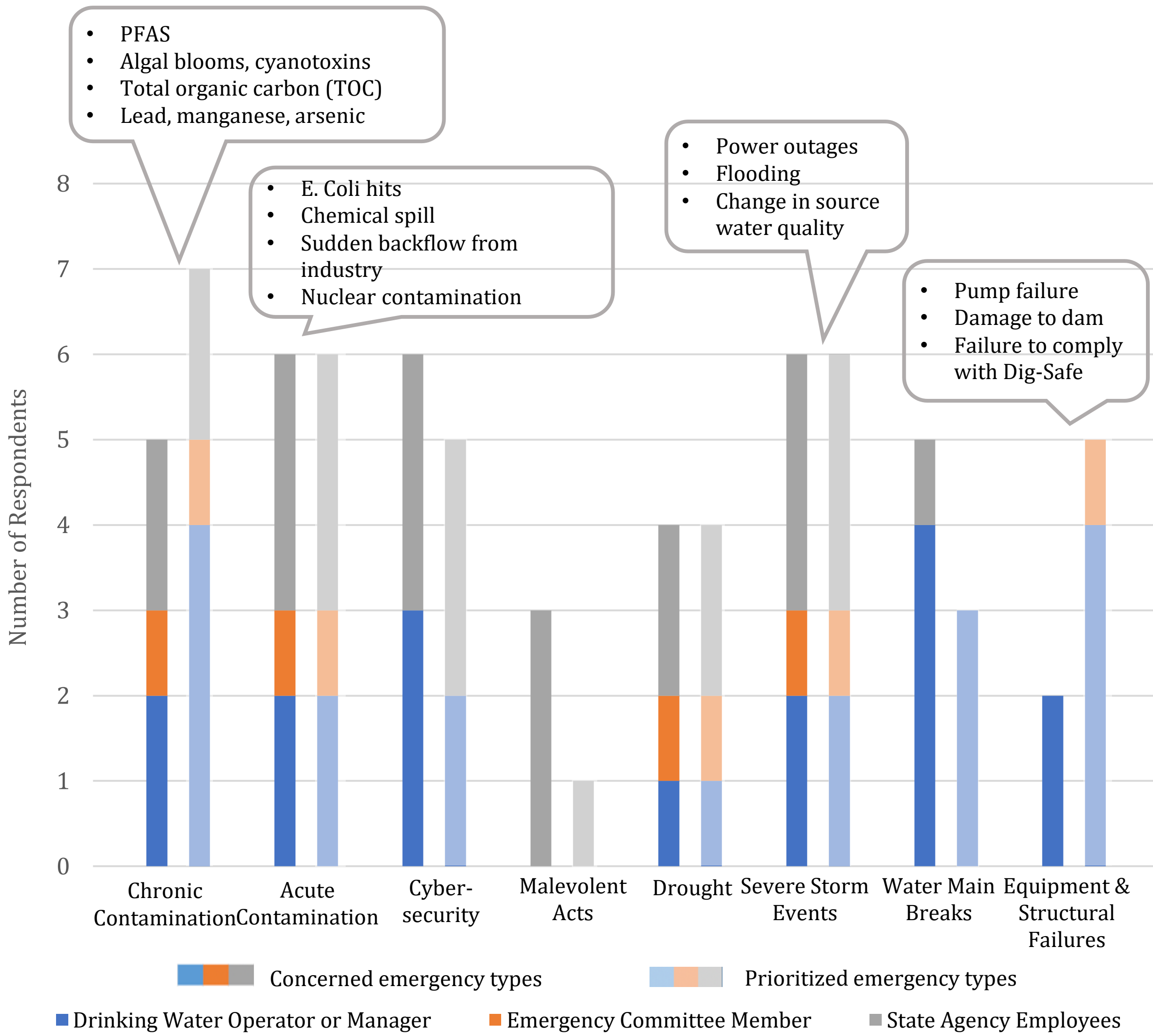
[1]The Engineering Corp, Hampton, NH, USA

[2]Department of Civil & Environmental Engineering, University of New Hampshire, Durham, NH, USA

[3]Natural Resources & Earth Systems Science Program, University of New Hampshire, Durham, NH, USA

[4]Carsey School of Public Policy, University of New Hampshire, Durham, NH, USA

Recommendations for Title Page Art



Key Takeaways

1. Eight drinking water industry professionals in New Hampshire, representing operators, state agency employees, and emergency committee members, were interviewed about their decision-making regarding drinking emergency planning and response.
2. There is a difference in attitude between frequent well-understood emergencies and less likely emergencies not previously experienced.
3. There is a consensus in terms of the importance of networking and knowing other stakeholder's capabilities and the benefits of planning and asset management.

1. Background

Safe and resilient drinking water supply is vital to the functioning and prosperity of the society. Drinking water emergencies can come in many different forms, including but not limited to natural disasters, malevolent acts, supply chain issues, accidents that cause contamination, naturally occurring contamination, and equipment failure. These emergencies require appropriate and effective responses for drinking water facilities to continue operating at their expected level of service. An ineffective response can result in damage to property, endangerment or loss of life, interruption of essential services, or loss of the public's trust in public drinking water systems. These high stakes require significant planning, training, and coordination among stakeholders to protect the community and the environment.

Accordingly, this project seeks to understand the prevalent drinking water emergencies of concern and priority, the current status of planning and response to prevalent emergencies, the inter-stakeholder communication for emergency planning and response, as well as the constraints and challenges associated with emergency planning and response through stakeholder interviews. Our interviews were carried out in the State of New Hampshire as an initial effort. From this effort, it will be possible to identify areas for improvement to further protect the public and the environment and to minimize negative impacts. It is also a first step in promoting stakeholder communication and collaborative planning and response in New Hampshire.

We conducted semi-structured interviews with stakeholders from three groups: drinking water operators and managers, state agency employees, and emergency committee members. The project was reviewed and approved by the University of New Hampshire Institutional Review

Board (IRB) for the Protection of Human Subjects in Research under IRB #8428. A total of 8 stakeholders were interviewed consisting of 4 drinking water operators or managers, 3 state environmental agency employees, and 1 emergency committee member representing a local fire department. The interviews were conducted virtually over Zoom or Microsoft Teams and lasted between 18-69 minutes. These interviews were transcribed with identifying information removed to protect confidentiality.

2. Prevalent Emergencies of Concern and Priority

Interviewees were asked to describe the types of hazards and emergencies that they are most concerned with as well as what types of emergencies are prioritized for long-term planning. Specifically, emergencies that the interviewees expressed less familiarity with, less preparation for, and worry over were classified as concerns; whereas, the emergencies that the most time and financial resources were allocated to were classified as priorities. Eight main types of drinking water emergencies of concern that have been brought up by the interviewees: chronic contamination (e.g., PFAS contamination, algal blooms, natural organic matter (NOM) contamination, and arsenic, lead, and manganese issues), acute contamination (e.g., E. Coli hits, chemical spills, sudden backflow from industry as a result of pressure change, and nuclear contamination), cybersecurity, malevolent acts, drought, severe storm events (e.g., flooding, changes in source water quality, and storm-related power outages), water main breaks, and equipment and structural failures (e.g., pump and chemical feed failures, dam damages, and failure to comply with Dig-Safe). Here chronic contamination is defined as contamination that is recurring or continually present at background levels, while acute contamination is due to a sudden event and is not recurring. Figure 1 shows the number of interviewees that identified each type of emergency as a concern and as a priority for long-term planning.

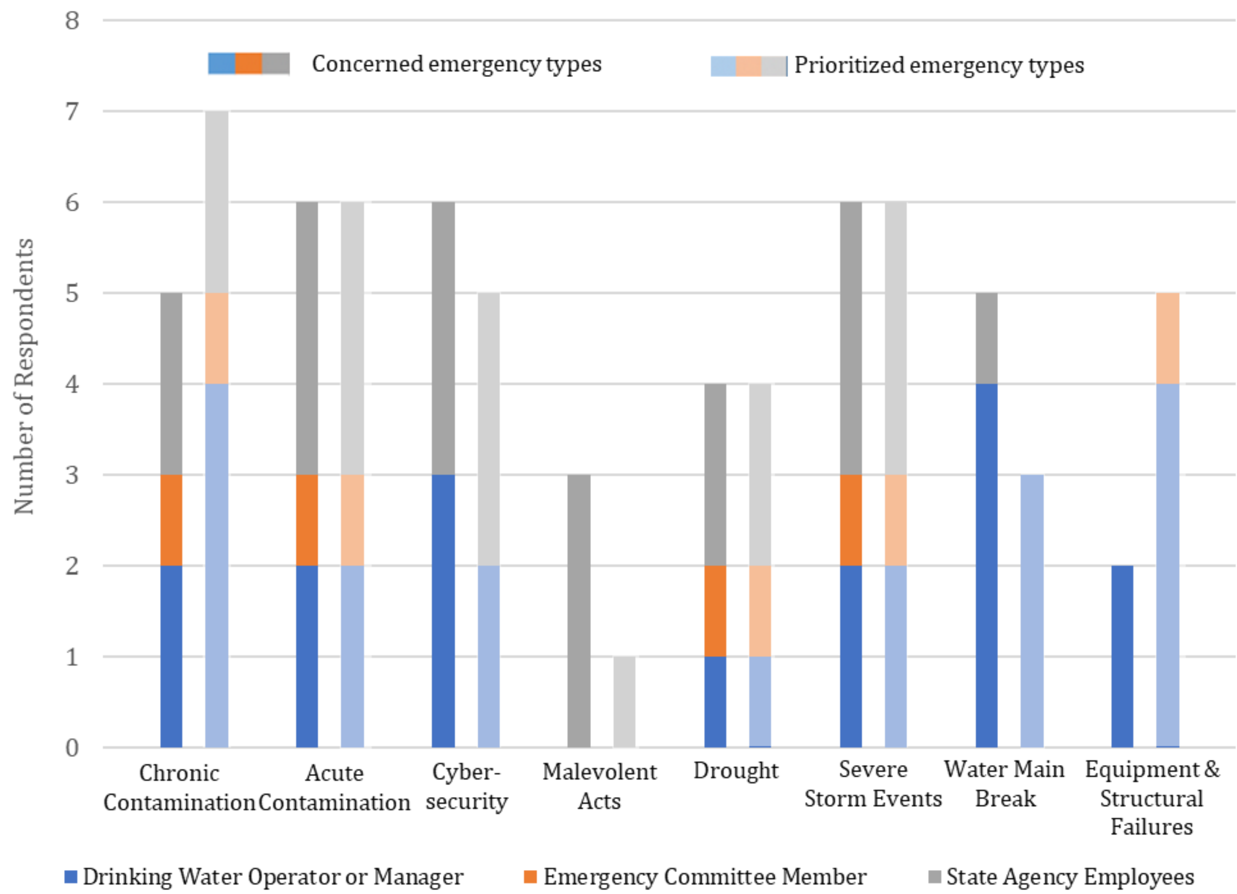


Figure 1. The number of respondents mentioned a type of emergency as either concerned or prioritized for long-term planning

Overall, interviewees are most concerned with acute contamination, cybersecurity, severe storm events, chronic contamination, and water main breaks. Resources are primarily prioritized for chronic contamination, acute contamination, and severe storm events. For certain types of emergencies, such as chronic contamination, cybersecurity, malevolent acts, water main breaks, and equipment and structural failures, there was a discrepancy between the number of stakeholders who were concerned about and the number of stakeholders who prioritized the emergency during planning. The higher concern than prioritization for both cybersecurity and malevolent acts could be attributed to a fear of the unknown. These emergencies have not been experienced in New Hampshire so there is no precedent on how to respond. However, they are less likely to occur and therefore do not have the same prioritization as emergencies that are more likely to occur. Malevolent acts were also only a concern for and a priority for state agency employees. This could be due to a similar uncertainty about the unknown, compared to drinking water operators who maintain and secure these systems and therefore see the low risk for a malevolent act. Water main breaks were primarily a concern and prioritized by drinking water operators and managers, but one state employee also cited water main breaks as a concern. The higher concern than prioritization for water main breaks could be explained by the higher frequency of occurrence and the understanding that water main breaks have historically, and will continue to be, a part of drinking water distribution that requires some financial planning, but mainly the ability to act immediately. The lower concern than prioritization for chronic contamination, and equipment and structural failures is likely due to the large amount of planning and allocation of resources needed to combat and/or prevent these emergencies. There is also a plethora of knowledge within the industry on how to mitigate chronic contaminants available to guide decision making and lessen concerns.

3. Planning and Response to Prevalent Emergencies

Information related to the planning and response to the eight groups of emergencies is summarized in Table 1. Stakeholders shared personal experiences during interviews to provide historical context. All four drinking water operators had experienced some type of chronic contamination, such as PFAS, naturally occurring arsenic, manganese, and radon contamination, and cyanobacteria blooms, during their professional history.

Table 1. Summary of historical frequency, precautions and planning measures, and emergency responses for the eight groups of emergencies in New Hampshire based on interviewees' responses

Emergency types	Historical Frequency[1]	Precautions & Planning Measures	Emergency Response
Chronic Contamination	Continuous or recurring annually (same contamination)	• Interconnections between municipal systems • Diversify water sources (e.g., have a groundwater and surface water source)	• Anionic resin[2] • Granular activated carbon filtration[2] • Dissolved air flotation[2]
Acute Contamination	Ranged from every 10 to 15 years	• Routine Sampling • Hazard inventory and material safety data sheets[3] • Backflow prevention devices • GIS maps	• Sampling, use restrictions, and flushing • Booming and damming
Cybersecurity	Has not been met by interviewees	• AWWA Cybersecurity Guidance and Assessment Tool • Full-time IT/security staff • Keep SCADA and all process controls off-line or limit what can be done online	• Remove compromised machine from network • Operate system mechanically
Malevolent Acts	Has not been met by interviewees	• Fence in wellheads • Security cameras	• Isolate impacted area and switch source
Drought[4]	Most summers	• Leak detection and repair	• Use restrictions
Severe Storm Events	Increasingly often	• Move pumps out of floodplains • Increase chemistry and experimental design training	• Generator power • Jar test source water
Water Main Break	Small breaks occurring weekly; large breaks occurring every couple of years	• Replace old pipes • On-call contractor • Separate distribution and treatment crews • GIS available in the field with valve locations	• Monitor for pressure drop • Flush system
Equipment & Structural Failure	Every few years	• Replace aging infrastructure • Regular maintenance • Long-term Capital Improvement Plans (CIP)	• Switch to redundant equipment or water source

		• Decommission and replace aging wells • Hydraulic models and GIS with infrastructure information	

1. The historical frequency describes the range of frequencies experienced and reported by the interviewees.
2. These treatment systems were likely not originally designed to treat the contaminant of concern but may happen to be effective at removing it. Operators must be careful to monitor the system and replace, for example the resin or granular activated carbon (GAC) media, more often to prevent breakthrough.
3. Hazard inventory methods for emergency prevention varied among interviewees. Methods included outreach to identified high risk businesses, inspecting businesses every three years for hazards, or mapping gas stations.
4. There were limited solutions to drought. Stakeholders recognized that drought was common, and the severity of a given drought is difficult to predict.

Overall, the most mentioned countermeasures included redundancy within the treatment system design and source waters, interconnections between different drinking water systems, and planning. When considering countermeasures, the cost compared to the risk reduction was an important consideration. One stakeholder said, “You can reduce a large number of risks with a small amount of capital investment…and then you get to this last little bit…but that little bit of risk might cost you 90% of what…everything else cost you in the end.” The applicability to multiple types of emergencies as well as the usability with day-to-day operations was also an important factor. “Most of what we have that can help us respond in emergencies is also there for day-to-day operations as well too. We'd like to have it be multi-tasking so to speak. You know, we don't want to have something just sitting there for emergency response that's actually not doing anything for 25 years and then you go to use it and doesn't work.” These considerations helped guide stakeholders when making decisions about which countermeasures to implement.

Planning was highlighted by 7 out of 8 stakeholders as critical to an effective emergency response. Emergency Response Plans (ERP), which are required by the State of New Hampshire for all community water systems, were mentioned as a useful planning tool by 7 out of 8 stakeholders. One stakeholder noted, “the quality of the emergency plans, I would say, would be the best indicator of how effective the emergency response would be.” These plans must be updated every six years and submitted for review and recordation by the New Hampshire Department of Environmental Services (NHDES) as stated in the New Hampshire Code of Administrative Rules (Env-Dw 503.21). The ERP includes step by step processes for different emergencies, public notices, lists of contractors with contact information, and chemical Material Safety Data Sheets (MSDS). These plans should be made readily available to all parties involved in the emergency response. One operator shared that, "I got a digital copy…we keep one out in the operations area, one in the office operations, and keep one in the lab, and there's one at the town hall…And the state has a copy." Another operator stated they review and revise the plan yearly. Another important document focused on planning was the Risk and Resilience Assessment (RRA) for compliance with the United States Environmental Protection Agency (USEPA) under the Water Infrastructure Act of 2018 (USEPA, 2019). This document was completed by an outside contractor or by the internal engineering group for the drinking water utilities.

4. Inter-Stakeholder Communication

Fifteen different stakeholder groups were identified during the interviews that are typically involved in the planning and response to drinking water emergencies (Figure 2). The drinking water utilities' chief operators have been identified as the primary communicator and coordinator during an emergency. It is also important to note that the primary coordinator and chain of command change depending on which stakeholder group first learned of the emergency.

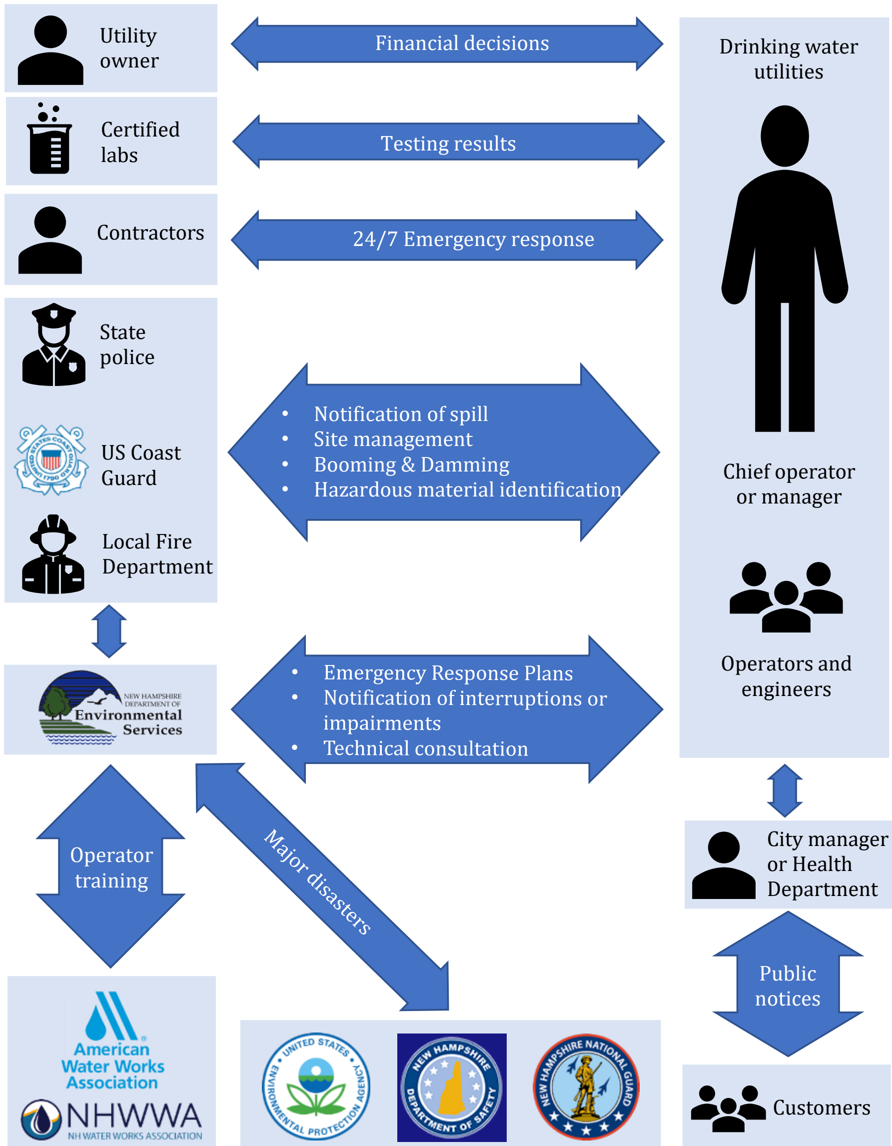


Figure 2. Stakeholder communication map for drinking water emergency planning and response

The emergency planning and response roles of each organization are summarized in Table 2. Most interviewees highlighted the importance of understanding other stakeholder's roles and capabilities so as to provide a clear decision of who to call first, second, third, and so on to mobilize the resources needed in an emergency. A common sentiment amongst the interviewees was the importance of building relationships with and understanding the capabilities of the other stakeholders on a regular basis before the emergency occurs. Interviewees expressed this in different ways including:

- "Communication and networking, knowing the people that are…involved…So [the] Emergency Response Plan has a lot of those key contacts, but a lot of contacts just come from daily operations in knowing people in the business,"
- "If we're not involving our players early and knowing what their capabilities are…unless ahead of time we are prepared and we know what each other's capable of. How can they support us, and we can support them?"
- "I can be on the phone within 10 minutes talking to the people that are the subject matter experts in this field, right? I know I'm not; I know there are people smarter than me and that's part of the game, right, is knowing who you've got to talk to."

Table 2. Summary of stakeholder roles in drinking water emergency planning and response

Stakeholders	Planning Role	Response Role
Drinking Water Operators and Managers	• Develop or contract out ERP and RRA • Train employees • Practice emergency response scenarios • Develop asset management strategies	• Notify and communicate with all applicable stakeholders • Deploy personnel to enact response • Notify NHDES within 24 hours if it is a reportable emergency
Utility Owner or Water Commission	• Accountable for delivering ERP and RRA to government agencies • Provide financial expectations	• Provide financial support and guidelines
Certified Labs	• Analyze routine samples	• Analyze emergency samples
Contractors	N/A	• Provide specialized services and equipment • Respond 24/7 if on-call
State Police	N/A	• Protect human safety • Communicate environmental concerns • Site control and management • Point of contact on weekends

<table>
<tr><td>US Coast Guard</td><td>N/A</td><td>• Manage environmental impacts in navigable waters</td></tr>
<tr><td>Local Fire Department</td><td>• Recordation of hazardous materials at businesses and filing of MSDS sheets
• Enforce proper storage and disposal of hazardous materials</td><td>• Protect human safety
• Identify potential contamination
• Damming and diking to prevent movement of spills</td></tr>
<tr><td>NHDES</td><td>• ERP support and record-keeping
• Encourage updating and practicing ERP protocols
• Operator certification and continued training</td><td>• Technical consultation and guidance over the phone and in-person
• Verify whether utility is taking proper actions and sampling according to the state protocol</td></tr>
<tr><td>American Water Works Association</td><td rowspan="2">• Training and networking opportunities for operators and other industry professionals</td><td rowspan="2">NA</td></tr>
<tr><td>NH Water Works Association</td></tr>
<tr><td>USEPA</td><td>• ERP and RRA support and certification</td><td>• Notified of severe emergencies</td></tr>
<tr><td>NH Department of Safety</td><td rowspan="2">N/A</td><td rowspan="2">• Notified of severe emergencies</td></tr>
<tr><td>NH National Guard</td></tr>
<tr><td>City Manager or Health Department</td><td>N/A</td><td>• Notify public of emergencies and actions necessary to protect human health
• Activate reverse 911</td></tr>
</table>

5. Challenges in Emergency Planning and Response

Interviewees were asked about constraints and challenges in emergency planning and response. Three interviewees identified employee training as a challenge, attributing to limited resources, the need to do on-the-job training due to the nature of the work, and a lack of background knowledge in advanced chemistry. Another drinking water operator interviewee mentioned a desire for more training time and emergency scenario-based practice drills. The interviewees employed different methods to avoid being constrained by a lack of qualified personnel. These methods included having different teams for distribution and treatment, employing outside contractors for repairs or water main break response so the operators could continue focusing on water treatment and communication, and having on-call employees 24/7 who were fairly compensated for their time on-call.

Another frequently mentioned challenge was communicating with the public and maintaining trust. Logistically, some populations in New Hampshire do not have competence with social media, or have access to cell service at their residence, or make use of a reverse 911 system. One drinking water operator noted that if a boil order was issued, town employees would have to go door-to-door with paper notices to inform the entire town. Concerning public relations, drinking water operator interviewees commented, “It's the confidence in the people. You don't want citizens to think that they're drinking bad water,” and, “It is the public's trust [that] is the biggest thing with us, you lose that trust it’s not good.” A state interviewee weighed in with, “the public has gotten a lot more involved…When there’s one issue, any issues, the public really reacts, and you have to have…mechanisms to be able to educate the public.”

Technical constraints mentioned included lab turnaround time, the limited availability of cyanotoxin testing, and supply chain disruptions causing coagulation and disinfection chemical to be difficult to acquire and increasingly expensive.

Funding, on the other hand, was not perceived as a constraint by most interviewees. With Capital Improvement Plans (CIP) and asset management strategies, utilities can effectively manage future funding needs through user rate adjustments. There was a consensus that if a major emergency occurred, insurance or borrowed money would be available to address the problem.

6. Final Thoughts

Although the physical systems and individual roles of the interviewees were quite different, there were many similar attitudes towards the state of drinking water in New Hampshire and thoughts on how the industry can and should adapt to the future needs of its users. These findings include a difference in attitude between frequent well-understood emergencies and less likely emergencies not previously experienced, the importance of networking and knowing other stakeholder's capabilities, and the benefits of planning and asset management. These discrepancies between levels of concern and prioritization on different types of emergencies should be investigated further to understand why stakeholder focus resources, time, or attention on one type of emergency as compared to another. Within these interviews, a recurring theme emerged of the importance of sharing knowledge, but also of recognizing one's knowledge gaps. There was an emphasis on developing relationships with other stakeholders that aide in communication during emergencies. An emerging challenge will be the transfer of knowledge and connections as the drinking water industry's workforce ages and retires. This problem may be exacerbated or ameliorated by the increase in online trainings and gatherings within the industry as opposed to in-person gatherings. This research has identified the necessity of communication through the consensus of the interviewees, but more information is needed to understand how to best promote this collaboration between stakeholders. Another point of consensus among stakeholders was how essential planning is to emergency response. With increasing severe weather events and aging infrastructure, planning was described as the critical way to proactively combat these risks. Asset management and CIPs are becoming present and future reality for drinking water systems in New Hampshire, even for smaller systems. Successes have occurred such as reducing demand by repairing pipe leaks despite a growing customer base.

The specific methods of planning and asset management available to and preferred by operators should be better defined, as well as areas for improvement. Last but not least, interviewees expressed their dedications and a sense of responsibility towards the customers, stating

- “I mean if one [an emergency] hits us we're gonna take it head on…I don't give up on it. Stay right with it,” and
- “It's about good quality water, first and foremost”

This sense of duty and pride in serving drinking water customers cannot be bought like any other countermeasure but is invaluable to the success of emergency response and planning.

Acknowledgements

We acknowledge the National Science Foundation’s support via a CAREER award (#2047199). The views, findings, and conclusions expressed in this study are those of the authors and do not necessarily reflect the views of the funding agencies. We would also like to thank all interviewees for their time and assistance in this project.

About the Authors

- Megan Cramton graduated from the University of New Hampshire in May 2022 with a BS in Environmental Engineering with honors. This work was led by Megan as a part of her honors thesis under the supervision of Dr. Weiwei Mo. She now works as a Project Engineer at The Engineering Corp in Hampton, NH.
- Sara Berg is a sophomore student in the Department of Civil and Environmental Engineering at the University of New Hampshire.

- Taler Bixler is a PhD candidate in the Department of Civil and Environmental Engineering at the University of New Hampshire.
- Jingyan Huang is a PhD student in the Natural Resources & Earth Systems Science Program at the University of New Hampshire.
- Dr. Weiwei Mo is an Associate Professor in the Department of Civil and Environmental Engineering, a faculty affiliate with the Natural Resources & Earth Systems Science Program, and a Faculty Fellow at the Carsey School of Public Policy at the University of New Hampshire.