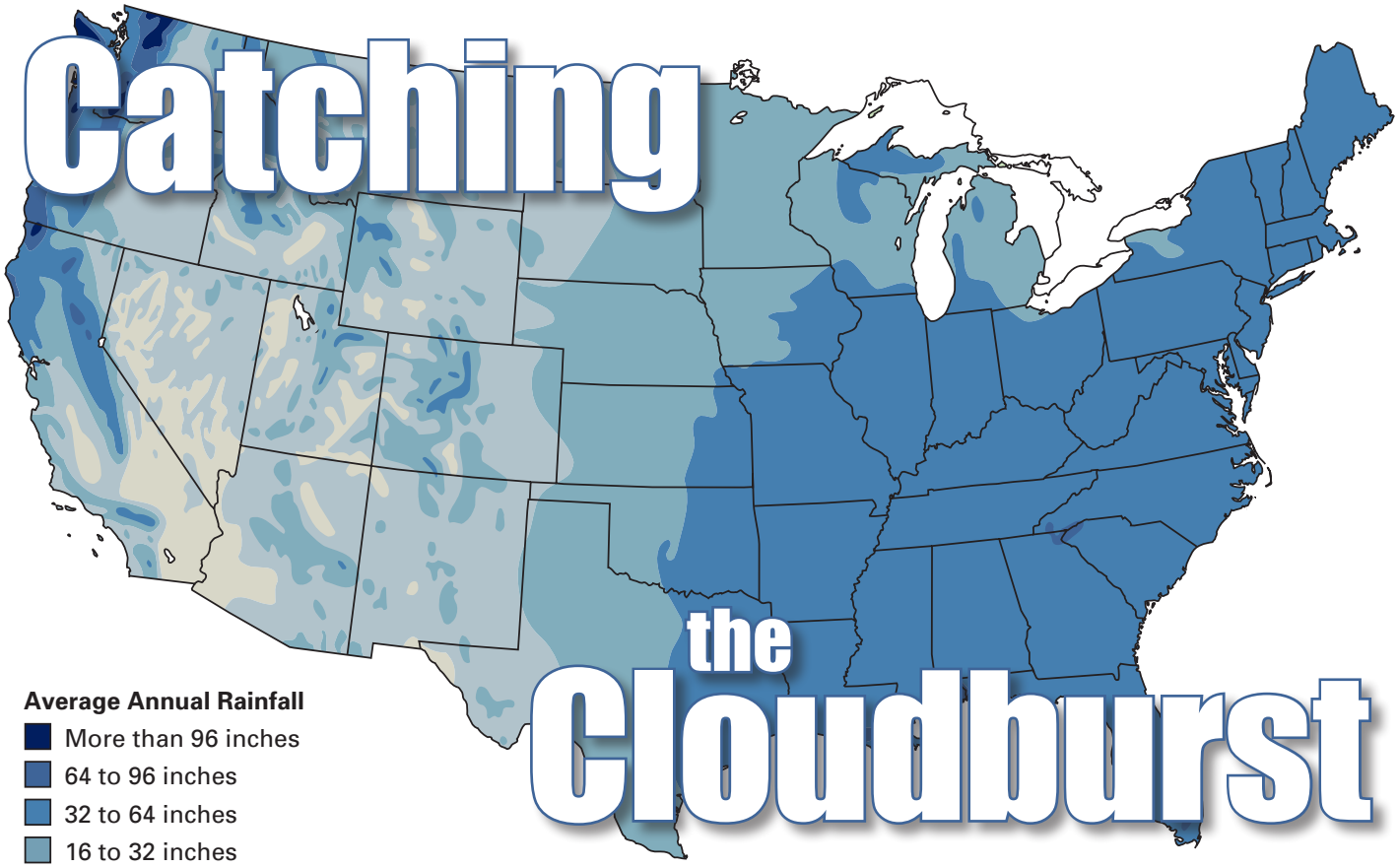
Catching the Cloudburst



Adapted from *Design for Water*
by Heather Kinkade

Like it or not, drought is becoming more common in many parts of the country. As dropping water levels in rivers and aquifers put the squeeze on freshwater stores, municipalities are tightening their belts, raising rates, and even implementing water-use restrictions. This past spring, Raleigh, North Carolina, residents and others in six surrounding towns were under "stage 2" water restrictions—no lawn sprinkling, no car washing, and no pool filling. Similar curbs are becoming more prevalent across the country.

Even those who rely on well water aren't escaping the consequences, as underground water tables drop below the reach of many wells. In 1999, a drought in the Northeast lowered water levels below their pumps in hundreds of wells in two New Jersey counties. Three years later, the prospect of parched wells pitted farmers against city dwellers of Cheyenne County, Nebraska, in an effort to secure water. And the situation is not getting better. According to a 2007 report by the U.S. Geological Survey, underground water supplies all over the United States are continuing to shrink.

Some people are looking to the skies: catching and storing rainwater. A rainwater harvesting system can reduce the need and cost to pump groundwater, and can be less expensive than tapping other water sources. It also provides a close-by water supply that contributes to self-sufficiency. Rainwater is "soft" water that's low in mineral content, which helps reduce buildup in your home's plumbing. In coastal areas where saltwater intrusion into aquifers is a problem, catchment becomes even more important. And, in some places, installing a rainwater system makes you eligible to receive rebates for reducing your use and dependency on municipal water.

System Components

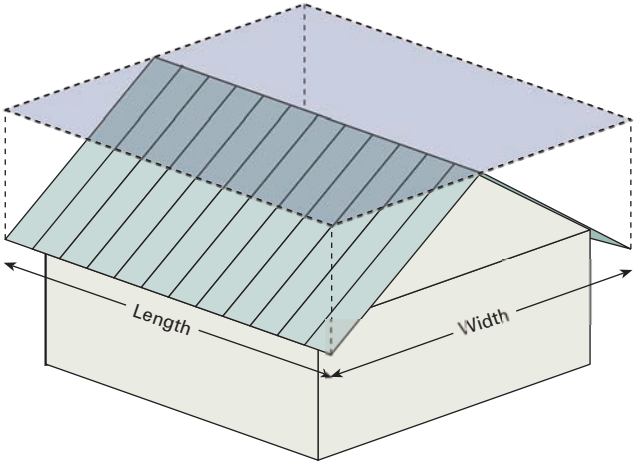
Rooftop rainwater harvesting systems are easy to construct, operate, and maintain. Whether it is large or small, a rainwater harvesting system has six basic components:

1. Catchment area: The surface upon which the rain falls, generally a roof or impervious pavement.
2. Conveyance: The channels or pipes that transport the water from the catchment area to storage.
3. Roof washer: The systems that filter and remove contaminants and debris, includes first-flush devices.
4. Storage: The tanks where collected rainwater is stored.
5. Distribution: The system that delivers the rainwater for its end use, either by gravity or pump.
6. Purification: The equipment that filters and distills, as well as additives that filter and disinfect the collected rainwater.

Catchment Area

Although rainwater harvesting for nonpotable use can be accomplished with any type of roofing material, for potable use, the best roof materials are metal, clay, or concrete. Water for drinking purposes should not be collected from roofs containing zinc coatings, copper, asbestos sheets, lead, or asphalt compounds. For flat or semi-flat roofs, an acceptable roofing material for potable water catchment systems is Weather Barrier Raincoat 2000 (www.haleypaint.com), a coating product approved by the National Sanitation Foundation (NSF).

Catchment Area



Length (ft.) x Width (ft.) x Annual Rainfall (in.) x Surface Area Efficiency x 7.48 gal./ft^3 = Annual Catchment Area Runoff (in gal.)

A *rainbarn* describes an open-air shed with a large roof area to catch rainwater. The structure can also provide shelter for a variety of uses—a patio, carport, hay storage, or farm equipment storage—thereby serving multiple functions. Typically, the rainwater storage cistern is housed under a rainbarn.

The quality of the captured rainwater depends, in part, upon catchment texture: The best water quality comes from smooth, impervious catchment or roofing materials. Quality is also determined by rainfall pattern and frequency. The greater the storm event (i.e. the rainfall extent) and the shorter the time between storms influence the cleanliness of the catchment area. Greater rainwater volumes and frequencies will transport fewer pollutants to the first-flush device and to storage.

Rainwater is slightly acidic, which means it will dissolve and carry minerals into the storage system from any catchment surface. For systems intended for potable water, first test the water collected from the proposed catchment surface to determine its contents. In some cases, filtration can remove some contaminants. In other cases, the catchment surface must be reevaluated or amended.

Conveyance

A common rainwater conveyance system features gutters with downspouts that direct rain from rooftop catchment

Rainwater Regs

Several communities are enacting regulations and guidelines for dealing with rainwater harvesting. In Arizona, the towns of Tucson, Flagstaff, Chino Valley, and Pason have enacted ordinances encouraging the use of harvested rainwater. In Washington state, Seattle and Friday Harbor, as well as King County, have recently established their own guidelines.

Currently, 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. The applicable plumbing code should be reviewed for any design of rainwater conveyance systems.

Roof Surfaces for Potable Catchment

surfaces to cisterns or storage tanks. The materials for gutters and downspouts range from vinyl and galvanized steel to aluminum, copper, and stainless steel. At a minimum, gutters should be 5 or 6 inches wide, with an outer edge higher than the roof-side edge and splash guards at roof valleys. Gutters should slope toward downspouts at 1/16 to 1/4 inch per 10-foot length of gutter, and be installed per manufacturer's guidelines for hangers and connection points.

Downspouts should have 1 square inch of outlet (downspout) for every 100 square feet of roof area to be drained—a 4-inch-diameter downspout can drain approximately 400 square feet of roof area. Add more or larger downspouts for larger collection areas. A typical connection material from a downspout to a cistern is a 3- or 4-inch-diameter, schedule 40 PVC pipe or ABS pipe, which is considered a more environmentally friendly plastic. However, for potable rainwater collection, PVC or stainless steel should be used. It is made from new material, not recycled material that may have picked up contaminants from its previous use. Coated aluminum downspouts are also acceptable for potable water collecting. Avoid ABS, DWV PVC, copper, lead-containing, or galvanized pipes.

Leaf screens are the first defense in keeping debris out of your system.

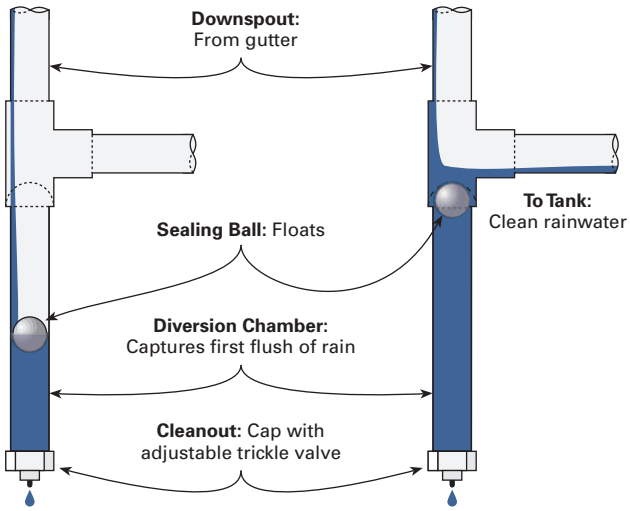
To keep leaves and other debris from entering the system, the gutters should have continuous leaf screens made out of 1/4-inch wire mesh or an equally efficient product covering the entire length of gutter. Installing leaf screens will help reduce system maintenance, reduce mosquito-breeding habitat, and eliminate the need for frequent ladder-climbing to clean the gutters. Downspout filtering rain heads, such as the Leaf Beater and the Leaf Eater, provide a second chance to capture and remove debris that might enter a storage system.

What's a Rain Head?

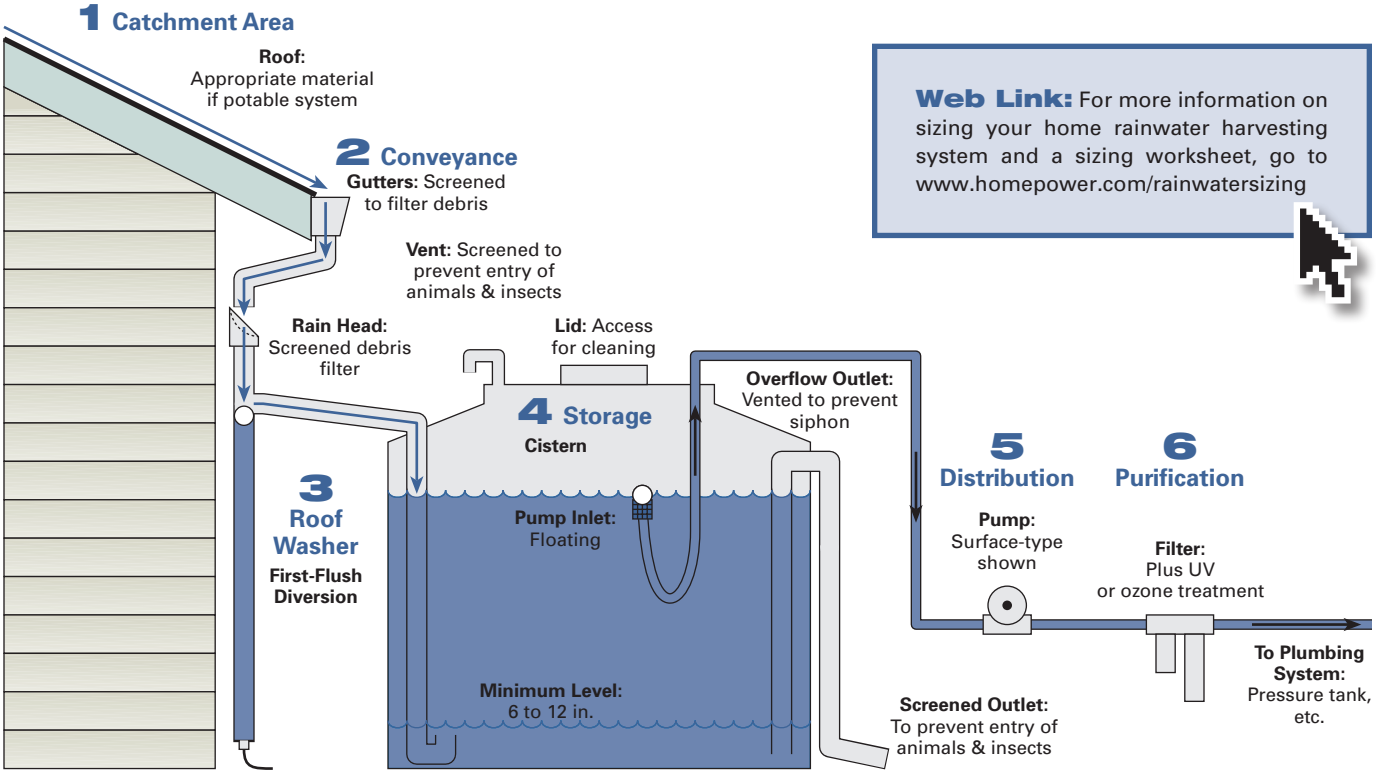
The filtering process can be augmented by using a rain head—a downspout that incorporates a self-cleaning system. This unit has a funnel topped by a screen, which is set at an angle of about 33 degrees to the lower horizontal edge of the funnel. As the water washes over the angled screen, the debris is forced toward the screen's lower edge and away from the building, while most of the rainwater continues through the funnel screen.

Courtesy www.rainharvesting.com

First-Flush Diversion



Basic Potable Rainwater Catchment System



Web Link: For more information on sizing your home rainwater harvesting system and a sizing worksheet, go to www.homepower.com/rainwatersizing

Roof Washing

Roofs, like other large, exposed areas, continuously receive deposits of debris, leaves, silt, and pollutants on their surfaces. One or several components can be used to filter or collect debris and soluble pollutants, including gutter leaf-guards, rain heads, screens, and/or first-flush devices. First-flush devices are important when rainwater is collected without the use of gutter leaf-guards, leafslides, or rain heads, or if the rainwater is to be used for human consumption.

The simplest roof-washing system is a first-flush device that consists of a standpipe (the diversion chamber for collecting the initial rainwater runoff) and a gutter downspout located prior to the cistern or storage tank inlet. When the first rainfall enters the standpipe, the pipe fills, and a floating ball seals the entrance to the diversion chamber, sending rainwater to the cistern. Because a typical standpipe does not automatically outlet to a storm drain, a screw-on cleanout plug should be located at the end of the standpipe. If it is not the self-draining variety, the standpipe should be emptied after each rain event. This will eliminate standing water from becoming foul from debris and soluble pollutants, and thereby contaminating future collected rainwater.

Another diversion device is a roof washer, which consists of a 30- to 50-gallon box, with leaf strainers and a filter, placed just ahead of the storage tank. Several models of roof washer are commercially available. Regardless of which type you use, cleaning the washer is imperative. Otherwise, clogging can result, restricting the flow of rainwater, and the stagnant water can encourage pathogen growth.

Storage

Cisterns or storage tanks represent the largest investment in a rainwater harvesting system, since already-existing buildings have most of the other components: a roof, gutters, and downspouts.

Above-ground tanks are available at most farm-supply and building centers. They allow for easy inspection and water extraction/draining by gravity. However, they also

A storage tank with a SafeRain first-flush diversion valve, which operates on flow rate instead of initial quantity.

Courtesy www.saferain.com.au

Courtesy www.corgaltanks.com

This 8,800-gallon, galvanized storage tank requires a lining to make it suitable for potable water.

take up yard space, can be expensive, and are susceptible to damage from constant exposure to the elements. Below-grade storage systems generally are reasonably priced, although you'll have to budget for excavation expenses. They require little or no above-ground space, and permit thinner cistern walls due to the support of the surrounding ground. However, extracting water from below-grade systems is more difficult—requiring a pump unless a tank is buried on a hill above its end use—and leaks and failures are more difficult to detect. In addition, tree roots or overhead traffic may damage a below-grade storage system.

Whether you go with above- or below-ground, a cistern that is kept cool and devoid of sunlight allows water quality to increase with time. When photosynthesis cannot take place, most organisms die as their food source is eliminated. With each rain event, a new supply of sediment and organisms will enter the storage unit. The sediment, while not usually unhealthy, can initially discolor and flavor the water, but will ultimately settle to the bottom of the storage container. It is best to remove water from a cistern or tank at a position that is farthest from a runoff inlet to allow settling before the water is used. Some storage containers may require baffles, inflow smoothing filters, or turbulence dissipaters to slow remixing with the aged water.

Rainwater Harvesting Costs

Collection	Estimated Cost	Typical Capacity /Size
Gutters	$0.30–$12.00 /lineal ft.	—
Roof Washing		
Vertical or horizontal box roof washers	$460–$1,000	—
Storage		
Precast concrete or ferro-cement tanks	$0.35–$1.50/gal.	Any
Fiberglass	$0.50–$2.00/gal.	500–20,000 gal.
Steel, corrugated & galvanized with liner	$0.30–$2.79/gal.	150–104,000 gal.
Polyethylene	$0.50–$1.90/gal.	210–5,000 gal.
Polypropylene	$0.35–$1.00/gal.	290–20,000 gal.
Welded stainless steel	$0.80–$4.00/gal.	Any
Wood (treated, with liner)	$0.88–$2.06/gal.	Any
Stone	Up to $1.00/sq. ft.	Any
Invisible structures underground retention reservoir	$8.00/cu. ft.	Any
Atlantis underground storage tank	$4.84–$5.15/cu. ft.	Any
Conveyance		
Prefilters	$50–$80	—
Pressure tanks	$200–$1,000	—
Pumps	$500–$600	0.75–1.00 hp
Filtration		
Cartridge filter sets	$100	—
1-micron filter	$265	—
Reverse-osmosis filters	$400–$1,500	—
UV filters	$300–$1,000	—
Ozone disinfection system	$700–$2,600	—
Chlorine disinfection systems (automatic dosing)	$600–$1,000	—
Chlorine disinfection system (manual dosing)	$1.00/dose	—

Courtesy Heather Kinkade

A variety of pumps are acceptable for rainwater distribution. This submersible pump has a floating intake to avoid sediment on the bottom of the tank.

Distribution

Stored rainwater may be conveyed (or distributed) by gravity or by pumping. If a tank is located uphill or above the point of use, gravity may work. Most plumbing fixtures, appliances, and drip irrigation systems require at

least 20 pounds per square inch (psi) for proper operation. (Standard municipal water pressures are typically in the 40 psi to 80 psi range.) As a general rule, water gains 1 psi of pressure for every 2.31 feet of rise, which would mean positioning a storage cistern almost 100 feet above the house to achieve typical household pressure.

In most installations, placing a tank above its point of use will also place it above the source, which is often the roof of the building where the end use is. Because of this, pumps, rather than elevated tanks, are typically used to extract both below-grade and above-grade stored water. Submersible or at-grade pumps may be used in any rainwater storage system. Self-priming pumps with floating screened intakes and automatic shutoffs—for times when water levels are insufficient—are recommended.

Generally, well pumps or any type of submersible pumps, as well as a pump located outside the tank, can be used to transfer the rainwater out of a tank. Some pumps keep the line pressurized, eliminating the need for a pressure tank. When the rainwater is brought into a house, a pressure tank is typically used in combination with a pump. Using a pressure tank saves wear and tear on the pump by reducing its run-time.

Purification

Rainwater intended for human consumption (potable) should be screened, settled, filtered, and disinfected. When stored water is being used, sediment filtration should be a maximum of 5 microns, followed by a 0.5-micron carbon filter or an equivalent 1-micron absolute filter. These ultrafilters should be NSF approved for cyst removal, since you'll want them to remove disease-causing giardia and cryptosporidia.

Specifically designed for potable rainwater filtration, the AquaEst RainPC MK II removes bacteria, and organic and inorganic contaminants.

Courtesy www. aquaesteurope.com

Solar Purification

Solar water distillation systems are among the simplest water purification systems available. No filters or membranes are required, no moving parts are used, and no electricity is needed.

Solar stills have a shallow pan with a sloping glass cover. Water is directed to the pan where it is heated by the sun. The water evaporates from the pan, rises, condenses on the underside of the glass cover, and runs down its slope into a collection trough and into a clean container for storage. The contaminants left behind in the pan should be flushed regularly. Solar stills can be mounted on roofs or on ground structures.

Courtesy www. solaqua.com

Most common filters are designed to be used with municipal supplies and do not have a convenient method of monitoring when they have become overloaded and are due for replacement. For safety's sake, filters connected to a cistern system should be changed more frequently than suggested by the manufacturer. Rainwater used for potable systems should be lab-tested periodically for quality.

Access

Heather Kinkade is a land-use planner, LEED accredited professional, and registered landscape architect in Arizona, and the author of the award-winning *Forgotten Rain*. She is president of Forgotten Rain LLC, a rainwater harvesting and stormwater reuse company. This article was adapted with permission from her most recent book on rainwater harvesting, *Design for Water* (New Society, 2007).