From Well Water To Rainwater

A Whole-House Water System

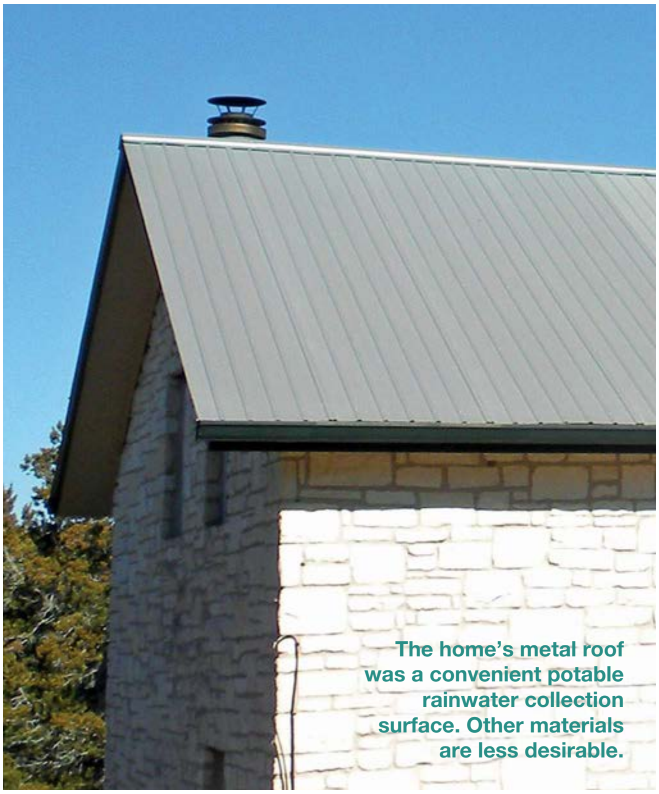
by Stephen Hren

Nancy Poage-Nixon's 5,000-gallon rainwater storage tank provides potable water throughout the year.

What do you do when your well runs dry? This proverbial question had real consequences for Nancy Poage-Nixon in Oak Hill, Texas, in the Hill Country outside of Austin. Development was encroaching from the east, and new subdivisions were drilling wells, tapping the already-stressed Edwards Aquifer. Although in its 28 years Nancy's 438-foot-deep well hadn't had any problems, in the summer of 2006, not a particularly dry year, its flow stopped.

Until then, Nancy had survived just fine with her well, although she'd never been particularly fond of the water that came out of it. The presence of sulfur meant that the tap water would often smell like rotten eggs. The water coming out of the karst limestone aquifer is also very hard, with a large amount of calcium and magnesium carbonates dissolved in it. This can have deleterious effects on household plumbing by building up in pipes and appliances, from hot water heaters to coffee pots, often shortening their lifespan. Hard water also doesn't take soap well (it is "hard" to lather), making cleaning more difficult.

Previous to the drought, Nancy had installed a 1,200-gallon above-ground storage tank with an aerator to help pull the sulfur out of the well water and make it more palatable. Also before the drought, she had replaced her asphalt roofing with a new metal roof to help reflect sunlight and reduce home cooling costs. These two installations were going to be



The home's metal roof was a convenient potable rainwater collection surface. Other materials are less desirable.

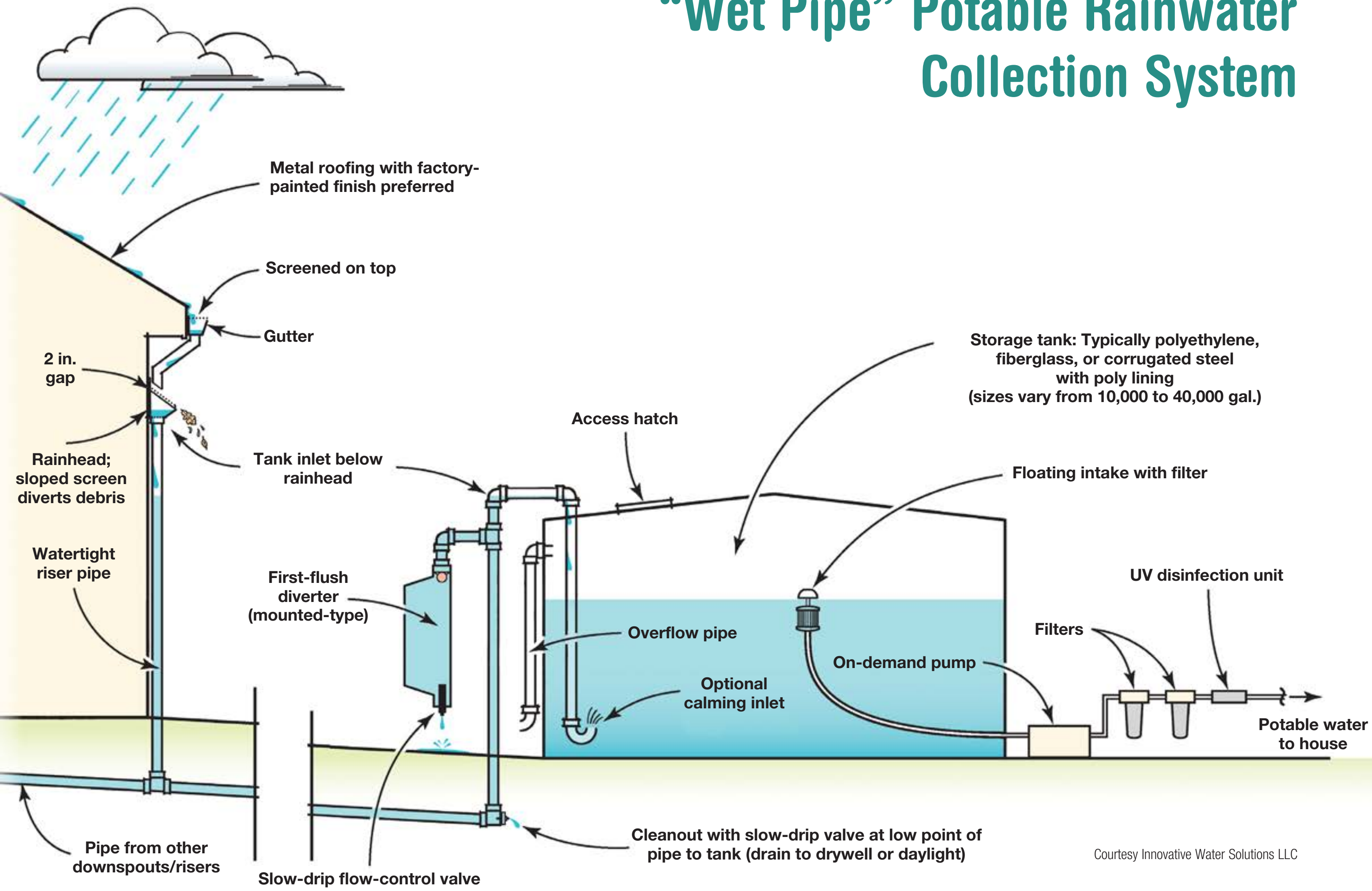
Courtesy Nancy Poage-Nixon (2)

Courtesy Innovative Water Solutions LLC. (2)

The first line of defense against con–tamination is to prevent debris from entering the system.

Left: One strategy is to place a metal or plastic screen over the gutter. Right: Another strategy uses permeable foam inserted into the gutter. (Note that the asphalt shingles on both of these roofs signify nonpotable water systems.)

"Wet Pipe" Potable Rainwater Collection System



Courtesy Innovative Water Solutions LLC

A rainhead is the second typical line of defense against contamination.

For this home, the roof height and lack of surrounding vegetation make this component optional.

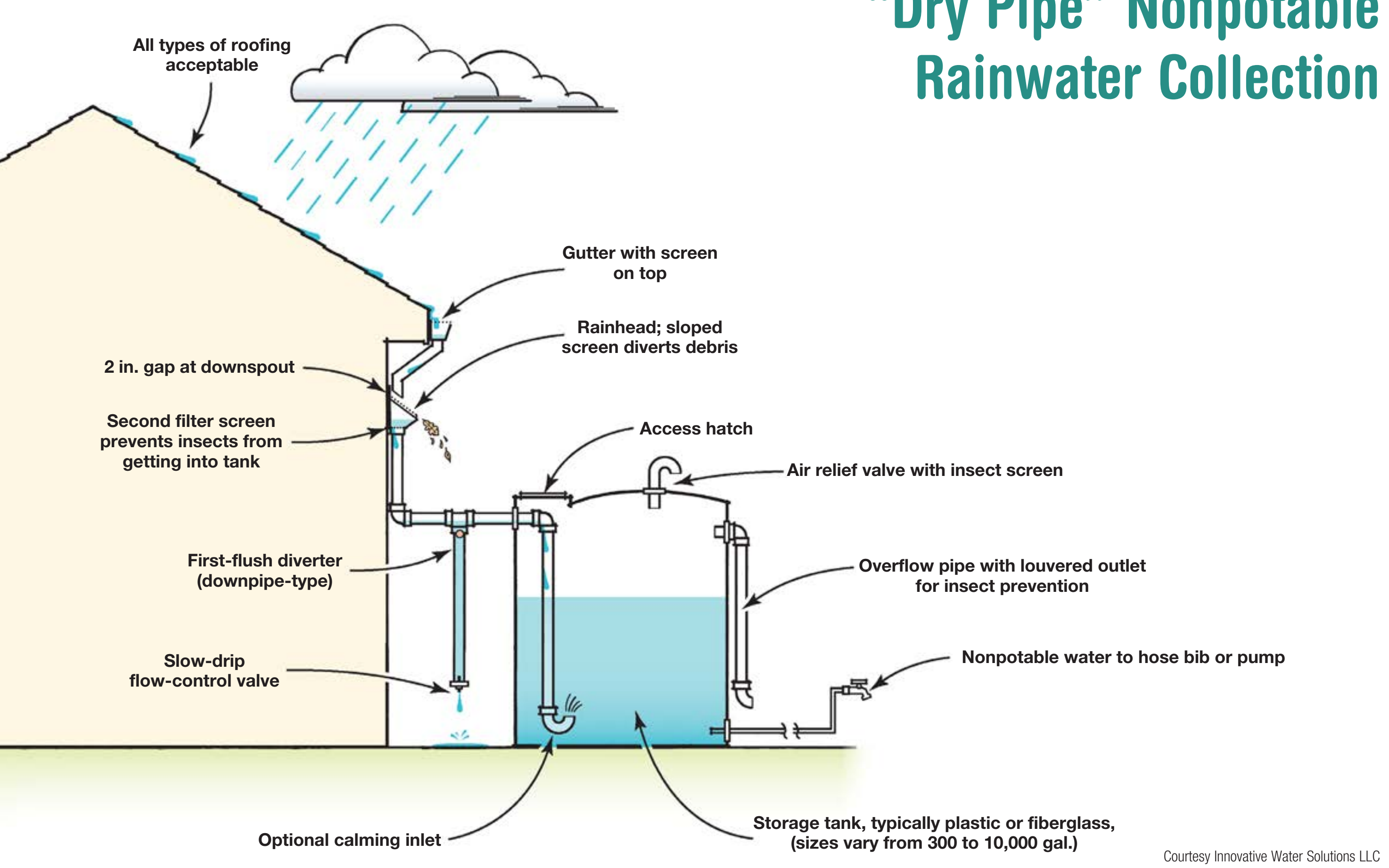
Courtesy Innovative Water Solutions LLC

propitious when it came time to decide how to get water into her home after her well ran dry.

One local well-drilling company quoted $12,000 to drill through the limestone to the next layer of water in the aquifer. Of course, with new housing still going up and old wells going dry as the water table continues to fall, there was no guarantee that this deeper well would not dry up in the future.

Fortunately, drilling deeper was not the only solution. In the last decade, a few Austinites had set up whole-house rainwater catchment systems to provide all of their home's water needs. Nancy teaches science at the local middle school, and she makes environmental ecology a part of her curriculum. Using rainwater for her home's water needs would square with what she was teaching in the classroom and make a great example for her students.

"Dry Pipe" Nonpotable Rainwater Collection



Courtesy Innovative Water Solutions LLC

Sizing a Whole-House Rainwater System

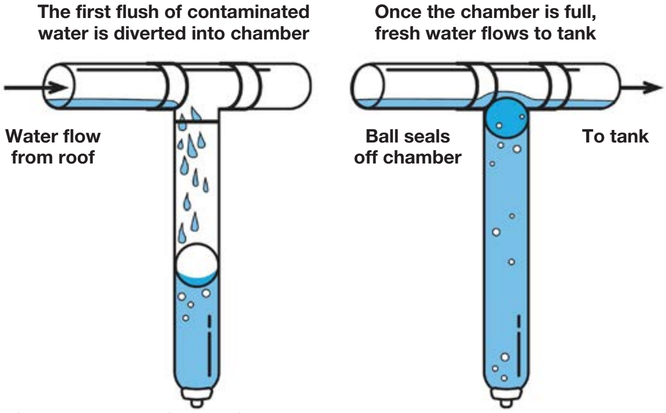
Your home's (or other building's) footprint determines its rainwater collection potential, not the square footage of its roof, because only horizontal area matters. For 1 inch of rain, 623 gallons of water can potentially be collected from a 1,000-square-foot horizontal roof area. But some loss occurs in even the best of systems, so 90% efficiency is considered a maximum.

First, consider whether it is possible, given your family's water consumption (look at a water bill or make an estimate based on plumbing fixtures), to live off your area's annual rainfall. Two water-conscious people will consume about 70 gallons per day. If they were living in a home with 1,000 square feet of horizontal roof area, they would need about 1 inch of rain per week (7 days x 70 gallons = 490 gallons per week consumed versus 561 gallons collected). It's possible to increase collection area by harvesting from nearby outbuildings as well.

Of course, all of this rain might not fall evenly throughout the year. In many areas, much of the rainfall comes only during a few months, so even if there is enough annual rainfall overall, collecting it and having enough storage capacity can be a challenge. Generally, you need to have a tank that is large enough to tide you over through your climate's three driest months. To calculate this, find your area's median rainfall amounts (from the National Oceanic and Atmospheric Administration's website) for the three driest months and assume two-thirds of that rainfall.

In three months, at 35 gallons per day each, two adults will consume 6,300 gallons of water. If supply during the dry months could be as low as 1,000 gallons, for example, then a 5,300-gallon tank would be the *minimum* you should consider installing. More storage means less risk of running out of water. Assuming two-thirds of normal rainfall might not be sufficient—Austin received only one-third of its median rainfall during its recent drought. So, the more people in a household and the longer the dry spells in your climate, the larger the tank. The more efficient your plumbing fixtures (and water use) and the greater your collection area, the smaller the tank can be. Polyethylene tanks are the least expensive and are used in most whole-house rainwater systems.

Function of a First-Flush System



Courtesy Innovative Water Solutions LLC (2)

System Sizing & Extreme Events

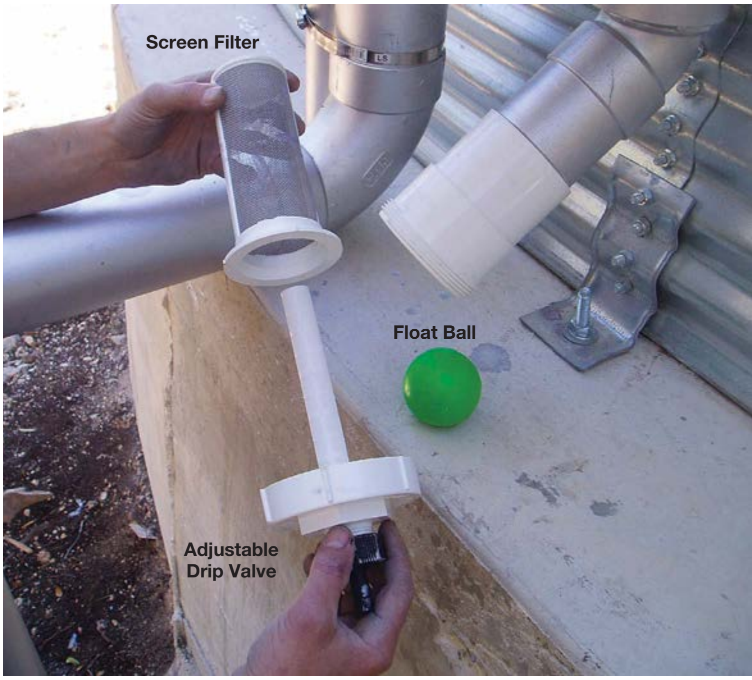
October 2010 to September 2011 was the driest year on record in central Texas, with only 11.2 inches of rain—about one-third of the 33-inch average. It also had the hottest summer since record keeping began in 1860, with 89 days hotter than 100°F. All this puts further strain on the already-stressed Edwards Aquifer. Aquifer replenishment is further hampered because rainfall now often occurs in larger bursts, rather than slower trickles—creating runoff and flash floods instead of recharging the aquifer.

Drought and heavy rainfall events also make living with a rainwater collection system like Nancy's more complicated. Nancy's system has a total of 6,200 gallons of storage, and for five years this was plenty. But the drought forced her to hire a water service company to fill her auxiliary tank with 1,200 gallons of water each month during the summer—just enough, if she scrimped, to get by.

Sizing your water storage system for "extreme" events, such as historic droughts, can be very difficult. It's often a give and take between the willingness of the homeowner to sacrifice their independence in times of extreme weather and the significant cost of much-larger storage systems. At $75 per month for trucked-in water, it wouldn't take too many similar summers to make it cheaper to have installed a larger tank at the outset, with additional storage in a larger tank costing about $0.50 per gallon at this size.

Rainwater catchment improves aquifer replenishment—heavy rains are caught by the catchment system and stored, and then released slowly into the ground as it passes through the household and septic system. Some of this groundwater flows into nearby streams, but much leaches into the aquifer. Nancy can take satisfaction that her home has gone from an impervious surface that contributes to runoff, to a building that helps rainwater percolate down to the water table.

A first-flush system is the third line of defense, discarding the first wash of a new rain, including small particles and water-soluble contaminants.



The intake screen in this primary tank floats just below the surface, avoiding both "floaters" at the top and sediment at the bottom.

Considerations for Rainwater Systems

Although harvesting rainwater is very satisfying, installing a complete system for all of your home's potable water needs should be weighed against the myriad other sustainable upgrades you could invest in, like a solar water heater or an electric car. If your home is already connected to a functioning well or city water system, then it probably makes more sense to install just enough rainwater collection for your landscaping needs and keep it simple.

That said, there are renewable energy considerations involved with how you get and use water. In some situations where water needs to be pumped long distances and/or heights, like in parts of southern California and other mountainous areas, water treatment and delivery consumes the equivalent of about one-third of the average home's electricity use to deliver water to your pipes. In situations like this, installing a whole-house rainwater system could save the energy equivalent to that produced by a multikilowatt PV system.

If you're in a situation where access to water is in jeopardy because of drought, earthquakes, or lack of infrastructure maintenance, there are a few things to consider before proceeding. Firstly, reduce your home's water consumption as much as you can. This means installing, at a minimum, low-flush toilets, front-loading washing machines, and low-flow shower heads (things we should all be doing anyway). Further reductions may be achieved by installing composting toilets and using greywater treatment systems for landscape watering. Fifty gallons a day per person is the most any household considering whole-house rainwater catchment should be consuming, with 35 gallons as a common goal.

Beyond your plumbing fixtures, other components of your home will make it easier—or harder—to incorporate a rainwater system. The biggest component is roofing. Prepainted metal roofing is the best material for most systems because it doesn't leach toxins. Plus, almost all of the water is shed from the roof rather than being absorbed by the material. Tile and slate are good options (although they absorb some water). Cedar shingles work, although they collect lots of dirt and mold, and hold a lot of moisture. The most common roofing material, asphalt shingles, is generally nixed by rainwater authorities (like the Texas Rainwater Commission) because of concerns about toxins leaching out of them. Extensive studies haven't been done (to my knowledge), so the jury is still out. Likewise, tar, treated wood shingles, copper, and gravel-based roof surfaces are out since the contaminant levels are too high. The other major concern about existing home infrastructure is older gutters that may be soldered with lead, which will need to be replaced.

After a bit of sleuthing, she found Chris Maxwell-Gaines at Innovative Water Solutions, who was happy to work with her existing well equipment and convert it to a rainwater collection system. Her metal roof was ideal for collecting water, as it leaves no residue in the rainwater it sheds. And the 1,200-gallon tank was a good start for storage. With these components—and if Nancy was willing to maintain her water-thrifty ways—the complete system would cost around $6,000, about half the cost of drilling a deeper well.

System Components

Nancy already had the metal roof, gutters, and 1,200-gallon tank. From there, Innovative Water Solutions opted for a "wet pipe" system that collects water in a similar fashion to a house's typical drainage system. The downspouts are connected to sealed 4-inch PVC piping, which feed a large underground p-trap located between the house and a cistern. This is common practice when the cistern is located more than a few yards away from the house, so there are not elevated pipes traversing the yard. In contrast, a "dry pipe" system enters the cistern from above without going underground—when it is not raining, the pipes hold no water, negating concerns about harboring mosquitoes. Nancy's wet pipe system includes a 2-inch pipe at the low point in the collection system that has a faucet with a slow drip to empty the pipe after a day or two of no rain, which reduces insect concerns.

Since her home has two stories, the gutters generally sit well above the tree line, so maintenance for tree debris isn't a big concern. There's no need for screens or other covers on the gutter, and her system doesn't include a rainhead—an open box that separates out leaves and other debris from the

A float switch in the secondary tank controls the pump that draws from the primary tank.

The 1,200-gallon secondary tank served as the original water storage. Now, it provides additional capacity and a place for incoming water to cool in the shade before entering the house.

Courtesy Nancy Poage-Nixon (2)

rainwater. Eschewing gutter screens and the rain head saved money initially, but meant the frequency of cistern cleanouts likely needs to be increased (something done on a typical rainhead-based system about once a decade).

At the cistern, the pipe comes above ground, stopping at a "first-flush" diverter that siphons off the first 50 gallons or so from each rainfall event and directs it to the surrounding landscaping via a slow-drip irrigation system. Small leaves, bird droppings, dead insects, and other unwanted bacteria-containing debris that have built up on the roof since the previous rainfall come off in this first flush. Keeping it out of the cistern greatly reduces sediment buildup and potential water contamination. The first-flush diverter has a rubber gasket at its bottom with a small hole in it for dripping out the water between rainfall events, as well as a 4-inch cap that unscrews for debris removal.

Keeping light out of the cistern is crucial, or else microorganisms such as algae can flourish. The polyethylene tank exterior is UV-resistant, with an expected life of 30 years or so. This can be extended if the tank is shaded, saving the top from becoming brittle and potentially broken by hail or downed branches. An overflow outlet drains off excess water and an access hatch on top allows periodic cleaning and maintenance. Sunlight heats up the water in the tank in the summertime to upwards of 90°F, but Nancy is able to cool the water by first routing it through her original, shaded 1,200-gallon tank. While hot drinking water coming out of the tap is not ideal, preheated water reduces the energy load for her water heater.

Water is pumped from the main 5,000-gallon cistern to the smaller 1,200-gallon auxiliary tank, activated by a float switch in the auxiliary tank. A screened floating intake valve—reinforced vinyl tubing attached by a short chain to a black-plastic floating ball—pulls water from a few inches below the surface, thus avoiding floating debris and bottom sediment.

From the smaller cistern, a Grundfos MQ3-45 pressure-booster pump with built-in bladder tank provides household water pressure. Before entering the house, the piped rainwater is forced through a two-stage filtration system—a 10-micron sediment filter and a 5-micron carbon filter. Nancy's water is then purified by an ozone injection system. Once thoroughly mixed with the water, the extra oxygen molecule kills any bacteria and viruses.

Reacting to the Drought

Although Nancy hasn't increased her potable rainwater storage, she has added two 250-gallon tanks for use in landscaping. She also switched from grass that dies in drought to purple prairie clover for her small yard. This perennial native is drought-tolerant once established, with

A Grundfos pressure-booster pump (bottom) provides the house's water pressure through a two-stage filter and ozone purification system (top).

Courtesy Chris Maxwell Gaines

Rainwater Regulations

Several states and communities have enacted regulations and guidelines for dealing with rainwater harvesting, including Tucson, Flagstaff, Chino Valley, and Pason (in Arizona); Seattle and Friday Harbor, as well as King County (Washington state); and Atlanta, Georgia.

The American Rainwater Catchment Systems Association is working with several national organizations to come up with general ordinances that communities can revise and adopt. Texas has state legislation dealing with rainwater harvesting and, along with Hawaii and Virginia, offers rainwater harvesting guideline booklets (see Access). The Uniform Plumbing Code has an appendix dedicated to rainwater systems, with sizing guidelines for gutters, downspouts, and lateral pipes.

Beware, though, not every locale is rainwater-system friendly, so if you want to keep to the letter of the law, you'll need to check with your local authority having jurisdiction to see what, if any, rainwater harvesting regulations are in place.

a deep root system capable of subsisting off erratic rainfalls and septic system discharge. As others fret over their wells running dry, Nancy can relax, knowing she has a more steady supply of water, and that she is helping recharge the diminishing aquifer.

Access

Stephen Hren (stephenhren@gmail.com) is a writer and builder living in Durham, North Carolina. He is the author of *Tales from the Sustainable Underground: A Wild Journey with People Who Care More About the Planet than the Law*. Find out more at www.earthonaut.net.

Further Reading:

"Catching the Cloudburst" by Heather Kinkade in *HP125*

"Free Rain: High-Tech, Hands-Off Rainwater Collection" by Doug Pushard in *HP115*

"Harvesting Rainwater" by Michael Durland in *HP107*

The Texas Manual on Rainwater Harvesting • twdb.state.tx.us/innovativewater/rainwater/docs.asp • Must-read publication