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Water Reuse in Rural Nevada: Challenges, Opportunities and Pathways for Adoption

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Introduction

Small water systems across rural Nevada face pressure to provide safe and reliable drinking water under increasingly difficult conditions. Aging infrastructure, limited staffing and constrained operating budgets are compounded by climate-related stressors such as frequent, more pervasive droughts, wildfires, flooding from atmospheric river storms, extreme temperatures and power outages. These challenges are particularly significant given that small systems in rural communities make up most public water systems in the U.S., yet often operate under significant operational, institutional and financial constraints. While water reuse has emerged as a potential strategy worldwide to enhance resilience and diversify water supply (Tortajada, 2021; Tzanakakis et al., 2023), reuse adoption remains extremely limited in rural communities in the U.S., including in Nevada (Scruggs & Hacker, 2025).

Water reuse is the process of treating wastewater so it can be safely used again for a variety of purposes, including supplementing drinking water supplies (Jeffrey et al., 2022). Two primary potable reuse pathways are recognized: indirect potable reuse, in which treated wastewater is first introduced into an environmental buffer such as a reservoir or aquifer before undergoing additional treatment for drinking water use; and direct potable reuse, in which advanced-treated wastewater is delivered directly to a drinking water treatment plant or distribution system without an environmental buffer (Abbaszadegan et al., 2025; Harris-Lovett, 2024). Both approaches are gaining traction nationally, with 15 U.S. states now having potable water reuse policies, though water reuse adoption remains concentrated in larger urban systems (Via & Messner, 2023).

To better understand the barriers to and opportunities for water reuse adoption in rural Nevada, this Extension publication draws on insights from a study involving small and rural water system operators and managers, and local decision-makers across the state. This publication is part of the Mobile Energy-Water Reuse Systems (MEWRS) project, which seeks to develop and evaluate potable water treatment and reuse technologies designed to improve water resilience in small, rural and Tribal communities. Understanding local perceptions, barriers and opportunities related to water reuse is an important step in ensuring that such technologies align with community needs and operational realities.

Methods

This study is based on qualitative data collected through a series of focus group (FG) discussions conducted across rural Nevada. Approximately 20 participants (P) took part in four regional focus group discussions representing rural communities in eastern Nevada (FG1), central Nevada (FG2), northern Nevada (FG3), and western Nevada (FG4). Participants included water system operators and managers, and local decision-makers with direct knowledge of local water system operations and challenges. Participants represented both Tribal and non-Tribal communities.

Focus group discussions were designed to capture real-world experiences related to water system management, including existing water quality challenges, water treatment practices, conveyance and storage infrastructure conditions, water supply risks, water supply emergency response preparedness and capacity, and attitudes toward water reuse. Discussions also explored perceived barriers to adopting water reuse technologies, particularly in small and rural, fiscal- and water resource-constrained systems.

Each session was audio recorded and transcribed using TurboScribe.ai (https://turboscribe.ai/), an AI-powered transcription tool (TurboScribe, n.d). All transcripts were reviewed and corrected for accuracy by the research team prior to analysis. Transcripts were coded and analyzed using Taguette (Rampin & Rampin, 2021), an open-source qualitative data analysis tool. A thematic analysis approach was employed, following Braun and Clarke (2019) thematic framework. Initial codes were developed inductively from the transcripts, then organized into themes through iterative review. This approach allowed the authors to systematically identify recurrent themes across the four regions, including perceived infrastructure limitations, water-quality treatment challenges, local water-system governance constraints and attitudes toward water reuse.

Water System Characteristics

Figure 1 illustrates the approximate locations of focus group discussions (FG1–FG4) conducted in Nevada. Focus groups were conducted in rural communities reliant upon water supplied by three of the state's major river basins: Humboldt, Truckee and Carson. These snow-fed river systems supply water to an arid, snow-dependent land where seasonal winter snowpack and spring snowmelt play a critical role in determining water availability. As such, they provide important hydrological context for the study regions.

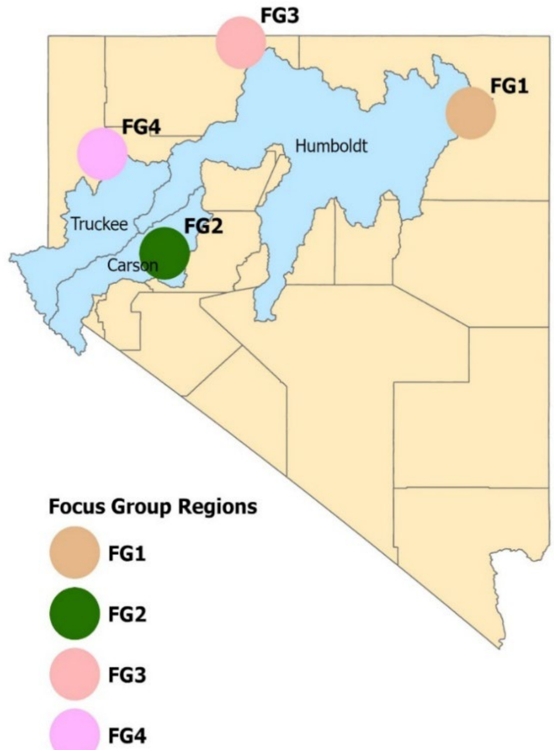

Figure 1. Focus group regions and major river basins in Nevada.

Characteristics of rural water systems represented by this study are shown in Table 1. Systems range in service area size from 16 to 370 connections and rely primarily on groundwater, with one system incorporating surface water sources. Key contamination concerns reported include naturally occurring contaminants in Nevada, such as arsenic and uranium, in addition to episodic microbial contamination, such as *E. coli.* Backup power availability varies, with half reporting no backup power sources. None of the systems currently practice water reuse. Monthly water use charges also vary widely, reflecting differences in system size, cost structures and local economic conditions.

Table 1: Water System Characteristics

Focus Group	No. of Connections	Water Source	Contamination of Concern	Backup Power	Water Reuse	Monthly Charge
FG1 (East NV)	16	Groundwater	Arsenic	No	No	$30
FG2 (Central NV)	370	Groundwater	Arsenic	Yes	No	$14
FG3 (North NV)	135	Groundwater	Arsenic + *E. coli*	No	No	$10
FG4 (West NV)	120	Surface + Groundwater	Uranium	Yes	No	$22

Results

Current Wastewater Management Practices

Across the four focus group communities, wastewater is generally managed through conventional disposal systems rather than treatment for reuse. In FG1, wastewater management is primarily decentralized, with septic systems serving users and no centralized wastewater treatment system in place. Participants noted that some water drains toward the aquifer, while hydrants are used seasonally to support fire response. In FG2, wastewater is conveyed through lift stations to sewer lagoons where it is managed through evaporation, while scattered homes rely on septic systems and leach fields. As one participant explained, “our [lagoon] system is completely passive. We do not treat it; we do not do anything… it’s evaporative” (FG2-P3). No wastewater reuse is currently being practiced.

In FG3, wastewater management details were discussed less extensively; however, participants emphasized the lack of centralized infrastructure needed to manage or reuse water, along with outdated pipes that contribute to leakage and operational inefficiencies. In FG4, wastewater is treated at a local facility consisting of facultative ponds before being discharged to an evaporation basin. One participant described the system as follows: “we have a wastewater treatment plant… it’s 2.8 acres of facultative ponds and it’s discharged to an evaporation basin… it just goes out into a holding basin to evaporate” (FG4-P1).

These practices indicate that wastewater is primarily managed as a disposal issue rather than as a potential resource. This pattern does not appear to reflect outright resistance to reuse. Rather, participant responses suggest that reuse is constrained by existing infrastructure, decentralized systems, limited treatment capacity, aging facilities, and limited familiarity with feasible reuse technologies for small rural and Tribal communities.

Limited Familiarity With Water Reuse Technologies

A key finding from our discussions is that participants have limited familiarity with water reuse concepts, practices and technologies. While participants are well versed in conventional water treatment processes, most reported having had little direct exposure to reuse systems, particularly those designed for potable applications. In several cases, the topic of water reuse was raised during community planning discussions but ultimately rejected due to perceived operational complexity. As one participant said, "we would have to have an entire wastewater treatment facility just to turn it from black to gray water, and even then, it's still not usable for human consumption" (FG2-P2). Another participant explained, "each home would have to have a backflow device… and then we try to tell them to take the hose bib off… that's a lot of time out there" (FG1-P2). These statements suggest that the perceived operational burden associated with reuse involves managing decentralized system components, monitoring compliance, and enforcing practices across dispersed households, which can be especially challenging for small systems with limited staffing capacity. More broadly, these and similar statements offered during focus group discussions reflect the perception that water reuse requires complex, multistage treatment systems that may exceed the operational scope of small rural utilities.

Infrastructure Constraints Shape Decision-making

The most immediate and pressing concern expressed by focus group participants relates to the condition of existing infrastructure. Participants consistently described aging pipelines, leaking conveyance and distribution networks, and outdated equipment that require ongoing maintenance and frequent repairs. Systems relying on older asbestos cement (AC) lines reported recurring failures and structural deterioration. As one participant explained, "they're old AC lines… they go from certain breaks and leaks in the water line system… that's a big deal dealing with these lines" (FG3-P1). Another participant emphasized the persistent and unpredictable nature of these failures, noting that "once these lines get brittle… it busted open again" (FG3-P3). Another participant added, "some pipelines are so old that leaks cannot even be located" (FG3-P5), illustrating the scale of infrastructure challenges. All focus group participants emphasized that these foundational issues must be addressed before considering water reuse. In this environment, reuse is perceived as a secondary priority, something that can only be considered once basic drinking water system reliability has been established. This shows a critical reality: water reuse adoption decisions are grounded in day-to-day operational survival rather than long-term innovation to enhance community water resilience.

Financial Barriers and Perceived Cost Burdens

Financial constraints represent a major barrier to water reuse adoption in rural systems. Focus group participants consistently described reuse technologies as requiring substantial capital investment and ongoing operational oversight, particularly when compared to existing low-cost, passive systems. In several cases, reuse had been considered during system planning but ultimately rejected due to its financial and operational demands. As one participant explained, "it was a proposal, but the tribe would have had to build a five-million-dollar water facility on top of the lagoon system… they decided to just go ahead and build the lagoon system instead, which is completely passive" (FG2-P3). This comparison highlights a key tradeoff faced by small systems: while reuse may offer long-term water supply sustainability, simpler, lower-cost alternatives such as lagoon systems are often preferred because they require minimal oversight and intervention once constructed.

Even when participants acknowledge the potential advantages of reuse, the scale of upfront investment and uncertainty surrounding operation and maintenance create significant hesitation. Another participant stated, "for us to actually own one [reuse system], it would have to be pretty inexpensive" (FG4-P1). Reuse adoption is strongly shaped by local fiscal constraints and the need to minimize long-term operational burdens. Importantly, these financial concerns are closely linked to broader perceptions of risk and uncertainty. As a result, adoption is likely to depend on external funding mechanisms, such as state or federal grants, that can offset both initial investment costs and perceived financial risk.

Governance Structures and Political Constraints

Decision-making in small water systems is often overseen by governance structures such as boards of trustees or local councils. These bodies play a central role in approving investments, prioritizing system improvements, and setting water rates. However, they can also introduce additional layers of political risk that can constrain innovation. As one participant noted, "our district is managed by a board of trustees," (FG4-P1). System-level decisions are not necessarily made by technical staff, such as system managers and operators, but by locally elected governing bodies with social networks and broader accountability tied to the community. In some cases, participants explicitly linked reuse proposals to potential electoral consequences, with one stating, "I don't think they would be reelected if we started talking about water reuse technology" (FG4-P1). This reflects a governance environment where decision-makers may avoid supporting projects perceived as controversial, even if such projects offer long-term benefits. In this context, maintaining the status quo is often viewed as a safer option than pursuing innovative but potentially contentious solutions such as water reuse, even in large urban utilities (Lach et al., 2004).

Public Perception ("Yuck Factor") as a Barrier

Public perception emerged as one of the most significant barriers to water reuse adoption. Participants repeatedly referenced concerns about how communities would react to the idea of using reclaimed water specifically treated, particularly as a potable water source. The so-called "yuck factor" was described as a major obstacle, with one participant noting that "you're asking people to drink sewage… it's bad optics" (FG4-

P1). Concerns about the color, odor and overall aesthetics were frequently mentioned, even when participants acknowledged that treated water could be highly purified to levels that meet safe drinking water standards. These perceptions are not easily addressed through technical solutions alone, as they are rooted in emotional responses to new or innovative resource management concepts and trust in science research and resulting technologies (Barnes et al., 2023). As a result, public acceptance is viewed as a prerequisite for water reuse adoption (Ormerod et al., 2019), requiring sustained public education, community outreach and Extension programs.

Technical Complexity and Emerging Contaminants

In addition to concerns about public perception, participants expressed uncertainty about the technical feasibility of water reuse, particularly in relation to emerging contaminants such as per-and polyfluoroalkyl substances (PFAS), synthetic chemicals commonly found in consumer products that persist in the environment. PFAS are increasingly recognized as difficult-to-remove contaminants in wastewater, raising skepticism about the effectiveness of treatment systems that can purify water to the levels required for safe direct (drinking) or indirect (e.g., irrigation, industrial) water reuse. As one participant explained, “water is loaded with PFAS… it’s in everything” (FG4-P1), highlighting the perception that reuse may introduce new risks rather than reduce or eliminate existing ones. This concern is compounded by the perceived complexity of advanced wastewater treatment processes, which may require specialized knowledge, monitoring systems and maintenance capabilities that are not readily available in small rural systems.

Staffing and Human Capacity Constraints

Staffing and human capacity constraints further limit the ability of small rural systems to adopt water reuse technologies. Many of these systems struggle to recruit and retain qualified licensed operators and managers, particularly in remote communities. A shortage of skilled personnel makes it difficult to manage existing infrastructure, let alone implement and operate more advanced treatment systems. In some cases, staffing limitations are severe, with one participant explaining, “I’m the only full-time employee of this district,” (FG4-P1) illustrating the extent to which system operations may depend on a single individual.

Participants also emphasized that limited staffing requires them to take on multiple roles simultaneously, further constraining their ability to adopt new technologies. As one participant described, “we’re really understaffed… all the roles I fill, I fill like five, six roles” (FG3-P1), highlighting the operational burden placed on small system managers. These conditions mean that even incremental increases in system complexity can quickly become unmanageable. As a result, participants stressed the importance of simplicity and ease of operation, indicating that any reuse technology must align with existing staffing and human capacity constraints. Without sufficient staffing, training and institutional support, even well-designed systems may be difficult to implement and sustain over time.

Conditional Openness and Opportunities for Innovation

Despite the numerous barriers identified, participants did not reject the idea of water reuse outright. Instead, a consistent theme of conditional openness emerged, with many participants expressing willingness to consider reuse technologies if they align with local system constraints. Similar sentiments were expressed across multiple focus groups, reflecting a pragmatic stance in which adoption is not dismissed but remains contingent on feasibility.

This openness, however, is closely tied to specific conditions related to cost, simplicity and operational fit. Participants emphasized that any new system must be financially viable and not impose additional burdens on already resource-constrained systems. As one participant explained, “it certainly couldn’t cost more than we’re spending now” (FG1-P2) while another noted that “for us to actually own one, it would have to be pretty inexpensive” (FG3-P3).

In addition to cost considerations, participants expressed a preference for technologies that are simple, mobile and easy to integrate into existing operations. One participant described their vision of a feasible system, stating, “I’m picturing it’s like a trailer,” (FG3-P1) suggesting interest in compact, mobile technologies rather than large, fixed infrastructure.

Importantly, many participants also identified improving emergency response as a key opportunity for innovation. Technologies that can be deployed during system disruptions to maintain water supply were viewed as particularly valuable. As one participant noted, what “makes the most sense… is a mobile response, emergency services-style response” (FG2-P3), indicating strong support for flexible technologies that enhance system resilience without requiring permanent, large-scale investments.

Overall, participants did not oppose water reuse but instead evaluated it through a lens of practicality. Adoption is most likely when technologies are low-cost, operationally simple and capable of addressing immediate system needs, particularly in emergency situations where the water supply is disrupted.

Conclusion

Direct and indirect potable water reuse have the potential to improve water security and strengthen water resilience in Nevada’s rural communities; however, adoption remains constrained by a set of interrelated institutional, technical and social barriers. Findings from this study highlight that aging infrastructure, limited financial resources, governance constraints, public perception challenges, technical uncertainty and staffing limitations collectively shape how participants evaluate reuse technologies. These barriers do not operate in isolation; rather, they interact to form a broader system of constraints that influences decision-making in small and rural water systems.

At the same time, a conditional openness expressed by study participants suggests that water reuse is not rejected outright but instead evaluated through a lens of practicality and feasibility. Adoption is more likely when solutions align with the operational realities of rural systems, including limited staffing; constrained budgets; and the need for low-cost, reliable and manageable technologies. This suggests that efforts to promote water reuse must extend beyond technological innovation to include strengthening institutional capacity, supporting governance processes, and engaging communities through targeted education and Extension outreach.

Importantly, the system characteristics and preferences identified in this study align closely with mobile and decentralized reuse technologies currently being developed and tested, such as Mobile Energy-Water Reuse Systems. These systems are designed to be portable, scalable and relatively simple to operate, making them well suited to address water supply disruptions, due to wildfire or floods for example, and to meet the needs of small, rural and resource-constrained communities. By reducing reliance on centralized infrastructure and enabling on-site treatment, mobile systems may offer a practical pathway to overcome several of the barriers identified by participants. They also create opportunities for phased adoption, allowing communities to gradually build familiarity, knowledge, skills, confidence and trust in reuse technologies over time. Overall, advancing water reuse in rural Nevada will require coordinated, context-sensitive approaches that integrate technological innovation with institutional support and targeted community engagement.

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