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Public-private partnerships in U.S. rural water infrastructure: challenges, opportunities, and needs

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Most water and wastewater systems serve small, rural communities that often lack the scale, funding, and staffing to maintain their critical infrastructure. Public-private partnerships (PPPs or P3s) may be a solution. In this Perspective we diagnose the problems of rural water services and map the strengths of P3s to solve them. We discuss the challenges of adapting P3s to rural water infrastructure and suggest the most beneficial opportunities for doing so—namely, water utilities' new assets, revenue/capital, and regional collaboration. The work offers insights into how rural water and wastewater systems might pursue P3s to sustainably manage their infrastructure needs.

KEYWORDS

water infrastructure, asset management, utility, project delivery, risk, public-private partnerships, P3s

1 Introduction

Small, rural water and wastewater systems struggle with issues of scale, revenue, expertise, staffing, and water quality relative to larger ones (Allaire et al., 2018; Marcillo and Krometis, 2019; Mueller and Gasteyer, 2021; McFarlane and Harris, 2018). The terms “rural” and “small” are often used synonymously with water systems, reflecting the strong overlap between small systems and rural communities (U.S. Environmental Protection Agency, 2016). These systems make up an outsized proportion of water service providers: in the United States, 81% of community water systems serve fewer than 3,300 people and serve just 7% of the population (U.S. Environmental Protection Agency, 2021). The Safe Drinking Water Act (SDWA), the governing U.S. statute for drinking water that is now 50 years old (Sowby, 2023), reaches most U.S. water suppliers, but not all; systems serving fewer than 25 people are excluded from regulation. Abroad, the challenges are even greater (McDonald et al., 2014): one-third of rural water suppliers in developing countries do not provide reliable service (Kleemeier and Lockwood, 2015).

Recognizing the immense need for improvement in rural water services worldwide, one proposed solution is adjusting the project delivery mode. In this Perspective we explore the potential in the United States of expanding the use of public-private partnerships or P3s (a type of alternative project delivery model) and ask, “How could rural water infrastructure benefit from P3s?” We review the literature to diagnose the problems of rural water and map the strengths of P3s to solve them. We also discuss the challenges and limitations of adapting P3s to rural water infrastructure, the opportunities and benefits of doing so, and additional research needed to remove barriers.

2 Challenges of rural water

Small, rural communities face challenges that their urban counterparts do not in the same degree: scale, funding, staffing, and water quality, among others.

2.1 Scale

Rural water systems lack the economy of scale that makes large, urban water systems efficient. Low customer density means longer conveyance distances per customer, and systems serving fewer people still have some of the same fixed infrastructure demands as their larger counterparts. Small water systems are also more energy intensive (Sowby and Burian, 2017; Sowby and Siegel, 2024). Together these comparative inefficiencies mean higher costs per customer. Consolidation is sometimes recommended, but Klein and Michaud (2019) and Dobbin et al. (2025) observed that consolidation does not automatically increase network density or reduce operating costs.

2.2 Funding

A small customer base and a lower-income population contribute to a rural water system's limited financial resources (McFarlane and Harris, 2018; Kozakevitch, 2025). Water infrastructure has both one-time capital and ongoing operational costs, and many rural communities are poorly positioned to design appropriate rates, let alone afford them (Harvey and Mukanga, 2020). Many water utilities, including and especially small systems, charge chronically low water rates because of local social and political pressures, and customers and community leaders may resist adjusting rates to full-cost pricing (Jarocki, 2004; Tanellari et al., 2015; Flora, 2004; Dziegielewski and Bik, 2004). For these reasons a system may depend on aid from state, federal, and foreign governments or nonprofits, and some rely on complex multilevel relationships among these entities (Greer, 2020). Even with financial aid, a rural water system may struggle to sustain a healthy infrastructure program, for example, when the aid comes as a loan instead of a grant (Ramseur, 2018), when economic factors or high local demand lead to above-average interest rates (Greer, 2020), or when utilities can no longer depend on previously appropriated aid (Flora, 2004). Much rural infrastructure has historically suffered from the challenge of state and federal programs paying the capital costs but leaving local communities to cover operation and replacement costs.

2.3 Staffing

The same factors that limit funding also limit staffing in rural water systems. Their limited human resources capacity is well acknowledged, albeit poorly studied since research in this space has favored technical rather than social topics (McFarlane and Harris, 2018; Kozakevitch, 2025). Communities with more than 3,000 people usually have sufficient human capacity for infrastructure operations, maintenance, and management, but smaller ones do not (Maras, 2004). Water infrastructure requires a specialized workforce that may not exist in small communities (Flancher and Kathleen, 2020). Moreover, the

shortage of human capital extends beyond technical knowledge: Small communities struggle to find and retain leaders with both the will and bandwidth to take responsibility for the utility's future, which is essential to maintain service (Flora, 2004; Dziegielewski and Bik, 2004).

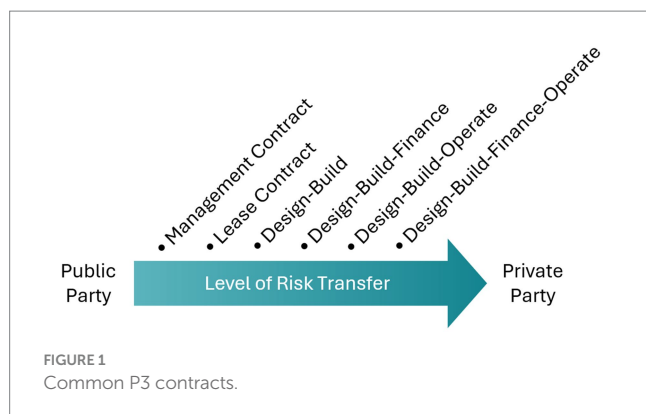
2.4 Water quality

In the United States and Canada, regulatory requirements have become stricter in the past 30 years, creating additional technical, financial, and managerial burdens, especially for small water systems (McFarlane and Harris, 2018). Small systems are expected to meet the same high standards as larger ones but with lower revenues and fewer personnel. As a result, SDWA violations occur more frequently in small systems (Allaire et al., 2018; Marcillo and Krometis, 2019; Mueller and Gasteyer, 2021). Their most chronic violations are monitoring and reporting, which means health violations may go undetected (Marcillo and Krometis, 2019; Dziegielewski and Bik, 2004). These violations can result in unique risks for rural populations. Liddie et al. (2023) reported that per- and polyfluoroalkyl substances (PFAS) are particularly common in water systems in rural counties with high poverty levels while water systems in urban counties with high poverty levels did not show a positive correlation. Additionally, many residents of rural areas rely on unregulated private wells. Shallow domestic wells are particularly vulnerable to high nitrate levels when located near agricultural activity common in rural areas (Dubrovsky et al., 2010), and private well users may also be at risk for excessive levels of coliform bacteria, lead, and other metals (Knobloch et al., 2013; Gibson et al., 2020). Rural systems that rely on groundwater sources may avoid some regulatory requirements but can face more difficult remediation if contamination does occur (Dziegielewski and Bik, 2004). The cumulative risks and disadvantages in rural communities create an increasingly difficult environment in which to provide a basic community service.

3 P3s for project delivery

Traditional project delivery (e.g., design-bid-build) involves sequential and discrete procurement of services to develop an infrastructure asset, and the public party retains the majority of risks associated with delivery and operation. A public-private partnership (PPP or P3) is an alternative project delivery solution. A P3 is a concession agreement—a long-term contract where a private party is allowed to participate in the provisioning of a public asset or service in exchange for payments from the public party (or the right to collect user fees) when certain performance conditions are satisfied. P3s are often selected as a way to transfer risks borne by public entities, attract specialized knowledge and capacity, and provide alternative means of project finance (Dewulf et al., 2011). While there are dozens of possible P3 arrangements (Ke et al., 2010; Delmon, 2017), Figure 1 shows a spectrum of common ones. They differ in their level of risk transfer, ideally aligned with which party can best provide what is needed for a given project or program. In the United States, most water P3s are currently for operation and maintenance, compared to highway P3s, most of which are for design and construction (CBO: Congressional Budget Office, 2020).

In Table 1 we compare traditional and P3 delivery for key aspects of rural water infrastructure provisioning. The final column indicates



relevance to rural communities, where the strengths of P3s are a good match for the rural conditions and a partnership could be worthwhile.

4 Challenges of P3s

The water sector in general is not a prime space for P3s. [Delmon \(2017\)](#) notes that the high cost of transporting water, the political sensitivity of water issues, the magnitude of regulation, and the uncertain condition of buried assets make the water sector unattractive to private investors. Another aspect of P3s is the question of whether or not risks can fully be transferred to a private party. The extent to which concession contracts are enforceable for various risk conditions and “unknown unknowns” continues to be a thorny issue. Beyond these general concerns, rural water infrastructure presents the additional specific challenges described below.

4.1 Profit margins and rates

In a P3, the private party needs a profit margin, and a small community may not be able to afford it. [Condon \(2019\)](#) wrote, “In tiny communities with average incomes well below the national average, it’s not clear if users will be able to shoulder the tripling or quadrupling of water rates necessary to entice private investors.” However, while elevated user costs are possible, they do not appear to be the pattern. [Gassner et al. \(2009\)](#), in their study of 1,200 water and power utilities over a decade, found “no evidence of a systematic change in residential prices” as a result of private sector involvement; if tariffs rose, they rose equally to cover the cost of service whether the utility was privately or publicly handled. Still, further study of rural water systems is needed. It is also unclear what effect private involvement would have on customers’ willingness to pay. In many systems where tariff increases are necessary to cover the service the private party provides, customers may initially experience “sticker shock” and reject the higher cost ([Jarocki, 2004](#); [Tanellari et al., 2015](#)). Little has been done to investigate the effect of private involvement on this behavior.

4.2 Government

Some rural communities are unincorporated and have no formal government structure; they lack authority to organize utilities, arrange P3s, and, as [Condon \(2019\)](#) said, even “vote on their own access to clean water.” In such cases, residents often rely on informal,

TABLE 1 Comparison of traditional and P3 delivery in rural water infrastructure.

Aspect	Traditional delivery	P3 delivery	Application of P3s to rural settings
Risk allocation	Public sector retains most risks	Risks shared between public and private sectors	Closes gaps in infrastructure, funding, and staffing
Capital access	Limited by public funding	Private sector provides funding	Eases financial strain on rural utilities
Operational efficiency	Public-led, variable efficiency	Private-led; efficiency incentivized	Improves system performance
Scalability	Limited by local capacity	Enables regional collaborations	Improves economies of scale for small systems
Timeline for delivery	Often delayed	Performance-based, time-bound	Ensures timely delivery

under-resourced systems to meet their water needs. Even where local governments are organized, they may lack the institutional maturity and sophistication to negotiate complicated concession agreements and administer sustainable water services, which include not only keeping up the infrastructure but also managing the associated customer relationships, financial systems, and regulatory commitments. [Flora \(2004\)](#) observed that communities with a shared vision of what to expect from their water utility have more sustainable services. However, not all small communities have this sense of cooperation, politically or socially. The absence of these critical functions creates systemic barriers to achieving long-term water security with P3s.

4.3 Skepticism

Skepticism regarding the benefits and costs of P3s remains a significant barrier to their adoption, particularly in the water sector. In an industry survey conducted by [EY and American Water Works Association \(2019\)](#), stakeholder skepticism was the most frequently cited obstacle. The P3 model is known to water utility stakeholders, they report, but the “stakeholders are skeptical over the general applicability of a P3 delivery model and are of the view that only a subset of projects will have the scale, technical or operational complexity, and risk profile to make the risk-transfer value case for P3.” While many utility managers are already aware of the P3 model, it is likely unknown to many rural citizens who would be affected by adopting it. Without their participation, an otherwise promising project may never reach completion. The need to build trust in P3 delivery thus extends to multiple stakeholder groups.

5 Opportunities for P3s

There are three specific areas where P3s might best perform in this space: new assets, revenue and capital, and regional collaboration. In [Figure 2](#) we suggest how P3s can bridge the gap between typical rural

water challenges and opportunities. Each opportunity is discussed below.

5.1 New assets

One study concluded that the best opportunity for P3s lies in developing new assets, particularly water treatment infrastructure (EY and American Water Works Association, 2019). New projects are generally more attractive to private investors because they avoid the problems associated with aging, underground assets that Delmon (2017) mentions, such as unknown maintenance needs, rehabilitation costs, and operational inefficiencies like leaks. Water treatment plants offer clear deliverables and measurable outcomes which align well with the performance-based nature of P3s—for example, a 30-month schedule for delivery of a 20-million-liter-per day microfiltration facility that meets U.S. National Primary Drinking Water Regulations.

5.2 Revenue and capital

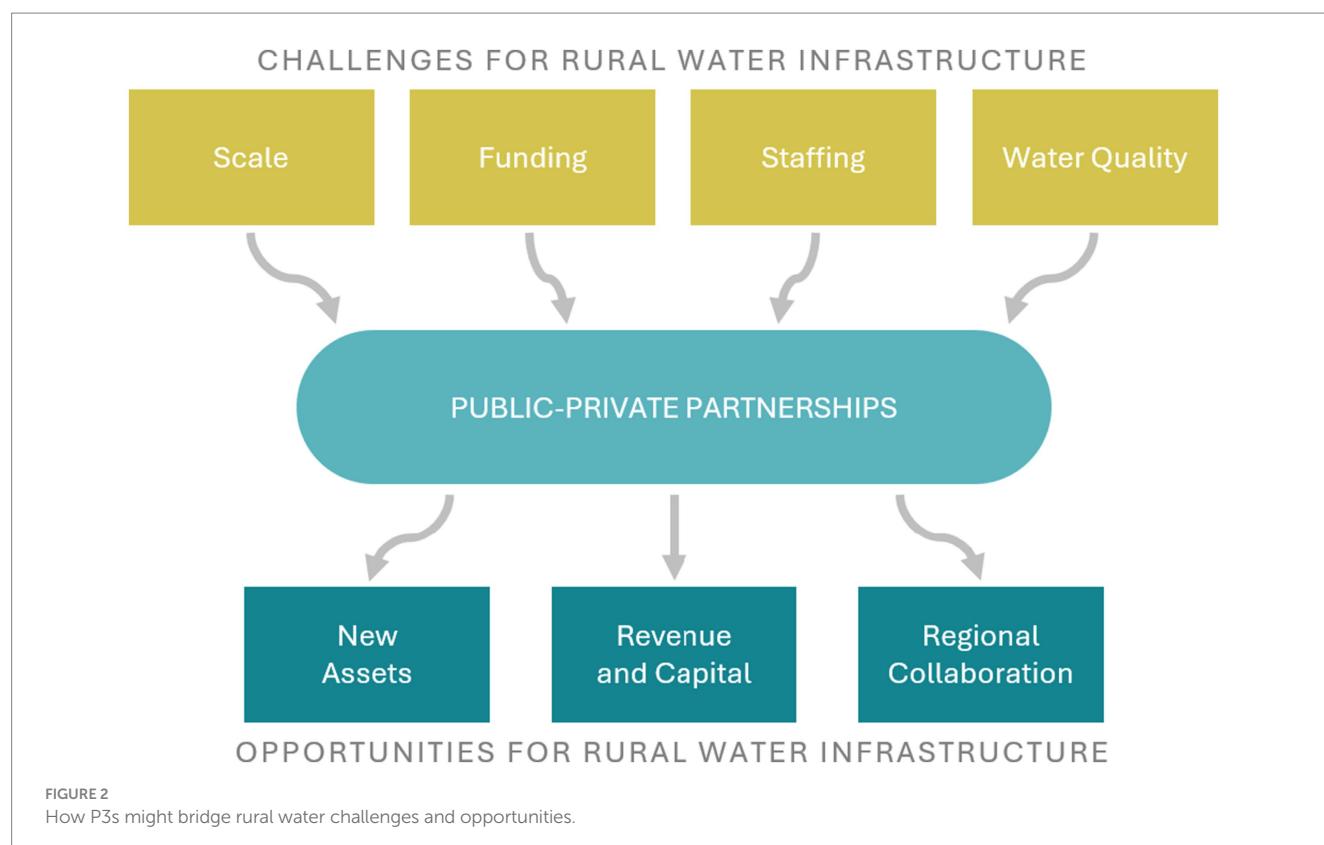
Sustainable infrastructure requires sustainable revenue. If tariffs have been kept artificially low, they may need to increase to cover the cost of service (Jarocki, 2004). A P3 can facilitate this healthy transition while mitigating the potential ire of constituents. A P3 often brings other visible changes, such as those in infrastructure and management, and may increase consumer confidence in quality of service. Thus, new tariffs can be part of a bundle that signals a better future for the utility.

Delmon (2017) suggests that private companies have better billing technology and can thereby improve revenues for a utility. Motivated by profits, the private sector is much better at issuing and collecting fees and has developed sophisticated systems to do so. By contracting these solutions through private sector expertise, public entities can meet their needs.

Access to capital is viewed as the top benefit of P3s in the water sector (EY and American Water Works Association, 2019), and indeed in most P3 sectors. This opinion aligns with what has for years been one of the two top-ranked concerns for the water industry: capital financing (American Water Works Association, 2024). Small water systems are most affected, and they say that their ability to access capital is worse now than in past years (American Water Works Association, 2024). P3s can fill this important role. When a private investor is willing to take on the financial risk that a rural water utility faces to obtain new assets, the utility is relieved of an enormous burden and can focus its limited resources on other aspects of improving service.

5.3 Regional collaboration

One barrier to rural water partnerships has been distance. Rural communities may be too far apart to benefit from partnerships with each other or with services from urban centers. However, Sowby and Price (2025) found that 48% of small U.S. water systems are within just 1 km of another small system and 35% are within just 1 km of a larger system. The study concludes that their proximity is even closer than previously reported, suggesting new opportunities for regional collaboration, including P3s.



American Water Works Association (2019) supports regional collaboration, including “sharing of water supplies and infrastructure; ... joint governance and leadership; public-private partnerships; and restructuring and/or consolidation/acquisition”. Milman et al. (2023) concluded that small systems could benefit most from consolidation, contract of service, or non-binding agreements. However, the barriers to regional collaboration are well documented, including limited knowledge of opportunities and risks, lack of a formalized legal structure, and capital and other financial barriers (US Water Alliance, 2019; Bakchan and White, 2024). Such findings indicate that P3s can be a governance solution as well as a technical solution.

We suggest that P3s can be a vehicle for regional collaborations. For example, multiple rural water systems in the same region may contract with a private firm to maintain certain assets. Such a regional contract approximates an economy of scale; the systems get the equivalent staff, expertise, and service all at a lower unit cost than each system could achieve, or even contract for, on its own. A private entity can also serve as the middleman, mediating between partner utilities with limited capacity to arrange an agreement on their own.

6 Action areas

The foregoing discussion of challenges and opportunities suggests that several needs must be addressed to facilitate P3s in rural water infrastructure. Table 2 identifies which action areas are appropriate for addressing the specific challenges associated with P3s.

6.1 Policy and institutional support

Enabling P3s in rural contexts requires policies that encourage collaboration between public and private sectors while protecting public interests. Governments at state and federal levels must develop regulatory guidance for the formation, operation, and oversight of P3s. Particular attention is needed for rural areas with unincorporated communities or immature governance structures to ensure accountability. While it may be tempting to develop sophisticated policies and models, the most effective P3 guidance should target rural water managers for whom, given the challenges already discussed, it must be a benefit, not a burden. State governments also can influence the legality and feasibility of regional governance structures to support P3s in rural systems. States can facilitate transboundary infrastructure cooperation by removing administrative barriers, enacting incentivizing policies, disseminating information on transition

assistance programs, and establishing clear political pathways to achieving consolidation and other cooperative inter-system relationships (US Water Alliance, 2019; Bakchan and White, 2024).

6.2 Financial mechanisms

Rural water systems often lack access to capital or stable revenue streams, and private parties often hesitate to take on so much risk without some assurance. This is where other financial tools specifically aimed at rural utilities can help. Subsidies, grants, loan guarantees, and tax incentives can attract private sector participation to rural markets while maintaining affordability for the small communities that occupy them. Like several other interventions, these can serve as scaffolding to demonstrate the viability of P3s and, if necessary, be retired once investment is common. Greer (2020) suggests that private activity bonds could be increasingly implemented for water infrastructure as they have been in transportation systems. Blended financing models, where public funds reduce private investment risks, can lower the barrier to entry and make P3s more viable in areas with limited financial capacity. However, as with other policy support, adding extra layers of complexity to the financial system may overwhelm instead of help rural stakeholders; they may benefit most from building capacity in financial management (Dziegielewski and Bik, 2004).

6.3 Capacity building

Rural water systems may not have the technical expertise and administrative capacity to engage in complex P3 agreements. Capacity-building programs—one of five fundamental policy tools defined by Schneider and Ingram (1990)—are essential to equip local governments and system operators with the skills needed to negotiate contracts, manage partnerships, and oversee performance. Training and technical assistance from state agencies, nonprofits, and professional associations can empower communities to implement sustainable P3 solutions. Within a water system, an executive-level champion is essential to help the organization overcome P3 skepticism and lead necessary change (EY and American Water Works Association, 2019). Ideally, the champion would be able to engage the entire community so that project goals complement local values, thereby mitigating potential opposition and encouraging project longevity (Flora, 2004).

TABLE 2 Challenges and action areas for water infrastructure P3s in rural communities.

Challenges of water P3s	Action areas					
	Policy and institutional support		Financial mechanisms		Capacity building	Demonstration projects
	Regulatory guidance	Regional collaboration	Subsidies, bonds, etc.	Blended financing		
Profit margins		x	x	x		x
Governance	x	x			x	x
Skepticism	x				x	x

6.4 Demonstration projects

To build confidence in P3s, successful demonstration projects are needed. Projects should focus on new infrastructure assets, regional collaboration, and measurable outcomes to showcase the benefits of P3s. They should address the unique concerns of both existing rural utility stakeholders and private investors but also reach out to rural communities and utility users about how the projects would work for them. Many water P3s have been documented, but they are mostly for large urban areas; successful cases in rural settings are scarce. Disseminating lessons learned by and for rural stakeholders will build trust and encourage adoption.

6.5 Research agenda

Further research is needed to address unresolved questions about P3 performance in rural water systems. The gap stems from what Pearsall et al. (2021) described: typical research approaches that miss infrastructure and governance across the urban–rural interface.

Key areas for investigation include the long-term financial impacts of P3s, strategies for overcoming institutional barriers, and mechanisms for balancing private sector profit motives with public sector service goals. Additionally, studies on regional collaboration, scale optimization, innovative delivery models, and user experience will help inform best practices tailored to rural water infrastructure. Even in the absence of many existing rural P3 projects, empirical research on typical rural water systems can lay the groundwork for P3 planning. Priority studies include baseline performance assessments to benchmark costs, reliability, and service quality; institutional and governance diagnostics to identify regulatory barriers and stakeholder dynamics; and cost and scale modeling to project financial viability under different delivery arrangements. Comparative analyses of non-P3 systems with P3-like features can reveal transferable practices, while developing a P3-readiness framework—combining financial, governance, and demand indicators—can help classify rural systems by their potential suitability for private participation.

We note that the next research steps, and the fundamental challenges to be addressed, are not of an “engineering” nature, but rather related to the social, economic, and political aspects of infrastructure delivery. This should be unsurprising, as decades of scholarship have repeatedly shown that the most significant barriers to successful infrastructure delivery are often social, economic, and political rather than purely technical. Ostrom’s (1990) seminal work *Governing the Commons* and Hirschman’s (2014) *Development Projects Observed* highlight that governance structures, stakeholder coordination, and adaptive capacity frequently determine outcomes more than engineering proficiency. This insight aligns with other frameworks which demonstrate that complexity, competing interests, and institutional constraints typically outweigh the solvability of technical challenges (Rittel and Webber, 1973; Flyvbjerg et al., 2003). We argue that improvements in water infrastructure delivery (and infrastructure generally) need academics and practitioners to address holistic scoping of such issues.

7 Conclusion

Despite their prevalence, small water utilities face perpetual challenges to deliver adequate service to rural communities. While

questions about P3s persist, their strengths—including access to capital, diluted risks, economy of scale, and personnel capacity—map well to small water utilities’ needs.

Ultimately, the potential of P3s in rural water systems hinges less on technical capability than on overcoming the social, economic, and political conditions that shape infrastructure outcomes. When supportive policies, viable financing mechanisms, and sufficient governance converge, P3s can help small systems overcome structural limitations and deliver sustainable, high-quality service. Advancing their potential will also require demonstration projects and a research agenda that reflects the realities of rural communities, positioning P3s as a practical option within a portfolio of delivery models. There are several scenarios where P3s could already be adopted with positive results.

While P3s will never be a one-size-fits-all solution, deconstructing barriers to their implementation will give water utilities one more tool to provide services essential for healthy and prosperous communities.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

RS: Writing – review & editing, Resources, Writing – original draft, Investigation, Conceptualization, Project administration. CF: Investigation, Writing – review & editing, Writing – original draft. AS: Investigation, Writing – original draft, Writing – review & editing. GG: Writing – original draft, Investigation, Validation, Writing – review & editing, Conceptualization.

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