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# Preparing Rural Water Systems for Extreme Weather and Climate Disasters

## Lessons from South Texas and Winter Storm Uri

*Corianne Payton Scally and Rebecca Marx*
URBAN INSTITUTE

*Ines Polonius*
COMMUNITIES UNLIMITED

*Alison Davis*
UNIVERSITY OF KENTUCKY

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As extreme weather and climate disasters—from hurricanes to tornadoes to wildfires to winter storms—become more frequent, the nation's basic infrastructure (such as its water systems) is increasingly vulnerable to service disruptions and failure. Most US water systems serve 10,000 customer connections or fewer and can lack the needed resources and capacity to adequately plan and prepare for these disasters, let alone respond to and recover from them. To improve rural water system resiliency to extreme weather disasters, we examine the experiences of two rural water systems in south Texas affected by Winter Storm Uri in February 2021 and suggest next steps for preparing for future storms.

## The Cascading Effects of Extreme Weather Disasters

The national record for the number and cost of extreme weather and climate disasters in the US continues to climb as these events become more frequent and intense (Wehner et al. 2017).[1] This increase in both frequency and intensity of extreme weather and climate events leaves critical infrastructure in rural areas more vulnerable to loss of function, which leads to the loss of valuable resources, productivity, and sometimes life. Disasters large or small have cascading effects, causing not just physical damage to infrastructure but also short- and long-term social and economic consequences. Such cascading effects are related to the interconnected nature of systems such as power, communications, water and sewer, and transportation. Although protection of critical infrastructure such as electric grids and water systems is often prioritized in disaster preparedness (Mukherjee, Nateghi, and Hastak 2018), there is no denying that a disruption in one critical infrastructure sector—namely, power—may lead to disruptions in other key public services and utilities. Disruptions in power can lead to the loss of phone service, internet connection, and computer systems, cutting off communication between residents, local governments, and first responders, who are often disaster victims themselves (Shimzu and Clark 2015). For underresourced, remote rural areas, the consequences can be dire.

## Water System Vulnerabilities to Power Loss and Winter Storms

Water pumps and treatment plants need electricity to run. When the power goes out, water treatment systems may not fully function and water monitoring and pumping mechanisms can fail, necessitating boil-water advisories and water restrictions to prevent negative health impacts (CDC 2004). The link between power and water is especially strong in rural areas that rely on well water systems with pumps for everything from drinking, to washing dishes, to flushing the toilet.[2] For example, in a study of blackouts, research showed that pumps stopped functioning, water pressure dropped, and contaminants became more likely (Klinger, Landeg, and Murray 2014). But boil-water notices can hardly be followed without electricity to run stovetops. Even when electricity is available, boil orders are not without risk because customers may not boil water long enough, they may accidentally cook food or brush their teeth with tap water, or children may ingest water while bathing.

Winter storms and other extreme weather disasters expose additional water system vulnerabilities. Systems in historically warmer climates may have exposed pipes that function fine under normal temperatures and weather conditions but are not built to withstand the stresses of freezing. Aging infrastructure, equipment, and pipes can complicate the matter and be more prone to failure and breakage. Both system weatherization—adding insulation and taking additional emergency preparedness steps—and consistent maintenance can help, but the lack of resources facing rural water systems makes this difficult. The recently passed bipartisan Infrastructure Investment and Jobs Act includes additional resources for rural water systems that may help build greater resiliency to extreme weather and climate disasters in the future.[3]

## Winter Storm Uri and South Texas

Texas experienced a record-breaking deep freeze in February 2021, triggering a Federal Emergency Management Agency disaster declaration during the 10-day period from February 11 through February 21.[4] In San Antonio, the temperature stayed at or below freezing for 107.5 hours, just short of the all-time record of 109 hours for the area.[5] Nearly 12 million people, or 41 percent of all Texans, experienced water service disruption across 590 public water systems in 141 counties.[6]

Texans had about one week's warning to prepare for Uri. Some may have remembered a similar storm 10 years earlier that exposed weaknesses in the power system that had yet to be resolved (FERC and NERC 2011).[7] The National Weather Service issued winter weather advisories and storm warnings across the state, and some news sources provided tips to protect pipes.[8] Facing chilling temperatures, millions of Texans lost power, with blackouts ranging from hours to days, cutting many off from vital information and communications.[9] For water systems and customers, the deep freeze resulted in a record number of burst pipes.[10]

# Before the Storm: Characteristics and Capacities of Two Systems

To understand the effects of Winter Storm Uri on rural water systems, we first define rural water systems and describe the general characteristics of their management and operations, physical system infrastructure, and water quality monitoring and reporting responsibilities. Then we describe two rural water systems in south Texas with regard to their age and size, ownership and treatment of water, customer rates, general system and equipment conditions before the storm, and compliance with federal water quality and reporting laws.

## Common Characteristics of Rural Water Systems

A small community water system is one that has 10,000 customer connections or fewer—all but 3 percent of the 156,000 public water systems in the US fall into this category.[11] Pipes that were laid after World War II are reaching or have already surpassed the end of their original design life.[12] Old age means leakages: an estimated 6 billion gallons of treated water gets lost in the US each day (American Society of Civil Engineers 2021).

In Texas, water access is most commonly provided by one of more than 1,350 special districts.[13] The most common district types in the state are governmental entities including municipal utility districts, water control and improvement districts, and special utility districts; water supply corporations are not-for-profit customer-owned cooperatives (Texas Commission on Environmental Quality 2019). Across the country, water districts are organized under a voluntary, locally elected board of directors responsible for overseeing the management and operations of the system. System responsibilities include maintaining system components—wells, storage tanks, pumps, water treatment equipment, and distribution lines—and ensuring ongoing systems operations and service to customers. Systems must also conduct appropriate water treatment and monitor compliance with the Safe Drinking Water Act, both in terms of required water quality testing and public reporting, including the issuance of boil-water notices when the system is compromised, such as through water quality problems, low pressure, or loss of power (CDC 2009; Congressional Research Service 2016). Customers connected to the water system are charged based on their water use and are responsible for maintaining the water lines and connections on their private property.

## A Close Look at Two Systems

To examine the effects of Winter Storm Uri on rural water systems, we selected two systems for case studies. Both systems issued boil-water notices as a result of the storm and had an existing relationship with Communities Unlimited, a community development financial institution serving the rural South with technical assistance and emergency and bridge loans for rural water systems.[14] In total, we conducted a series of nine interviews across the two systems: six with system representatives including current and former water system board members, managers, and operators and three with residential customers. Interview topics included steps taken to prepare for the storm, immediate and longer-term effects on the water system and access to drinking water, broader effects on the community and customers, and ideas and progress on preparing for the next storm. Table 1 summarizes key system characteristics and capacity prior to Winter Storm Uri.

TABLE 1

**Key Water System Characteristics and Capacity, Mirando City and El Oso**

| | Mirando City | El Oso |
|---|---|---|
| **Location** | About 165 miles southwest of San Antonio | About 70 miles southeast of San Antonio |
| **Age** | 32 years | 50 years |
| **Size** | | |
| *Number of service connections and people served* | ▪ 200 connections serving approximately 500 people | ▪ 2,200 connections serving approximately 6,000 people |
| *Geographic spread of system* | ▪ Small and spread out<br>▪ Wells and transmission lines about four miles out of town | ▪ Large and dispersed<br>▪ 600 miles of pipe across five different counties; furthest facility is 30 miles out |
| *Number of facilities* | ▪ One facility plus office<br>▪ Three wells<br>▪ Three pumps<br>▪ One storage tank | ▪ Seven facilities plus office<br>▪ Six wells<br>▪ Twelve pumps<br>▪ 10 ground storage tanks, four elevated tanks, and two standpipes |
| *Number of staff* | ▪ Two full-time operations staff<br>▪ Two office staff | ▪ 10 full-time operations staff<br>▪ Four office staff |
| **Water ownership and treatment** | ▪ Pays royalties for the water<br>▪ Owns the equipment and treats water | ▪ Owns groundwater source<br>▪ Owns the equipment and treats water |
| **Rates charged** | Stable | Increase annually, most recently at 2 percent |
| **Maintenance** | ▪ Infrequent line replacements<br>▪ Well motor repairs one to two times a year<br>▪ Repair line breaks | ▪ Repair line breaks |
| **Pipes** | ▪ Pipes are above ground<br>▪ Lines are old<br>▪ Mostly PVC | ▪ More pipes are buried<br>▪ Lines are old<br>▪ Mostly PVC |

| | | |
|---|---|---|
| **Monitoring equipment** | No electronic system to monitor water levels in tanks or leaks | Supervisory Control and Data Acquisition system to monitor water levels in tanks and identify potential leaks |
| **Regulatory compliance** | Yes | Yes |

**Source**: Urban Institute interviews; "Mirando City Water Supply Corporation," accessed November 16, 2021, https://www.buzzfile.com/business/Mirando-City-Water-Supply-Corporation-361-586-5092.

The 32-year-old Mirando City Water Supply Corporation serves approximately 500 residents through 200 connections almost three hours southeast of San Antonio. Its three wells are all at one site where there is one tank, but the site is four miles out of town. Some of the connections are miles apart, extending to weekend ranchers and the small town of Aguilares, about seven miles away. Parts of the system are connected on private property, making it harder to identify leaks and make repairs. The Mirando City Water Supply Corporation is staffed by four employees: two office staff and two full-time operations staff. The corporation works with contractors on occasion to supplement staff.

The aging system, although compliant with regulations, experienced recurring service issues even prior to the freeze. The system often ran out of water because of the small size of the water tank compared with community water use. Sometimes pumps would be cut off unexpectedly because the electrical current was not strong enough. Often, the water pressure was low, which community members had grown accustomed to. Lastly, the system was losing water, particularly in the summertime, but it had no way to monitor the water loss. Prior to the deep freeze, a generator and diesel fuel were placed at the well site in preparation for the storm.

The El Oso Water Supply Corporation recently celebrated its 50th anniversary. It is a larger, dispersed system just over an hour southeast of San Antonio with 2,200 connections and 600 miles of pipeline across five counties that provides service to towns up to 45 miles away. Recently, a small water system of about 150 connections merged with the El Oso system. It has seven facilities, with the farthest being 30 miles away. Ten full-time operations staff work for the corporation and four staff work in the office. The company uses a Supervisory Control and Data Acquisition system to control equipment remotely. Prior to the freeze, four out of seven facilities were equipped with generators.

# Key Findings

Despite facing incredible obstacles, including losing power, water pump failures, complete system shutdowns, and extensive line leaks and water loss spanning multiple days, the two water systems' managers and staff demonstrated some strengths in responding to the crisis (table 2). Dedicated staff mobilized quickly and worked tirelessly to bring the water systems back online, including going above and beyond to assist individual customers on their private property with leaks. Both systems got creative in communicating with their customers, even while many were without power. This included getting county staff with electricity to post proper boil-water alerts; visiting and calling customers and neighbors; and posting updates to a system Facebook group. Local social networks connected customers to drinking water supplies and access to natural gas connections for temporary cooking and power needs, when possible.

Unfortunately, there were many challenges that created hardships for water system staff and customers. Not enough financial or physical resources were available to prepare adequately (e.g., purchasing extra generators or equipment) or to respond quickly. A shortage of trained staff in the region, including contractors that could help in emergencies, also slowed responses and increased the burden on existing staff. In the end, equipment failures, water loss, and repair of leaks as systems came back online took significant time and money beyond existing system budgets and customer ability to pay, particularly in Mirando City.

## Preparation

Although interviewees across both systems noted they were aware of the weather forecasts, most did not expect that a freeze of this intensity and length would materialize. Despite widespread belief that the cold would not be as severe as forecasted, there were attempts by the systems' staff and their customers to weatherize. Prior to the weather hitting, both systems' staff checked their equipment to make sure it was all running as expected. Both systems' staff took steps to insulate any exposed system pipes and line connections as best as possible and ensure fuel was on hand for generators. One system proactively updated its customer contact information, and one called some customers to tell them to wrap their pipes. Although community water systems serving 3,300 people or more must certify to the Environmental Protection Agency (EPA) that they have an emergency response plan, Mirando City falls below this population threshold and did not have formal emergency response plans in place; El Oso did not discuss its plan in detail.[15] A lack of sufficient planning may have hampered both system preparation and response.

TABLE 2

**Water System Preparation, Response, and Recovery, Mirando City and El Oso**

| | Mirando City | El Oso |
|---|---|---|
| **Preparation** | ▪ Made generator available at facility<br>▪ Stocked diesel fuel for generator<br>▪ Checked that pipes were online and well running<br>▪ Made calls to some households to tell them to wrap their pipes | ▪ Stocked generators at four of seven facilities<br>▪ Stocked diesel fuel for generators<br>▪ Added extra wrapping and heat lamps at the stations<br>▪ Bought transistors ahead of time<br>▪ Had enough pipes stocked to fix leaks |
| **Crisis** | | |
| *Length of power outage* | ▪ Initial community-wide power outage lasted one week<br>▪ Rolling blackouts continued | ▪ For half of service area, power went out just one time for five hours<br>▪ For other half of service area, power outage was three days |
| *Length of water system outage* | ▪ The pumps stopped due to power outage and low generator capacity<br>▪ Initial water outage was two to four days, "then come and go after that" | ▪ Some facilities went down for three to five days due to a downed electrical pole and no generator<br>▪ Other half of system maintained electricity and water with generators |

| | | |
|---|---|---|
| **Immediate response** | ▪ Boil-water alert<br>▪ Staff worked overtime<br>▪ Customer outreach<br>▪ Staff helped fix household leaks<br>▪ Made drinking water available<br>▪ Made water to flush toilets available<br>▪ Delivered water to some homes | ▪ Boil-water alert<br>▪ Staff worked overtime<br>▪ Customer outreach<br>▪ Made drinking water available<br>▪ Delivered water to some homes |
| **Recovery time** | ▪ Two to three weeks of inconsistent service<br>▪ Month of boil alerts<br>▪ Provided water to residential areas before ensuring water at the ranches | ▪ 7 to 10 days of inconsistent service<br>▪ Three to four days of boil water alerts for part of system; 2.5 weeks for another part of system |
| **Long-term response** | ▪ Replace electrical lines near the well<br>▪ Keep more materials on hand<br>▪ Connect residents to programs to support repairs<br>▪ More active information sharing<br>▪ Drill a new well to improve system capacity and maintenance | ▪ Apply for funding for more generators<br>▪ Work on an emergency response plan<br>▪ Work on a plan to upgrade water lines<br>▪ Actively seeking grants<br>▪ Drill a new well to improve system capacity and maintenance |

**Source:** Urban Institute research interviews, September 2021.
**Notes:** Respondents sometimes gave different responses to the same question (e.g., lengths of time, due to challenges remembering a past event). We provide ranges in those instances.

*The plumbing wasn't really set up to take that kind of weather because it's so rarely needed.*
*—Interviewee*

Customers of both systems took individual steps to weatherize the pipes on their private property. Most customers insulated the pipes and connections, some with extra blankets. Some noted leaving faucets on to drip, while others turned off the water lines into their homes. In preparing for potential water loss, some residents noted having a backup supply on hand at their home, especially in Mirando City, where disruptions in water service are not uncommon. Others who did not have additional supplies of water on hand mentioned local stores running out of bottled water.

## Crisis and Response

Because of both the power outage across the Texas electric grid and a downed electrical pole in the El Oso service area, both water systems experienced failures for either the whole system (Mirando City) or parts of the system (El Oso). Power outages lasted from a few hours to an entire week, and although generators helped in both cases, neither system had enough backup power at all its facilities.

Communication during the crisis was key to keeping customers informed of service interruptions as well as posting required notices on the status of both systems. The El Oso Water Supply Corporation's ability to communicate with its customers was cut off by the power outage. Internet and phone service was down, so corporation staff relied on a relationship with a county official to get the word out about the boil water alert. Both water systems got creative with communication: some was done through a phone tree (e.g., each customer was responsible for calling several more neighboring customers until each customer was reached), some through automated text messages, some through their official website, and some through Facebook.

The weather itself caused problems in monitoring equipment and physically reaching facilities. In El Oso, the water system's automated monitoring system went down. Signals could not be sent between the office and the plant to control the equipment, which then had to be controlled manually. However, it took over a day for roads to be clear enough to safely get to the equipment. Once the equipment was reachable, staff had to stay there 24 hours a day to ensure it was running as expected. Similarly, water system staff members in Mirando City could not reach a malfunctioning pump until the ice on the roads thawed, and they had to stay at the site to shut equipment off manually when they expected the power for the community to cycle off again.

*We had our staff working basically 'round the clock. They would try to keep our equipment going, then they would go help individuals with plumbing problems at their home even though we're not really required.*
*—Interviewee*

A large portion of both communities depends on electrical power for heating and cooking. Without power and water, customers who could leave town did, including elderly residents who were picked up by family members living in nearby towns or cities that did not lose power or water. Many who remained either had a neighbor or family member with a natural gas connection to use for cooking or were elderly and did not have the ability to leave. In those cases, the water systems tried to deliver bottled water and help fix leaking pipes.

Customers we spoke to who remained in town reported having adequate drinking water access during the time the water system was shut down but not having enough to maintain necessary hygiene and sanitation, particularly during a global pandemic. There were decentralized efforts to provide potable drinking water (some worked better than others). For example, although bottled water was provided in Mirando City, some residents would have preferred access to a tank of water so they could fill buckets with water to use to flush toilets, wash hands, and bathe. When an official delivered water bottles to Mirando City instead of a tanker truck of water the community had requested, the official tried to supply water to the community through a fire hydrant but ended up losing a lot of water in the attempt.

*A lot of people weren't here, because a lot of people had to leave town to go be with loved ones or something, so they could find ways of being warm*
*—Interviewee*

## Consequences

Because of the deep freeze, the power outage, and the subsequent water outage, both water systems experienced widespread equipment failures. For example, in Mirando City the water pump stopped working and it took two weeks for a replacement to arrive. Had a more powerful generator been available to keep the pumps running and water flowing through the system, there may not have been as many pipe breaks. In addition, the chlorinator broke in Mirando City, and it had to be replaced before the system went back online so water could be properly treated. The freeze also affected chlorine levels in El Oso, most likely because reduced water pressure plus line breaks can allow untreated groundwater into the system (Reed 2011).

Leaks were widespread across both systems. In Mirando, a leak at the well site had a domino effect on the whole system, causing the chlorinator to get wet and need replacing. Although the system's field staff members have a sense of where leaks in the lines might be, most lines are buried and with no machinery to monitor leaks they are difficult to detect. There was no way of knowing where water was being lost other than walking the lines. In El Oso, the size of the system made it difficult to identify leaks. Sections of the system had to be isolated to help with this but, ultimately, interviewees shared that the system needs better technology to identify leaks and monitor water loss—a cost this system cannot currently afford.

*"We had water, but things were constantly breaking."*
*—Interviewee*

The combination of equipment disruptions and leaks led to the loss of treated potable water. Leakage was so high for parts of the El Oso system that some customers had bills they could not afford for water that they did not actually consume. The water corporation covered some percentage of expenses on a sliding scale. In Mirando City, when the system was brought back online, water was lost through so many leaks and breaks that not enough water was making it to the storage tank. A lot of water was lost at the pump facility but still had to be paid for. Burst pipes were more common in the part of the system leading out to the ranches where there are smaller pipes and higher pressure. Weekend ranchers were also less likely to be around to detect leaks. Some residents in Mirando City experienced flooding even when they closed the pipes leading to their homes.

Responding to leakages was further complicated by a shortage of labor and parts, which translated into rising costs. Although both systems had some parts on hand, there were not enough. In Mirando City, the water system used up its full inventory of parts, and it was difficult to get more. Other parts that were needed were too expensive for the system to have on hand "just in case." Both systems had to purchase parts online and wait for them to be delivered while losses from leakages added up. On top of the rising prices of parts due to demand, shipping costs were an extra expense. The greatest expense, however, was labor. Staff of both water systems worked around the clock; Mirando City was still making up for staff overtime more than seven months after the freeze.

## Recovery and Next Steps

Costs incurred from the winter storm impacts and recovery needs were higher than both systems could cover with only revenue from water sales. In Mirando City, cash that the company had on hand was cut in half; however, an increase in rates is not expected for the system that serves a large elderly population living on fixed incomes. In El Oso, which has the larger system, a larger-than-planned rate increase is anticipated to cover the costs of the increase in materials, supplies, and replacing old infrastructure.

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*"We have been doing more preparations now, getting generators and trying to get a plan together for the next time."*
*—Interviewee*

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Despite limited system funds, both systems are working toward making large improvements, including securing new equipment and planning for future emergencies. In Mirando City, a fourth well is being built with funds secured by Webb County, and new electrical lines are being laid near the well. A new well has also been approved in El Oso, and the company is working on a five-year plan to upgrade old water lines.

Both water systems also need more generators. In Mirando City, the company wants a bigger generator because the one it has is too small, but generators are expensive. The Texas Commission on Environmental Quality wants a plan in place to have another generator by 2023. In El Oso, the company would like to have a generator at every site and at the office to support the Supervisory Control and Data Acquisition system and communications. The company has already been approved for a loan from the US Department of Agriculture to purchase a generator at the office. Because of high demand after the storm, it will take time for a generator to become available. The generator supply company also was requesting a deposit to get on the waiting list, which the water system was not able to afford at the time of our research.

# Preparing for the Next Storm and Beyond

A number of federal programs provide funding and technical assistance to rural water systems to upgrade their physical infrastructure, improve their operations and financial management, and help them plan and prepare for future disasters. But these programs are not comprehensive. And, fewer resources are available directly to rural homeowners and private property owners to help them prepare water lines and connections on their own private property so that they do not fail during a disaster. In the following sections, we review the current resources available for preparing for future disasters like Winter Storm Uri and make recommendations for improvements that support greater rural water system resiliency.

## Support Ongoing System Maintenance

Although many rural water systems have good track records on maintaining compliance with federal regulations on the health and safety of their water, some have insufficient revenues to support more than basic daily operations. Both low incomes and politics make rural water systems averse to raising customer rates. Many systems serve customers with low and fixed incomes, and these same customers elect the water system board members. These factors mean system revenues can fall short of what is needed to prepare for extreme weather and climate disasters, such as addressing deferred maintenance and upgrading older equipment and pipes; stocking adequate inventory of additional equipment parts, pipes, and other emergency supplies; and replacing equipment that fails or adding generators to better plan for the future. To help support the physical preparedness of rural water systems for future extreme disasters, we suggest the following strategies to support rural water systems and their customers.

***Reform water system finance programs.*** Most resources available to rural water systems are in the form of loans. But some rural water systems with a limited customer base and customers on fixed incomes find it difficult to cover additional debt payments, particularly if they are already making payments on older loans, like Mirando City. Some existing programs also require states to match the funds. EPA's Clean Water State Revolving Fund provides low-cost loans for large water system investments in each state, and the Drinking Water State Revolving Fund is capitalized by EPA and a 20 percent state match for smaller system upgrades.[16] The US Department of Agriculture's Rural Utilities Service has a direct lending program that offers grants up to 75 percent of the total project cost (requiring at least a 25 percent match loan through the agency) to utilities on the basis of the local population's median household income.[17] Rural water systems may apply to their states to help improve system resiliency, extend service lines, and complete other improvements using federal Community Development Block Grant funds from the US Department of Housing and Urban Development. However, these funds are competitive, limited, and only available to governmental entities, so water supply corporations like Mirando City and El Oso are ineligible. To be proactively prepared for future disasters, the smallest rural water systems need additional grants or forgivable loans to do the deep upgrades that some require simply because of the age of their equipment and distribution lines and the need to modernize facilities and monitoring systems to provide improved and reliable service to their customers.

***Expand loan/grant support for system emergency preparedness.*** Of the limited financial assistance programs available for rural water systems, few seem specifically available for preparing for disasters. Some programs can be used for related system and equipment upgrades, such as purchasing generators, but activities such as burying or insulating lines and stocking backup equipment and materials are not directly stated as eligible uses. Our research shows that rural water systems could use help in weatherizing their equipment and lines and stocking emergency supplies.

***Implement water payment assistance***. For 40 years, the federal Low Income Home Energy Assistance Program has helped eligible customers pay their heating and cooling bills to avoid the negative health effects of extreme temperatures.[18] And although water is just as essential as energy, until the COVID-19 pandemic elevated access to water for handwashing as a public health issue, there was no existing federal program to assist customers with water and sewer bill payments. The new Low-Income Household Water Assistance Program—established by the American Rescue Plan Act of 2021, expanded by the Consolidated Appropriations Act of 2021, and run through the US Department of Health and Human Services—is only temporarily authorized.[19] It is clear that lower-income customers of rural water systems need ongoing support to generate the revenues that systems need to adequately maintain their systems and to generate reserves to be better prepared for disaster response.

***Institute customer emergency preparedness grants***. In general, water system responsibilities to customers stop at the water meter connecting the public system and the customers' property. But customers could take steps to lessen the negative effects of disasters on their private water lines and service connections. Several federal programs, including the Low Income Home Energy Assistance Program and the Community Development Block Grant, provide resources to help homeowners weatherize their homes to save on energy costs and improve the livability of their homes during extreme temperatures. Expansion of those resources, or the creation of new ones, to cover weatherization of private water lines and connections could give customers with lower incomes the means to proactively prepare their homes against pipe bursts and flooding caused by extreme weather disasters.

## Improve Planning and Expand Outreach

In addition to having sufficient resources available to improve rural water system infrastructure and general system and customer disaster preparedness, systems need emergency response plans in place, and both systems and customers need technical assistance and training on how to prepare for an efficient response when disaster strikes.

***Emergency planning for small rural water systems***. Although systems serving fewer than 3,300 people are not required to have a plan by federal law, there are some planning tools available from the EPA (2004) that have been adapted by the Rural Community Assistance Partnership (2005) for smaller systems. Planning templates ask systems to record specific information about the system and make decisions in advance on a suite of actions they can take when faced with emergencies (box 1). On the basis of this study, additional details might include a staffing plan for each system facility in the event of loss of power and a plan for maintaining customer contact information and reaching out through a variety of communication strategies, particularly in the event of loss of power and phone service.

BOX 1

**Sample Water System Emergency Response Plan Components**

- **Basic system information**: system identification, ownership, and staff roles and contact information; maps and facility plans; number of people and service connections; and operations and procedure manuals for system and equipment.
- **Communications procedures**: contact lists, procedures, and responsible staff for notifying priority customers (e.g., hospitals, schools), public safety and regulatory agencies, service and repair professionals and suppliers, and media.
- **Event risk assessment and action plan:** assessment of risk and planned response procedures to different emergency events, including immediate actions, notifications needed, and follow-up actions to make repairs and return system to normal operation.
- **Alternate water source identification**: sources of safe drinking water (e.g., bottled water, tankers) and nonpotable water. This response includes a feasibility assessment of tying into a nearby water system for longer-term stability (also known as “redundancy”).
- **Equipment and supplies**: an existing inventory and replacement strategy.
- **Property protections**: to ensure safety of facilities against any security threats.
- **Water sampling and monitoring**: procedures for continuous monitoring and reporting.

**Sources:** EPA (2004); Rural Community Assistance Partnership (2005).

Small rural water systems face practical challenges in preparing and carrying out emergency management plans. These challenges include the small number of full-time staff compared with the size of the distribution systems, insufficient resources to stock all equipment and materials that may be needed in an emergency, and the lack of nearby alternative sources of water to create system redundancy. With disasters such as winter storms, which stress systems in multiple ways simultaneously (e.g., power failure, pipe breaks, pump failure, pressure loss, chlorinator failure), small rural water systems need access to technical assistance in how to plan and respond to such complex emergencies.

***Clear customer guidance on how to prepare***. Water systems do their best to help customers prepare for inclement weather and freezing temperatures, including posting guidance on websites at the beginning of the cold season and providing other notices and recommendations. However, we heard of customers taking a range of actions to prepare, including some that were contradictory, such as completely turning off their water connection versus leaving their connection on and their faucets dripping. Some customers still experienced flooding in their homes.

***Expanded outreach on available technical assistance***. Neither the Mirando City nor the El Oso water system was familiar with all the resources and technical assistance available to them to proactively develop emergency response plans and evaluate the capacity and resiliency of their systems. This may be because organizations like Communities Unlimited are frequently called in by federal or state agencies to help systems respond to emergencies like disasters or address urgent needs like bringing systems into compliance with federal regulations on water quality monitoring and reporting. But assistance is also available through Communities Unlimited and similar organizations to help rural water systems prepare for future extreme weather disasters through proper planning and training and to connect to financial resources to build greater resilience, from resources to dig new wells and replace aging lines to paying for the purchase of new generators. Small rural water systems may require additional outreach to help them grow from a position of reaction to one of preparation.

# Conclusion

Climate-related crises are clearly a growing threat for rural water systems and the communities they serve. And in underresourced rural communities, the potential for cascading, long-term impacts on aging systems in need of maintenance and upgrading jeopardizes reliable access to safe drinking water for millions of customers. In addition to pushing for policies to combat climate changes that are making extreme weather disasters like Winter Storm Uri more frequent, we need to help rural communities and water systems like Mirando City and El Oso be more prepared for the future and increase their ability to respond rapidly to disasters. To do this requires

- investing more grant resources in small rural water systems for overall maintenance and upgrades as well as equipment and supplies needed to prepare for and respond to disasters,
- ensuring customers with low incomes can pay their water bills and know how to protect their homes and water lines when disaster strikes, and
- requiring emergency preparedness and response plans for all water systems regardless of size and funding the technical assistance and outreach to help very small systems develop plans and assess their capacities and resiliency.

# Notes

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# About the Authors

**Corianne Payton Scally** is a principal research associate in the Metropolitan Housing and Communities Policy Center at the Urban Institute. In her work, Scally explores affordable housing and community development policy and practice from large cities to rural towns.

**Rebecca Marx** is a research analyst in the Climate and Communities practice area of the Metropolitan Housing and Communities Policy Center at the Urban Institute. She conducts research on the connection between our built and natural environments and social and economic outcomes.

**Ines Polonius** is the CEO of Communities Unlimited, the southern partner of the Rural Community Assistance Partnership and a Community Development Financial Institution, which takes a holistic approach to rural development including technical assistance and capital to rural water and wastewater systems.

**Alison Davis** is the H.B. Price Professor of Agricultural Economics at the University of Kentucky and the Executive Director of the Community and Economic Development Initiative of Kentucky, an integrated engagement and research center with a mission to build engaged communities and vibrant economies.

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500 L'Enfant Plaza SW
Washington, DC 20024

www.urban.org

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