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AWWA WATER SCIENCE

Management of point-of-use and point-of-entry for regulatory compliance: Survey of state administrators

Katherine Alfredo[1] | **Madelyn Wilson**[1] | **Alan Roberson**[2]

[1]Department of Civil and Environmental Engineering, The University of South Florida, Tampa, Florida, USA

[2]The Association of State Drinking Water Administrators, Washington, DC, USA

Correspondence
Katherine Alfredo, Department of Civil and Environmental Engineering, The University of South Florida, Tampa, FL, USA.
Email: kalfredo@usf.edu

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Association of State Drinking Water Administrators

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Abstract

The USEPA (United States Environmental Protection Agency) Lead and Copper Rule Revisions allow the use of distributed treatment approaches such as point-of-use (POU) and point-of-entry (POE) treatment for systems with 10,000 connections or less as a compliance strategy. However, this poses an opportunity for the USEPA to reevaluate system size recommendations for distributed treatment. The current research uses online surveys and semi-structured interviews (SSIs) to highlight the general sentiment of state regulators managing POU/POE devices and inquiries. Analysis of the 43 survey responses and 13 SSIs revealed that most state regulators described systems of approximately 30–50 connections as the most successful. Resident cooperation, operation and maintenance, monitoring, and the actual implementation of distributed treatment approaches were repeatedly listed as the greatest concerns. As the use of distributed treatment continues to expand, the water sector must devote research efforts to quantitatively determining the drivers of success as well as highlighting clear indicators of potential failure.

KEYWORDS

management, POE, POU, regulatory compliance

1 | INTRODUCTION

The Safe Drinking Water Act (SDWA) (42 U.S.C. 300f et seq. (1974)) requires the U.S. Environmental Protection Agency (EPA) to list feasible treatment technologies for each National Primary Drinking Water Regulation. The 1996 SDWA Amendments added Section 1412(b)(4)(E)(ii) to include point of use (POU) and point of entry (POE) treatment approaches for regulatory compliance. In the nearly three decades since the 1996 Amendments, POU and POE distributed treatment are extensively discussed in the literature in terms of contaminant treatment efficiency (i.e., J. Wu et al., 2021) and as case study lessons discussing the feasibility of this approach (i.e., USEPA, 2006); however, what is lacking is the regulator perspective on the long-term effectiveness of this approach for regulatory compliance.

POU treatment is typically defined as a treatment technology installed within buildings and homes to treat drinking water immediately prior to a tap/faucet/fountain and a POE treatment approach is one that treats water prior to entering a building, confined to the treatment of a single building unit. A POE approach treats all water entering a home or building, providing additional treatment for water from all taps/faucets throughout the building as compared to POU devices (Rozelle, 1987; USEPA, 2006); however, this approach does not protect users from contamination arising in premise plumbing such as lead and copper and, thus, device selection is highly dependent on the contaminant of concern (J. Wu et al., 2021). POU and POE technology include off-the-shelf products sold as a unit and an assembly of individual products to address specific contamination concerns (Hamouda et al., 2010). These products can achieve certification via certifying agencies for the mitigation of specific contaminants, although this is not required by the SDWA (USEPA, 2018b). Certification of POU and POE is available for a wide array of organic and inorganic contaminants; however, microbial contaminant and volatile organic compound mitigation is only approved for POE approaches and not at the POU (USEPA, 2006). In certain situations, consumer installation of POE devices may create a new public water system (PWS) if the device serves an average of at least 25 individuals daily for a minimum of 60 days per year (USEPA, 2021).

POU and POE treatment technologies typically fall into one of four major categories: filtration, membrane, UV disinfection, and remineralization (J. Wu et al., 2021). POE treatment technologies are usually identical to POU except for the treatment system scale. In addition, POE approaches may include aeration or ozonation to target microbial removal (USEPA, 2006). Reverse osmosis (RO) is one of the most widely used methods for inorganic contaminant removal (Rozelle, 1987; USEPA, 2006) and one study demonstrates that RO is capable of treating per- and polyfluoroalkyl substance (PFAS), a type of emerging contaminant of concern (Herkert et al., 2020). One of the most common POU technologies is activated carbon either in granular or carbon-block form (C. Wu et al., 2017). Activated carbon is often used to mitigate taste, odor, heavy metals, emerging contaminants, and disinfection by-product contamination concerns at the home (NSF International, 2011, 2015). Widespread POU filter distribution occurred in the wake of known or expected lead contamination (i.e., the Michigan Department of Environmental Quality has distributed POU filters to residents in Flint, Michigan since 2016; USEPA, 2016) and the District of Columbia has installed under the sink activated carbon POU filters at all water fountains in district public schools (Alfredo et al., 2020).

With increased federal attention to lead abatement and the promulgation of the Lead and Copper Rule Revisions (LCRR), the EPA has listed the use of POU treatment as an alternative to corrosion control treatment for water systems with 10,000 connections or less. The LCRR provides the EPA with an opportunity to reevaluate the system size for both POU and POE distributed approaches with some recommendations to lower the system connection threshold to 100 connections or less for use as a lead abatement strategy. In one case study, a system using POU technology for fluoride reduction in a community increased from 40 connections to 57 connections and thus faced many administrative challenges related to operation and maintenance (O&M) that, eventually, led to the abandonment of the distributed approach and the connection of these households to city water (USEPA, 2006). Concerns regarding O&M often lead state regulators to prohibit the POU/POE distributed treatment approach for regulatory compliance.

Article Impact Statement

State regulators noted systems with fewer than 100 connections had the most successful installation of distributed treatment. Resident cooperation and logistics were listed as the greatest concerns.

In 2011, the Association of State Drinking Water Administrators (ASDWA) distributed a three-question survey[1] to its state and territorial members to capture POU and POE use across the U.S. receiving 44 responses (43 states and the Navajo Nation). The results showed that 48% of respondents allow POU treatment for regulatory compliance whereas 59% of respondents allow for a POE approach. The respondents indicated the maximum number of device installations for any one location was 26 systems, far below either the EPA size category ceiling of 10,000 connections or the recommended 100 connections. At the time of this initial 2011 survey, the most widespread use of POU and POE treatment for compliance was for adherence to the revised arsenic rule thresholds. As the community prepares to comply with the LCRR, this research examined the management and deployment of POU and POE treatment approaches at the state level to develop the key research questions the drinking water community must address before large-scale application.

2 | MATERIALS AND METHODS

2.1 | Online survey of regulatory administrators

To evaluate the allowance of POU and POE approaches to regulatory compliance, we used a short online survey targeting regulatory administrators of drinking water programs.[2] We chose to use a survey to ask consistent questions of each respondent since a review of regulatory guidelines for POU and POE uses at the state level were varied and often not detailed. The 2011 survey was extremely brief, asking a total of three questions: (1) Did the regulations allow for POU installations, (2) POE installations, and (3) the number of CWSs with installations? The 2021 survey was more expansive to gather additional details. The survey was distributed by ASDWA to the leaders of the drinking water programs for the 50 states, 5 territories, the District of Columbia, and the Navajo Nation. Using the online survey tool Qualtrics, the survey employed display logic and survey branching to group respondents by allowance type to ask specific questions based on regulatory compliance allowance. In total, a maximum of 23 questions were possible (see Supplemental Material for the full survey). Initial questions sorted respondents into five allowance categories:

1. allow both POU and POE approaches for compliance,
2. allow POU only,
3. allow POE only,
4. do not allow either approach for compliance, or
5. allow for either POU or POE in temporary compliance situations.

Additionally, open-ended questions were included for states to share comments regarding the use of POU and POE approaches. Administrators of state drinking water programs were targeted due to their knowledge of state drinking water regulations and experience with small water systems using these devices. The survey was administered between July and October 2021.

2.2 | Semi-structured interviews

The final question of the online interview was a request to schedule a follow-up semi-structured interview (SSI) to gather additional evidence and develop case studies. Respondents with substantial POU/POE application experience and/or those that provided lengthy responses to the open-ended questions were prioritized for SSI selection with no formal exclusion metrics employed during selection and outreach. In total, respondents representing 13 different states participated in the SSI. The SSIs took place virtually on Microsoft Teams lasting approximately 45 min each and were recorded with participant permission to ensure data quality and integrity. Questions varied across interviews; however, the anchoring questions to initiate the discussion included:

- What benefits (if any) do you feel the use of POU and/or POE provides when compared to central treatment methods? Please explain
- What limitations do you feel the use of POU and/or POE provides when compared to central treatment methods? Please explain
- Do you believe there are sufficient federal regulations and guidance regarding POU/POE devices and their use?

For a more holistic picture, a total of four (4) SSIs were also conducted with a select few water systems to capture the experiences of small systems using these devices. Participants were recruited with the assistance of state regulators who had participated in the regulator SSIs.

3 | RESULTS AND DISCUSSION

3.1 | Online survey of state regulators

A total of 43 states responded to the 2021 online Qualtrics survey. The seven states missing from the 2021 data set include Kentucky, Maine, Michigan, New Jersey, Tennessee, Washington, and Wyoming as well as the District of Columbia. The state of Indiana responded separately for arsenic and lead compliance allowance for POU and POE distributed approaches. Since the responses varied between these two categories, we kept the two entries separate. Comparing the 2011 survey to the current survey, there were 37 states that responded to both. The use of distributed treatment for regulatory compliance remained largely unchanged, with only 15 states changing allowances. Seven of the states that previously did not allow for POU and POE use for regulatory compliance began allowing POU and POE device use for SDWA compliance. Evaluating all the answers regardless of answering both surveys, while the number of respondents allowing for both POU and POE compliance strategies remained unchanged (21 respondents in both years), those that did not allow for distributed treatment under any condition decreased from 18 respondents to 12, suggesting an increase in potential use for compliance.

Of the 44 unique responses to the 2021 survey, 21 allow both POU and POE approaches for compliance, 3 allow POU only, 2 for POE only, and 12 do not allow for either approach. The remaining six respondents indicated that their state allows distributed POU and/or POE approaches but only on a temporary basis. Of the 26 respondents indicating that the states they represent allow some form of distributed treatment approach to compliance, 12 reported size limitations to their application, summarized in Figure 1. Most respondents indicated restricting POU/POE use to systems with less than 500 connections; however, two regulators indicated sizes as large as and exceeding 3300 as a threshold. However, despite the stated limitations, no regulator reported knowing of a POU compliance application in exceedance

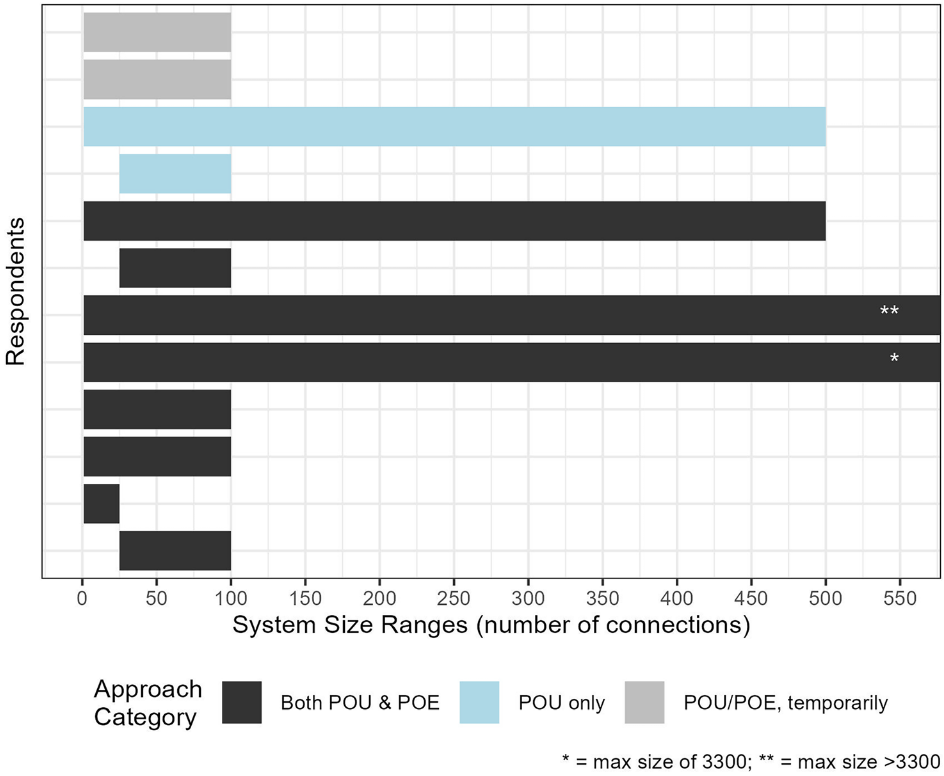

FIGURE 1 Public water system connection size restrictions for point-of-use and/or point-of-entry applications.

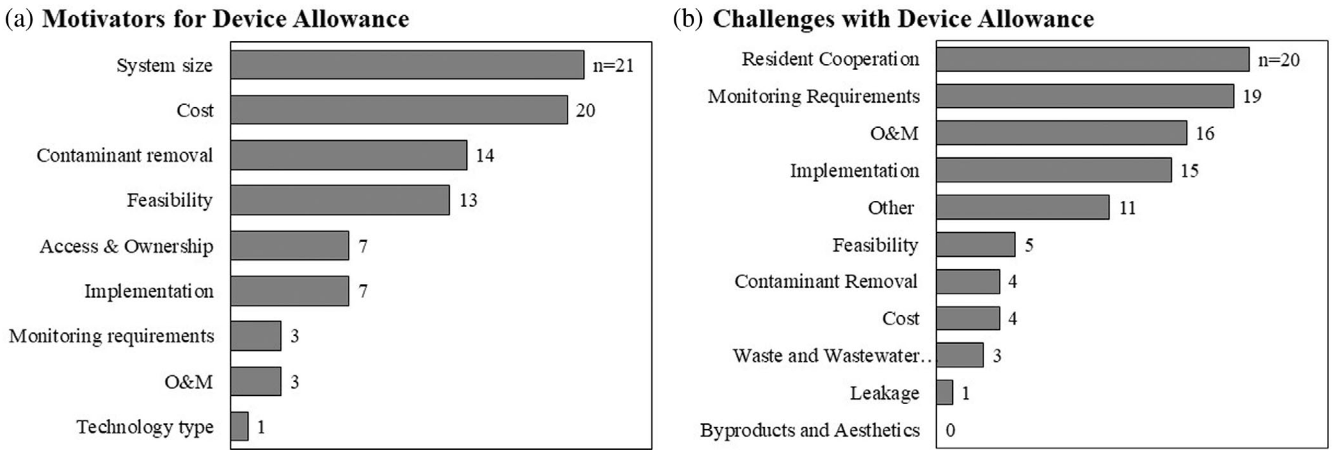

FIGURE 2 Device allowance challenges and motivators as reported by state regulators on the 2021 survey. This data is only for states that allow either point-of-use and point-of-entry devices or either of the devices ($N = 30$). Respondents were allowed to select up to three responses for motivators and as many challenges as they desired. The number of respondents selecting a motivator or challenge (n) is shown to the right of the bar.

of 50 or a POE application exceeding 500 units. There appears a large gap between theoretical limits to applications and actual installations. While we know some systems distribute temporary POU treatment after lead service line (LSL) replacements (American Water Works Association, 2014; Lindwall, 2022) or as preventative measures for potential lead contamination (Alfredo et al., 2020; USEPA, 2018a), these are not for compliance monitoring purposes and, therefore, do not require the same rigor of testing to ensure proper treatment efficiencies. It is assumed, in the case of the pitcher filters distributed after LSL replacements, that after the probationary period, residents will discontinue use.

If we subset the 2021 survey to focus on those respondents reporting allowance of POU and POE approaches for regulatory compliance (including temporary compliance scenarios) (Figure 2), most respondents indicated that the major motivators for allowing use was system size followed by cost. It is important to note that respondents were only allowed to select three responses, thus indicating the top motivators. This again suggests that restriction on system size is an important condition for distributed treatment for regulatory compliance allowance. The major challenges respondents reported are related to gaining resident cooperation, monitoring installed units, O&M, and implementation challenges. It is easy to argue that these four answers are all interrelated as implementation requires resident cooperation and the daily logistics of a compliance program that includes distributed treatment would include monitoring requirements and O&M concerns. These major concerns for those state regulators reporting POU and POE allowance are echoed by those not allowing either or both distributed compliance approaches.

Respondents that indicated not allowing one or both devices were asked to select which concerns prevent distributed treatment within their state. In this question, respondents were allowed to select as many choices as they saw fit. Despite the differences in the two survey questions, the top four concerns are the same in Figure 3. Notably, cost and contaminant removal were not identified as major challenges or concerns for either set of respondents.

The 2021 survey concluded with three open-ended questions, "Are you aware of any POU/POE installations success stories from utilities within your state? (1–5 examples preferred). In brief, why were these installations a success?", "Do you have any examples of less than successful POU/POE installation stories from utilities within your state? (1–5 examples preferred). In brief, why were these installations less than successful?", and an opportunity to provide any additional information. Several themes emerged throughout these additional comments such as the management burden on both regulators and PWSs, the lack of control associated with POU/POE technologies installed within a private residency, and the use of a distributed treatment approach as a last resort and not as a best practice. More than one respondent mentioned abandoning distributed treatment in favor of consolidation due to challenges. In addition, many of the successful examples were installed within non-community systems.

3.2 | State regulator SSIs

All interview participants were asked to describe both the major benefits and limitations associated with distributed treatment approaches as compared to central treatment methods. In general, more challenges were identified than benefits across all interviews, and the most common benefit identified was cost. Out of the 13 SSI participants, 10 explicitly mentioned that POU and POE treatment approaches are cost-effective and economical for systems unable to afford central treatment. Repeatedly, in both the online survey and the SSIs, cost, and affordability are stated as one of or even the primary driver for distributed treatment approaches. Other benefits mentioned include sustainability, water efficiency, and maintenance. With respect to the POU approach, some states recognized that treatment of only the water consumed is more water-efficient and can provide significant water savings, especially in drought-prone regions. The sustainability of distributed treatment was widely debated when participants were asked to compare the approach to central treatment. We intentionally left the term "sustainability"

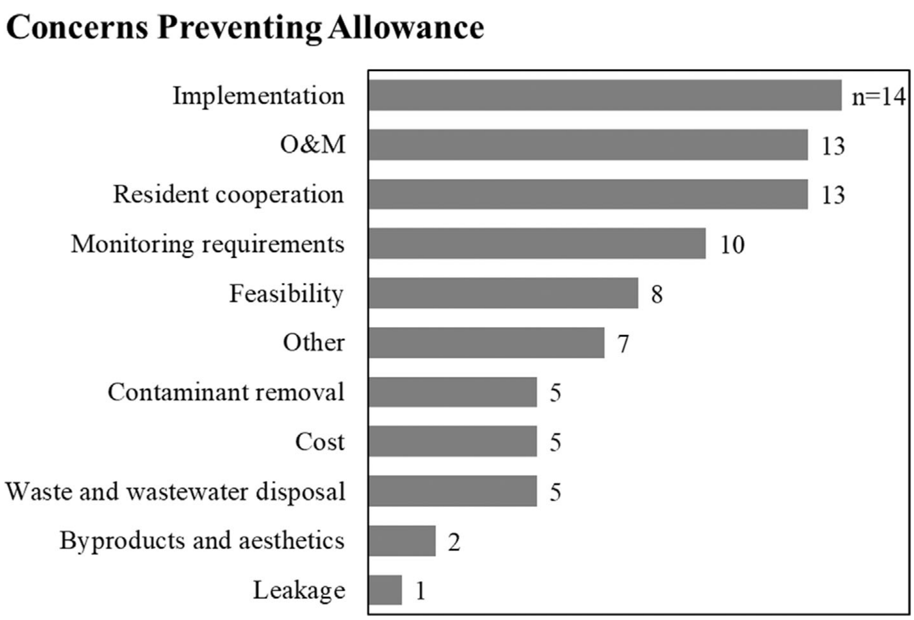

FIGURE 3 Concerns preventing device allowance for states. This includes respondents who allow one type (point-of-use or point-of-entry) but not the other or disallow both devices ($N = 17$). Respondents were allowed to select as many concerns as they desired. The number of respondents selecting a concern is shown to the right of the bar.

undefined in our interview to allow the participant to define and explain. Most respondents were unable to give a direct assessment since, in their experience, "sustainability" is very system specific. One argument for distributed treatment being more sustainable referred to the classification and production of waste. Not only are fewer wastes produced (less water is treated at the POU) than central treatment but most filters and cartridges for POU systems can be disposed of as household wastes under the Resource Conservation and Recovery Act (RCRA). This reasoning spurs an important question—if distributed treatment use increases across the U.S., then do we need to reevaluate the disposal of spent POU cartridges and what are the environmental impacts of this increased waste stream? The counter argument on sustainability focused on sustainability in terms of personnel resources. The time required for the management and maintenance of distributed treatment applications, in addition to the frequency with which components such as filter cartridges require replacement, is a great concern. From a labor perspective, it requires more time to address distributed O&M issues than for central treatment. Regardless of the time requirement for O&M, one regulator argues that a benefit of using these devices is that the actual maintenance on the devices is technically easier.

This benefit, of an easier technology to maintain, is not inconsequential. For over a decade, the water sector has been concerned with an aging operator population and the potential loss of institutional knowledge (Karasik, 2008; Lacey, 2005; Boepple-Swider, 2008; Olstein, 2005). This fear became a reality during the height of COVID-19 lockdowns in 2020 and 2021 when many eligible for retirement retired (AWWA, 2021a, 2021b; Meko, 2019). A serious consideration for the use of distributed treatment must include the availability of the workforce and their associated skill levels. Central treatment operators require various educational and certification requirements, whereas replacement and testing of filters might not require the same training; however, in some locations, even the lower skills positions at utilities remain vacant. While certified technologies that comply with treatment standards are required, some states also require certified operators to manage the testing and maintenance of the distributed treatment units. It is unclear if this certification is similar to the operator certification, but for those states requiring an operator, the looming shortage might pose yet another challenge to distributed treatment.

One of the anchoring questions in the SSI pertained to federal regulations and guidance regarding POU/POE technologies and their usage in regulatory compliance. Responses to this question were split almost evenly with half of the respondents stating the level of guidance was adequate and the other half indicating a need for more clarification. Almost in every instance that a respondent noted that the federal guidelines were adequate, the respondent supported this stance by stating that state guidelines were more detailed and were tailored to local needs. In a review of specific POU and POE guidance at the state level, these documents are scattered and difficult to locate. We were able to locate guidance documents for 46 states. Some state guidance documents (i.e., Arizona, Idaho, Kansas) were easy to locate with explicit limitations and certification requirements (Arizona Department of State, 2016; Idaho DEP, 2023; Kansas Department of Health and Environment, 2019). Other states simply list the definition of "point of" treatment and provide no additional guidance. This appears to be an area of improvement that could help standardize the implementation, monitoring, and permitting of distributed treatment. For example, many states required 100% resident buy-in throughout a water system prior to installing either POU or POE treatment for compliance with an MCL. Some states go as far as to require written agreements signed by a representative at each connection, but others do not. There is no apparent standardization for residential agreement or formal consent. Similarly, there is little to no public education. Some participants mentioned that the primary public communication was in the form of the Consumer Confidence Report (CCR). This is not a document that typically provides education on non-centralized treatment. In some scenarios, public education was implemented prior to the installation during the permitting stage, focusing on the MCL violation and health risks. In no instance was a formal education platform mentioned after distributed treatment was installed.

As system size and the number of connections were major themes identified as concerns and/or challenges, this was a topic explored further in the SSIs. Many participants voiced that limiting the number of system connections increases device feasibility. Two respondents mentioned connection limits of 200 and 100 connections, yet both respondents also mentioned that this was too high. In the SSI discussions, connection limits of approximately 30–50 were recognized as a "sweet spot," especially for POU applications. This is even lower than the ASDWA recommended maximum of 100 connections and far below the "small system" cut-off of 10,000 connections. This size directly relates to the other challenging aspect of residential cooperation and monitoring requirements, especially when 100% community cooperation is required. Residential cooperation can also influence how and when operators access distributed systems. In at least one case, system operators worked irregular hours to perform monitoring and maintenance on devices inside homes where the resident is unavailable to give access to the property during normal business hours. These access issues are then exacerbated when factoring in vacation homes and still reaching monitoring requirements.

Often, these distributed systems are targeted at smaller systems that lack the ability to consolidate; however, this can raise an interesting equity issue. One regulator voiced this concern by stating, “it seems like we are setting up a 2-tiered system where those who can, will have centralized treatment and all the protection it affords and other systems who just have these POU devices are getting second class treatment and second-class water quality.” This idea of equity of distributed treatment is not well explored in the literature. Beyond the actual quality of delivered water, the perception of water quality is equally as important, especially when traditionally disadvantaged communities are considered for distributed treatment approaches. Other equity issues arise for renters when property owners refuse to install these devices.

3.3 | Utility interviews

The utility interviews completed included water systems from four different states: Alaska, Florida, New Hampshire, and Nevada. All the utilities interviewed managed a POU compliance approach. Table 1 summarizes the system information for the four utilities interviewed. Note that the utility in Nevada manages three different water systems with POU devices for arsenic compliance and the utility interviewed in Alaska manages five small water systems for arsenic compliance. All systems managed by the utilities interviewed are residential CWSs except for the system in Florida which is a non-transient non-community water system (NTNCWS). Although the system in Florida is not a CWS, the utility still faced challenges in gaining access to properties as some businesses were hesitant about installing POUs since they already paid for bottled water. The largest number of system connections is 60 managed by the utility in Nevada and the smallest number of system connections is 14 managed by the utility in New Hampshire.

The utility SSIs primarily confirmed the viewpoints of the state regulators. Utility survey participants provided practical, experiential knowledge beyond what many regulators might consider especially with regard to monitoring and maintenance. While regulators were concerned with the residents' cooperation to initiate the program, utilities were concerned with accessing them once installed. The utility in Alaska indicated that placing POU devices in the garage instead of under the sink was one method they employed to combat residential access issues as residents are more willing to let water operators into the garage instead of the home. Once in the home, residents often tamper with the units creating leaks or even removing POU treatment units.

Regardless of location, the idea that these distributed treatment units would treat only consumed water is not necessarily proving true. This in turn feeds into the access challenges as the utility must “jump through hoops to get approval to change out filters.” Utility respondents also focused staffing concerns on the need to schedule two service technicians during routine monitoring and maintenance for safety and to avoid liability issues. Successful applications discussed by the utility representatives were small, for example, the 14-home mobile park in New Hampshire. However, when asked about larger implementation efforts, one participant indicated that with their experience managing a system with more than 100 houses is a “nightmare.”

3.4 | Installation success is a spectrum

One of the key takeaways from this study is that a POU/POE approach for regulatory compliance cannot take a one size fits all approach. Compiling the examples pulled from our surveys and interviews, Figure 4

TABLE 1 Summary of select utility interviews.

State	SDWA contaminant	State allows POU/POE	No. of systems managed	Largest no. of connections or devices	System type
Nevada	Arsenic	Both	3	60	CWS
Alaska	Arsenic	Both	5	50	CWS
New Hampshire	Uranium, gross alpha	Both	1	14	CWS
Florida	Lead	Both	1	45	NTNCWS

Note: Four utilities were selected for interviews.
Abbreviations: CWS, community water system; NTNCWS, non-transient non-community water system; POE, point of entry; POU, point of use; SDWA, Safe Drinking Water Act.

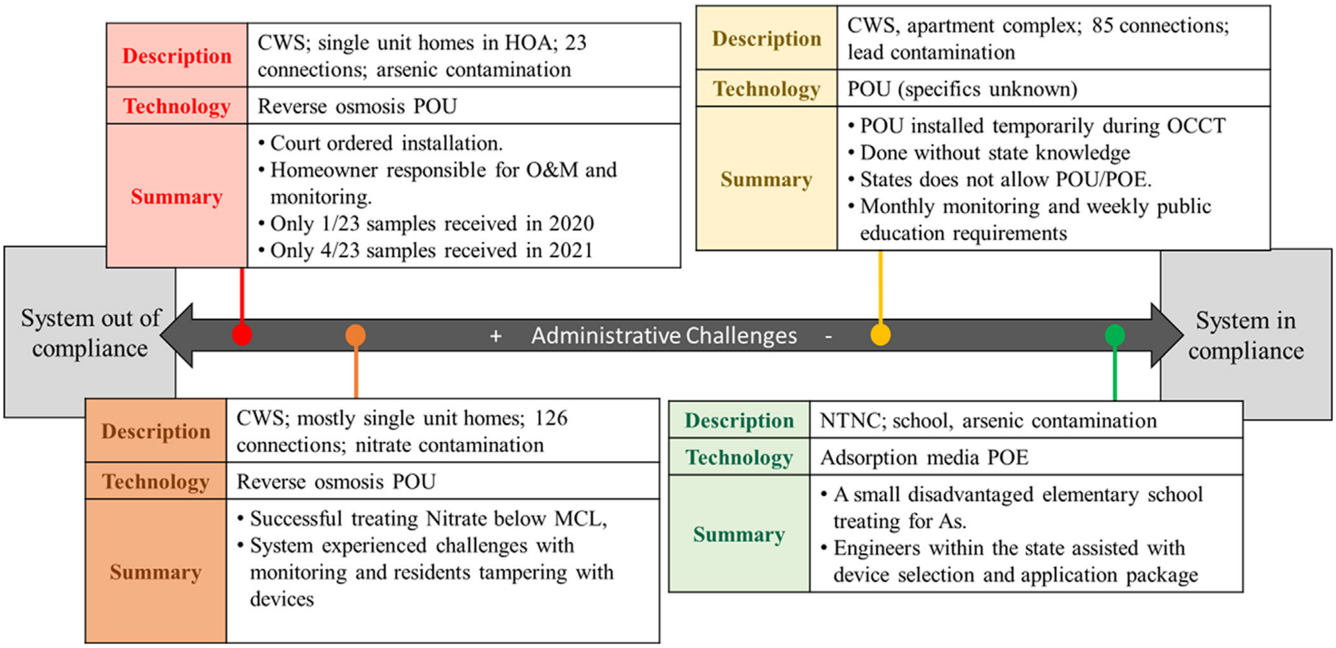

FIGURE 4 Summary of state regulator interview information into categorical "cases" to highlight the spectrum of success. CWS, community water system; HOA, homeowners association; MCL, maximum contaminant limit; NTNC, non-transient, non-community water system; O&M, operation, and maintenance; OCCT, optimum corrosion control treatment; POE, point-of-entry; POU, point-of-use.

depicts a potential installation spectrum. On the right, there are systems that use these devices to successfully reduce constituent concentrations below their respective MCLs with fewer administrative challenges. The most successful example provided was a small disadvantaged elementary school in an NTNCWS system which uses an adsorptive media POE to treat arsenic. Internal engineers within the state drinking water program assisted with the device selection and application package which resulted in approximately $5000 in cost savings. On the left are systems out of compliance even after device installation and are additionally overburdened by a plethora of administrative issues. The most unsuccessful example has less than 100 connections, yet a court-mandated install rather than obtaining 100% resident agreement hints at a lack of system acceptability, complicating a distributed approach.

4 | CONCLUSIONS

Using online surveys and SSIs with state regulators, this research defined the areas of greatest concern concerning using the distributed treatment for SDWA regulatory compliance. While more states appear to allow a POU/POE approach for compliance as compared to the 2011 survey, there was very little consensus as to what makes them successful. The regulatory compliance rules typically limit distributed treatment to "small" systems of 10,000 connections or less, yet we did not find a state regulator that could identify an installation greater than several hundred. Furthermore, even though many state regulations might set lower system size maximums, most state regulators and utilities described systems of approximately 30–50 connections as the most successful. This threshold is comprehensible when the primary challenges to POU/POE approaches are interpreted. Resident cooperation, operation and maintenance, monitoring, and the actual implementation of a distributed treatment approach were repeatedly listed as the greatest concerns. Smaller systems translate into fewer residents, fewer field teams (staff concerns), and fewer devices to schedule and monitor.

The increase in using POU and POE approaches for regulatory compliance is inevitable. A recent publication by the National Alliance for Water Innovation states that distributed treatment should be autonomous, resilient, and modular among other traits, POU and POE approaches have an opportunity to improve in all of these categories (Sedlak et al., 2021). The LCRR and treatment for emerging contaminants of concern are likely to significantly contribute to this increase. While this research defined the areas of gaining resident cooperation, monitoring installed units, O&M, and implementation challenges as the primary concerns, we cannot determine the true drivers of distributed treatment for compliance success. Beyond case study analyses, there is no complete database to perform robust analyses to move beyond qualitative analyses. As the use of distributed treatment continues to expand, the water treatment and regulatory sectors must devote research efforts to quantitatively determining the drivers of success as well as highlighting clear indicators of potential failure.

AUTHOR CONTRIBUTIONS

Katherine Alfredo: Conceptualization; formal analysis; supervision; methodology; writing – review and editing. **Madelyn Wilson:** Data curation; formal analysis; investigation; writing – original draft. **Alan Roberson** Conceptualization; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

Alan Roberson is the Executive Director of the professional organization that supplied funding that partially supported this research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Katherine Alfredo https://orcid.org/0000-0003-4392-9031

ENDNOTES

[1] This survey inquired only about POU and POE device use within a community water systems (CWS). The results of this survey are unpublished and were provided to the authors for a comparative analysis.

[2] IRB#002949, exempt.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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