Rainwater Harvesting Manual for Southwest Missouri

Table of Contents

Introduction

Compared to many parts of the world, fresh water is plentiful in southwestern Missouri, where springs, streams, lakes and groundwater abound. In most parts of the region, wells can be drilled to provide sufficient water for individual residences, farms, towns or even small cities. Two groundwater aquifers are available: the uppermost Springfield Plateau Aquifer, up to about 300 feet thick, which provides water to springs but produces relatively low yields to wells (and is vulnerable to contamination); and the underlying Ozark Aquifer, which is better protected from contamination, contains over 1,000 feet of saturated thickness in many places, and can deliver water to wells in the range of hundreds of gallons per minute. In most places, groundwater from the Ozark Aquifer is clean enough to use for drinking water with no treatment.

The region also has abundant surface water resources, with several very large reservoirs and many perennially flowing streams augmented by the flow of numerous springs. The James River, for example, each year delivers over 230 billion gallons of water to Table Rock Lake, and the lake itself holds about 1.1 trillion gallons. Because of the abundance of surface water resources, the two largest cities in the region, Springfield and Joplin, use streams and reservoirs as primary sources for their public drinking water systems.

In spite of the magnitude of the available sources, prolonged drought can create serious problems in southwest Missouri. As water levels fall in streams, lakes and aquifers, these sources become more difficult and expensive to use. Pumps must be lowered in wells, and intakes on lakes dropped into lower, less oxygenated zones, where water may be of lower quality. Southwest Missouri has witnessed major droughts in the past. In the early 1950s, the region suffered through a forty month drought. Reservoirs dried up, springs quit flowing and groundwater levels dropped significantly. Emergency measures had to be taken to ensure that residents had adequate supplies of water.

But only rarely has the availability of water become a critical issue in southwest Missouri. While the population of the region has steadily increased, several large reservoirs have also been constructed, holding back huge quantities of surface water. Outside of a few urban and agricultural areas, groundwater levels have not declined drastically because the level of demand has remained small in proportion to the total quantity of groundwater available.

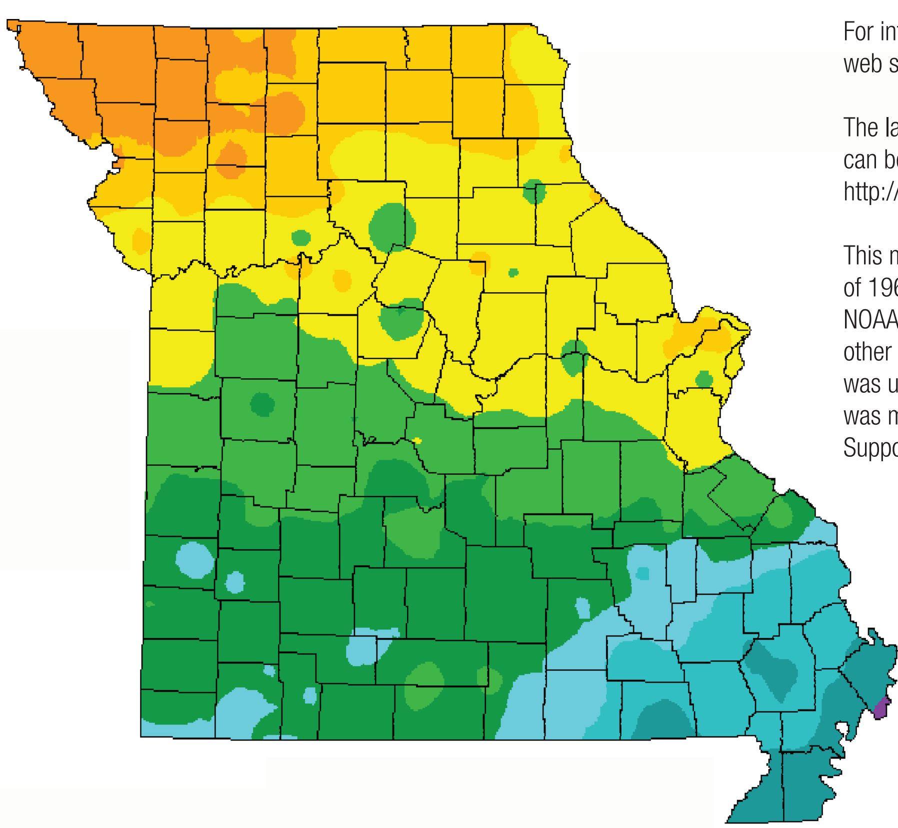
This is not to say that water availability won't be a concern in the future. Some of the counties in southwest Missouri, along with northwest Arkansas, are among the fastest growing in the nation. With this growth, thousands of new wells have been drilled. As a result, the top of the Ozark Aquifer has declined as much as 500 feet under some zones of urbanization and irrigated agriculture. Existing sources are also vulnerable to water quality problems from intensive agriculture and increasing development. In some localized areas, groundwater contamination has forced residents to look for alternative supplies. Both surface and groundwater resources in the region have, at times, been identified by the state as "impaired" for certain beneficial uses, such as aquatic life protection, drinking water and whole body contact.

Over the last few decades, serious droughts in some parts of the United States have brought water management issues to the national forefront. In this and other developed countries, water conservation is increasingly seen as an important facet of responsible development and environmental stewardship. With this increased focus on water conservation, per capita water use in the United States has dropped, but we still use more water per person than any other country in the world. Some citizens are beginning to view the use of highly treated drinking water to flush toilets or water landscapes as inherently wasteful, even though inexpensive drinking water is typically readily available for these purposes. There is also a heightened awareness that climate change could affect the amount and accessibility of water in the future.

Rainwater is not necessarily the answer to all future water availability problems, but it is a virtually untapped resource in southwest Missouri. The region receives an average of about forty-three inches of precipitation per year, equivalent to one million gallons falling on every acre per year (see Figure 1). For the purpose of rainwater harvesting, that amounts to about 25,000 gallons per year per 1,000 square feet of collection surface. At the present time, very little of this rainwater is harvested or used directly, although it is obviously very important for recharging aquifers and replenishing streams and lakes, as well as for growing food and sustaining ecosystems.

In many parts of the world, rainwater is already being harvested extensively. Where it is the most accessible source, this option may be preferred, or even required. In some Caribbean Islands, for example, where fresh surface and groundwater sources are not available, rainwater harvesting is mandated on all new buildings for drinking water supplies as well as other uses. In Australia, 10% of the population currently uses harvested rainwater as a major source for drinking water. In the U.S., some drier states, such as Texas, now encourage the use of rainwater harvesting in conjunction with public water supplies, provided the rainwater system is physically separated from the public supply and the water is used for non-potable purposes.

Figure 1
Average Annual Precipitation Missouri



For information on the PRISM modeling system, visit the SCAS web site at http://www.ocs.orst.edu/prism

The latest PRISM data sets created by the SCAS can be obtained from the Climate Source at http://www.climatesource.com.

This map of annual precipitation averaged over the period of 1961-1990. Station observations were collected from the NOAA Cooperative and USDA-NRCS SnoTel networks, plus other state and local networks. The PRISM modeling system was used to create the gridded estimates from which this map was made. The size of each grid pixel is approximately 4x4 km. Support was provided by the NRCS Water and Climate Center.

Legend (in inches)

- Under 36
- 36 - 38
- 38 - 40
- 40 - 42
- 42 - 44
- 44 - 46
- 46 - 48
- 48 - 50
- Above 50

The situation in southwest Missouri is markedly different from these more arid or groundwater poor regions. Because the deep groundwater (Ozark Aquifer) here is plentiful and generally clean; because most communities in the region are served by adequate public water supplies; and because tap water is inexpensive (some might say artificially so), the demand for harvested rainwater to this point has been minimal. That being said, there is no reason why harvested rainwater couldn't be more widely used. Probably the most logical, cost-effective and directly applicable uses for harvested rainwater in southwest Missouri are landscape watering and irrigation. Entities that use large amounts of public drinking water or pump groundwater to water landscapes should at least investigate the feasibility and cost-effectiveness of installing rainwater harvesting systems for these non-potable uses.

In a wider context, rainwater harvesting is now being seen as one reasonable and cost-effective component of sustainable water management. Rainwater harvesting, in fact, is one of a whole suite of "green" or Low Impact Development (LID) building practices, including green roofs, rain gardens, vegetative filters and pervious pavement, which are being used as "green infrastructure" (as opposed to traditional infrastructure like pipes and concrete channels) to infiltrate stormwater and reduce urban runoff and pollution of waterways. And more and more home and business owners will eventually figure out that capturing free rainwater, in many cases, makes sense economically, as well as for benefiting the environment. With greater awareness and thoughtful planning, rainwater harvesting could become an important addition to our total source water portfolio, a practical alternative in our palette of water source options, even in "water rich" southwest Missouri.

History of Rainwater Harvesting

Our purpose here is not to give a detailed account of the history of rainwater harvesting. Suffice to say that it has been going on since the beginnings of civilization, if not before. Rainwater was being harvested in China at least 6,000 years ago, and huge cisterns were in use in the Middle East by 2,000 B.C. These large storage vessels collected roof and street runoff water and even had sophisticated filtering systems to keep the harvested water clean. The Romans also made extensive use of rainwater collection systems, along with elaborate and highly engineered aqueducts to move water by gravity from pristine sources to points of use.

In the 19th and early 20th centuries, many, if not most rural Missourians adopted rainwater harvesting on a household or farmstead scale, through the use of cisterns. By the late 1800s, rainwater harvesting equipment had become rather sophisticated, with a myriad of products and devices on the market to help the farmer or homeowner collect, divert and re-use rainwater. This is not surprising, because the basic concepts involved are very simple. It does not take an engineer to design a workable rainwater harvesting system.

But, there have also long been problems with utilizing harvested rainwater. In southwest Missouri, springs were preferred over cisterns as sources of drinking water because soot from wood burning and other pollutants that accumulated on roofs were washed into cisterns, making the water taste stale or foul. Filters used to clean harvested rainwater were rudimentary in design, even at the commercial or municipal scale, so nuisance conditions persisted in stored water. Still, because they were simple to design and install, fairly reliable (as long as it rained) and relatively cheap, cisterns were widely used.

The probable reason that cisterns fell out of favor, at least in Missouri, was the rise of affordable water supplies obtained by other means. With the advent of hydraulic rotary drilling methods in the 1890s, and the electrification of Missouri soon afterwards, drilled wells came into common use for farms, isolated residences and towns. In the region's larger cities, individual wells, springs and cisterns could not keep up with population growth, so larger surface water sources were brought on line for public water supplies. Today, the city of Joplin uses Shoal Creek, which came on line in 1881. Springfield, which initially used a large spring, Fulbright Spring, beginning in 1883, began building water reservoirs shortly after 1900, and in 1996 completed a pipeline to the massive Corps of Engineers Reservoir, Stockton Lake.

In southwest Missouri, some farmsteads and homes still have and use cisterns, but for the most part, rainwater harvesting has gone out of vogue. The benefits of harvesting rainwater, however, including simplicity, affordability, and ease of operation, remain to this day. The idea of harvesting rainwater is catching on once again. But the harvesting technologies themselves, as well as the rules that govern the construction, installation and operation of harvesting systems, need to be updated for more widespread use in the 21st century.

Benefits of Using Harvested Rainwater

Perhaps one of the best reasons to harvest rainwater is that it is free. There are no legal restrictions in Missouri on collecting as much rainwater as desired. The collection area (usually a roof) is typically very close to the site of end use, reducing the length and therefore the costs of pipes to get water from source to point of use. Rainwater harvesting systems are simple to design and construct, relatively easy to maintain, and the water collected is of sufficient quality for most outdoor uses with little or no treatment.

The most commonly seen rainwater harvesting system in southwest Missouri is the simple rain barrel, which is gaining in popularity for home landscape and garden watering needs. Harvested rainwater is very good for this purpose. It is usually of nearly neutral pH (unless it is acid rain), free from disinfection byproducts such as chlorinated organics, and low in salts and minerals. Setting up rain barrels allows homeowners to gain experience with using harvested rainwater. More widespread use of rain barrels should increase public support for rainwater harvesting in general, and could motivate citizens to amend local codes and regulations to allow for larger and more widespread applications of harvested rainwater in the future.

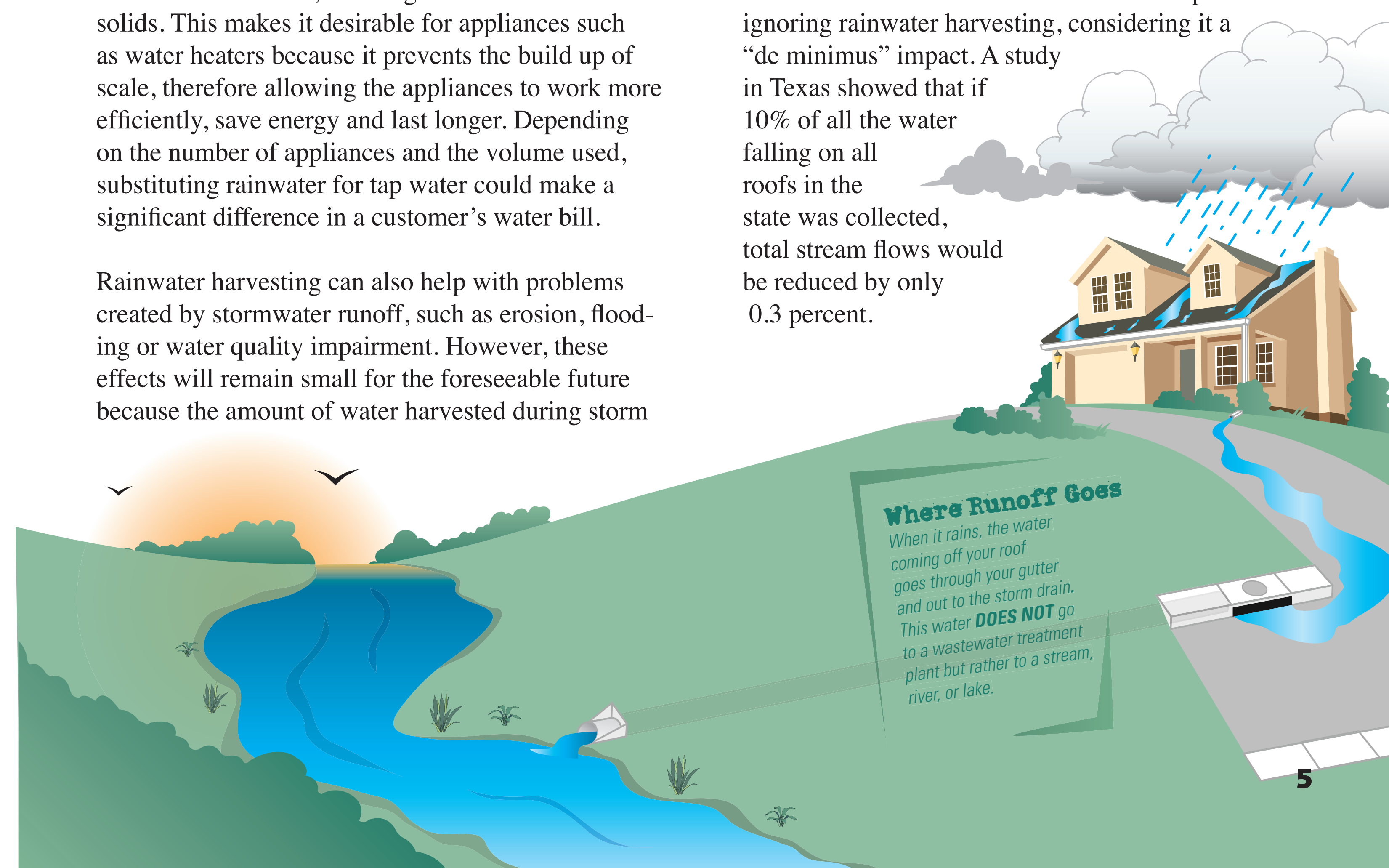
Most homes and businesses in southwest Missouri use high quality municipal drinking water or potable well water for all indoor and outdoor uses, even though at least 80% of the water demand at a typical home would not require water to be of drinking water quality. Rainwater harvesting can provide water for lawn and garden watering and irrigation needs that ordinarily would be taken from a municipal supply. The use of harvested rainwater for non-potable uses like toilet flushing and plant watering avoids the use of treated tap water for this purpose and allows the quality of the water provided to more closely match what is actually needed. At remote sites, the incorporation of rainwater harvesting technologies could even allow an owner to avoid the expense of drilling a well.

Summertime uses such as irrigation greatly increase demands on public water systems (as much as a 50% increase in Springfield), which must be designed for these peak demand periods. Thus there is an incentive for water providers to help customers find alternative sources for summertime water use in lieu of the utility being forced to invest in larger infrastructure to meet peak demands. Using rainwater for irrigation and non-potable indoor uses will get citizens comfortable with rainwater as a component of the water supply without the health concerns or perceptions of risks associated with "human contact" applications such as showers, cooking and drinking water.

Relatively simple techniques for cleaning and storing harvested rainwater can allow it to be used effectively with indoor appliances and equipment. Rainwater is "soft" water, meaning it is low in dissolved solids. This makes it desirable for appliances such as water heaters because it prevents the build up of scale, therefore allowing the appliances to work more efficiently, save energy and last longer. Depending on the number of appliances and the volume used, substituting rainwater for tap water could make a significant difference in a customer's water bill.

Rainwater harvesting can also help with problems created by stormwater runoff, such as erosion, flooding or water quality impairment. However, these effects will remain small for the foreseeable future because the amount of water harvested during storm events is a vanishingly small portion of the total rain that falls. In order to collect 1% of the roughly 35 billion gallons of water falling on the Springfield Urban Area annually, all of the water flowing from 320 acres (1/2 square mile) of roof would need to be collected. Rainwater harvesting will not significantly reduce volumes of runoff until the practice becomes very widespread. But harvesting could help with localized situations such as the infiltration of runoff around foundations or seeping into leaky basements, or the erosion of nearby steep banks or runoff swales. And harvesting, when used in conjunction with other "green" infrastructure such as rain gardens and vegetated swales, can help significantly to reduce the negative water quality impacts of urban runoff.

In western "prior appropriation" states, concerns have been expressed that widespread harvesting of rainwater could negatively impact the volumes of flow downstream. Under western water law, water in the stream has already been appropriated for use, so an upstream rainwater harvester could, in effect, be "taking" water that already belongs to someone downstream. This is not a legal concern in Missouri, which is a "riparian" state, not a prior appropriation state. And even some western states are at present ignoring rainwater harvesting, considering it a "de minimus" impact. A study in Texas showed that if 10% of all the water falling on all roofs in the state was collected, total stream flows would be reduced by only 0.3 percent.



Because rainwater harvesting makes sense in many situations, and is a useful conservation measure, Missourians may eventually receive financial incentives for implementing the practice. To date, incentives have primarily been "rebates" for rain barrels. But significant financial incentives could be considered in the future if water conservation becomes a higher priority, or if water availability becomes a more pressing issue. In drier states, such as Texas, financial incentives are already in place. Texas law, for example, exempts rainwater harvesting equipment from state sales tax, and another law allows local governments to exempt rainwater harvesting systems from property taxes.

There is no technical reason why rainwater could not be collected and treated to meet all drinking water needs and all applicable quality standards. Many people think that rainwater has a superior taste. It is also nearly sodium free, a benefit to people on sodium restricted diets. Today's sophisticated water treatment systems are capable of filtering and disinfecting rainwater to make it safe and palatable for human consumption. In spite of this, there is considerable resistance to the wider use of harvested rainwater for drinking water in many locations, including southwest Missouri.

Public water systems can, and in some places now do, incorporate harvested rainwater into their source portfolios, but only for non-potable uses. With adequate financial capacity and in-house expertise, public water providers are in a good position to manage rainwater supplemented drinking water systems and prevent problems. This forces a more thoughtful consideration of demand management strategies, or matching the amounts of water used or the timing of needs more closely to the natural water cycle. Individual residents, on the other hand, can not always be relied upon to provide proper operation and maintenance of home drinking water systems. For this reason, many agencies discourage or even prohibit individual home or business owners from installing drinking water systems using harvested rainwater.

Problems or Issues with Harvesting Rainwater

While the "lost world of rainwater harvesting" is being rediscovered in Missouri and may eventually move back into the mainstream, we now live in a world that is much more regulated than the one our forefathers inhabited. Building codes must be followed. The impacts of our actions on the health, safety and well being of others are more heavily scrutinized and controlled. The result is that some of the issues related to rainwater harvesting today are more complicated than they were in the past.

As a rule of thumb, if a person wishes to avoid any potential regulatory hurdles, it is best to use harvested rainwater outside the home or business for lawn and landscape watering, and never hook pipes containing rainwater, whether treated or not, to public or private drinking water systems in any way. If you intend to use rainwater for non-potable uses such as flushing toilets in a home or business (which is actually a very good and practical use for rainwater), then you need to find out what local regulatory body has jurisdiction over this area. Before spending money to design or install a rainwater system for this type of use, it is always best to check first with the city or county where you live to see what specific rules apply.

Some general statements can be made considering the practice of rainwater harvesting in our state: 1) It is perfectly legal to harvest rainwater in Missouri from your roof, in any quantity desired. 2) If you intend to use harvested rainwater only for outdoor uses, such as watering plants or general cleaning (where no toxic or hazardous materials are involved), you do not need permission from any agency or unit of government. 3) If you intend to bring harvested rainwater into a home or business in a pipe, even for non-potable uses such as flushing toilets, then you will most likely need permission from a regulatory body. 4) If you intend to use harvested rainwater for drinking water purposes, even more restrictions will apply. There is a good chance that this will not even be allowed where you live.

Rainwater is probably the cleanest surface water source in the urban environment, but it certainly is not pure. Rainwater tends to collect dust and airborne contaminants from the sky as it falls. When raindrops hit roofs, they encounter and entrain contaminants such as deposited dust particles, pollen or microbes from bird and rodent droppings. In gutters, rainwater can flush accumulated leaves, sticks, dirt, organic matter and shingle grit into the collection system. Rainwater can also become acidic in contact with leaves and can then corrode metals, including leaded solder in gutter pipes, creating potential toxicity.

Because rainwater can be slightly contaminated (even after the first flush is diverted from storage), designing the system for the intended end use is very important. For any system more complicated than a simple rain barrel, the "first flush" of rainwater runoff should normally be diverted away from the storage tank or tanks. This more contaminated slug of runoff should ideally be treated in an onsite stormwater treatment system such as a rain garden or vegetative filter.

If the intent is to use harvested rainwater beyond landscape watering or outdoor cleaning, there may be legal and regulatory hurdles in addition to technical ones. Rules can differ depending on the particular political jurisdiction, but typically where building and plumbing codes are administered, rainwater harvesting is either not directly addressed, or else is lumped with "reclaimed water." Reclaimed water is actually wastewater or gray water which has been cleaned. This non-drinkable water can be used for a variety of purposes, but it is regulated to make sure it isn't ingested by humans or potentially connected with drinking water systems. Codes may require signs or colors of pipe to make sure that occupants and plumbers know that pipes contain non-drinkable water.

The largest constraint on the collection and use of harvested rainwater is typically the amount of storage available. Typically, roofs can provide much more water than there is capacity for storing it. For simple systems, large storage tanks or cisterns are often the most costly components of the rainwater system. Providing enough water storage between widely spaced rainfall events can be a real problem if the water is needed for necessary and ongoing uses such as toilet flushing or industrial processes. In these cases, the owner may need to provide an alternative source of water to be used in conjunction with the rainwater system (a dual system), or provide make-up water for tanks from another source. Obviously, this increases the complexity of the system and may impose regulatory constraints if the rainwater system is tied to another water system, particularly a regulated system.

Uses of Harvested Rainwater

Landscape Watering

The most common use of harvested rainwater in southwest Missouri is for watering plants. Rain barrels for this purpose have become popular in recent years, and many can now be seen under the downspouts of homes in the region. These systems are simple, cheap and easy to operate. Programs like those available from the James River Basin

(continued on page 10)

How to Make a Rain Barrel

Directions

What do I need to get started?

You will need the following supplies:

- 55 gallon plastic (food grade) barrel
- Silicone
- Felt tip pen
- Teflon tape
- 4” atrium basket
- Old pantyhose or knee highs
- Flexible downspout
- (1) 3/4” hose bib
- Metal garden hose adapter 3/4“ x 3/4” x 1/2“ (brand we use: Watts A-665)

Tools needed:

- Jigsaw or 4” hole saw
- 1” holesaw
- Hacksaw (for cutting downspout if desired)
- 1 1/16” open or pipe wrench

Clean out barrel as needed.

Place atrium basket upside down over the opening and trace.

Use jigsaw or 4” holesaw to cut out hole just inside of traced line.

Decide which side you want your over- flow, then measure down 2” from the top of barrel.

Drill hole using 1” holesaw.

Wrap threads of metal hose adaptor with Teflon tape.

Put a bead of silicone around hole.

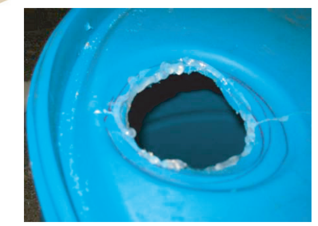
Using wrench, screw in the metal hose adaptor. This you can then attach a garden hose to and will be your overflow.

Drill hole using 1” holesaw two inches from bottom of the barrel.

Wrap spigot in Teflon tape, add a bead of silicone and screw into hole. Here you can either attach a hose/soaker hose or fill bucket or watering can.

Place foot of panty-hose inside of atrium basket and drop in the hole on top of the barrel.

May need to line the edge of the hole with silicon and then let dry before placing basket in hole to ensure a tight fit.



At this point paint barrel if desired.

Elevate the constructed barrel next to down-spout. Concrete blocks work well. Bend flex-ible downspout into the basket, align with structure’s downspout, and mark where the flexible downspout will be connected.

Using a hacksaw, make a horizontal cut on the the structure’s downspout.

Attach flexible downspout to regular downspout.

Attach piece of hose to overflow valve and direct away from your home’s foundation.

Be sure to let all silicone dry thoroughly before filling with rain.

Enjoy your new rain barrel!

Rain Barrel Use and Care

Place on raised surface to increase water pressure.

Clean out atrium basket to keep free of debris.

Clean out gutters on a regular basis or use gutter screens.

Unhook barrel in winter to prevent freezing.

Direct overflow outlet away from foundation and toward a grassy area or rain garden. Use water in barrel regularly so it will be empty for next rain.

For more information, contact:
James River Basin Partnership
(417) 836-6183
www.jamesriverbasin.com
Watershed Committee of the Ozarks
(417) 866-1127
www.watershedcommittee.org

Partnership, Watershed Committee of the Ozarks, City Utilities of Springfield and City of Springfield's Stormwater Services Division of Public Works provide homeowners with barrels, storage tanks, or rainwater harvesting "kits" containing barrels, filters, taps, tubing, and first-flush diverters. These organizations and agencies also have brochures on how to build your own rain barrel system (see brochure on how to build a rain barrel, included here).

Livestock Watering

Another potential use of harvested rainwater is livestock watering. Harvested rainwater is typically cleaner than water provided in ponds. Also, many livestock facilities have buildings with expansive roofs, offering the potential to collect large amounts of rainwater. An additional benefit of harvesting rainwater from the roofs of livestock barns is that the soil around the barn is often the most saturated with animal wastes, so preventing roof runoff from contacting this soil can help with localized erosion and water quality problems. Guttering large buildings can be a significant expense, however. As with other harvesting systems, the highest cost items are often the large volume storage tanks that are required for sufficient water through dry periods.

Urban Agriculture

There is a growing trend toward producing more food in urban areas. This obviously requires water, which would normally be provided either through direct rainfall or through a municipal water supply. Harvested rainwater could provide a significant portion of this need, particularly since numerous roofs are often present in the vicinity of urban farms. However, intensive agricultural operations may require more water than can be economically collected and stored on site. These operations will probably need to have access to a back-up supply, most often a municipal system or a drilled well. There is also the potential for poor water quality from contaminated urban surfaces, such as parking lots, that could be connected to a collection system.

Toilets/Urinals

The use of harvested rainwater for flushing toilets and urinals is increasing. However, in southwest Missouri it may be difficult to justify this type of use on a strictly economic basis, since public tap water or well water is typically accessible and inexpensive. This use requires a separate line from the storage reservoir to the fixtures, and the water must arrive at the fixtures under pressure, provided either through a pump or by the elevation of the storage tank. The water for toilet or urinal flushing is usually not disinfected. However, disinfection may help to reduce the microbial growth that might otherwise occur in untreated water lines, potentially causing discoloration or sediment or odor problems in fixtures.

Water Heaters/Washing Machines

Rainwater is "soft," so prevents the buildup of scale in water heaters and other appliances. However, soft water may also be more corrosive to metal parts than typical tap water. If heated rainwater is going to be used for human contact, for example in bathtubs or showers, the health risks of using untreated water (not filtered and disinfected) may increase. Washing machines are typically the second largest water user in the home after toilets, (see chart on domestic water uses on page 13), so substituting rainwater for this use could have a significant impact on volumes of water used and therefore on water bills.

Commercial/Industrial

Harvested rainwater is a virtually untapped resource for industrial applications. Many industrial uses do not require water to be of drinking water quality. But in most cases, public water supplies or deep wells are easier to use and will probably be the most cost-effective sources. However, the capital investments in rainwater harvesting systems should be compared to the "pay back period" of using tap water or pumped groundwater. Managers and owners of industrial operations, which often have large roofs and collection surfaces, should at least take a look at this option to determine the actual costs, engineering challenges and pay-back periods anticipated.

Drinking Water

Reliable water filtration and disinfection systems are available for homes or businesses. The biggest concern for allowing rainwater to be used for drinking water is the potential for inconsistency of operations and maintenance. While one owner may manage his or her individual water system very carefully, the next owner may not fully understand the system's operation and maintenance procedures, or be willing to invest the time and resources in maintaining the integrity of the system. For this reason, regulatory agencies rely on construction standards for individual private water wells to protect drinking water, rather than homeowner training or periodic testing. These agencies may discourage or even prohibit a private home or business owner from installing drinking water systems using harvested rainwater as the source.

Designing a Rainwater Harvesting System

Ultimately all water sources, whether surface or groundwater, depend on periodic rainfall. One problem with collecting rainwater for later use is that rain falls erratically and sometimes infrequently. However, rainfall records in southwest Missouri go back well over 100 years, and can be used with some confidence to forecast how much rain is likely to fall in any given period. When designing harvesting systems, the data of interest are typically the average amounts of rain that fall in given months and the average number of days between rains in the driest season. Figure 2 shows the average monthly precipitation amounts at Springfield over the period 1971 to 2000. As you can see, the highest average precipitation is in the month of June, with 5 inches, followed by September at 4.8 inches. The lowest precipitation month is typically January, at just over 2 inches.

Figure 2

Springfield, MO Average Annual Precipitation by Month

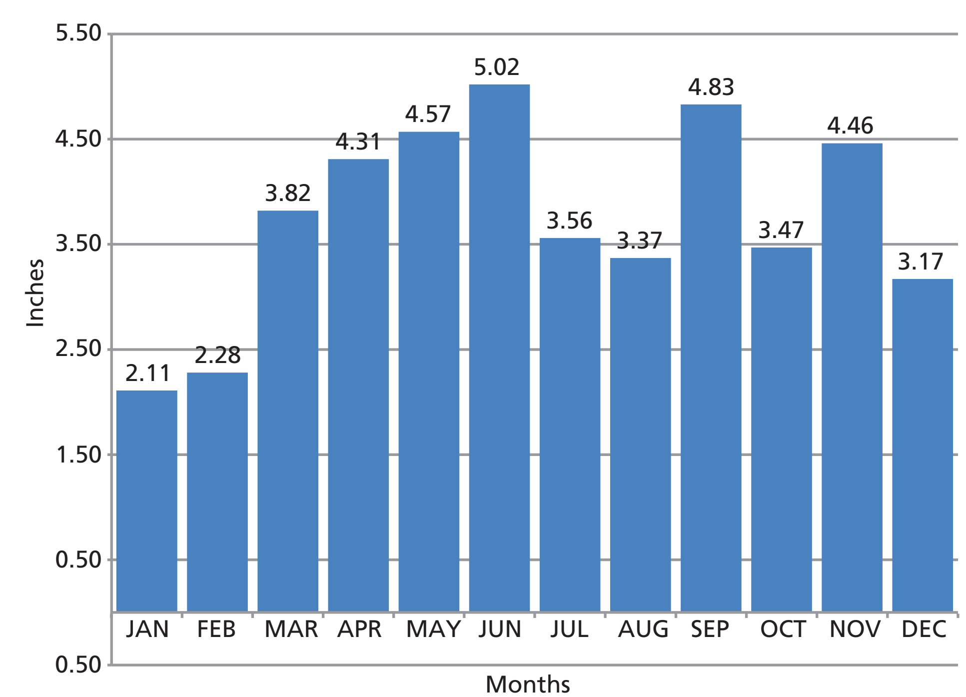
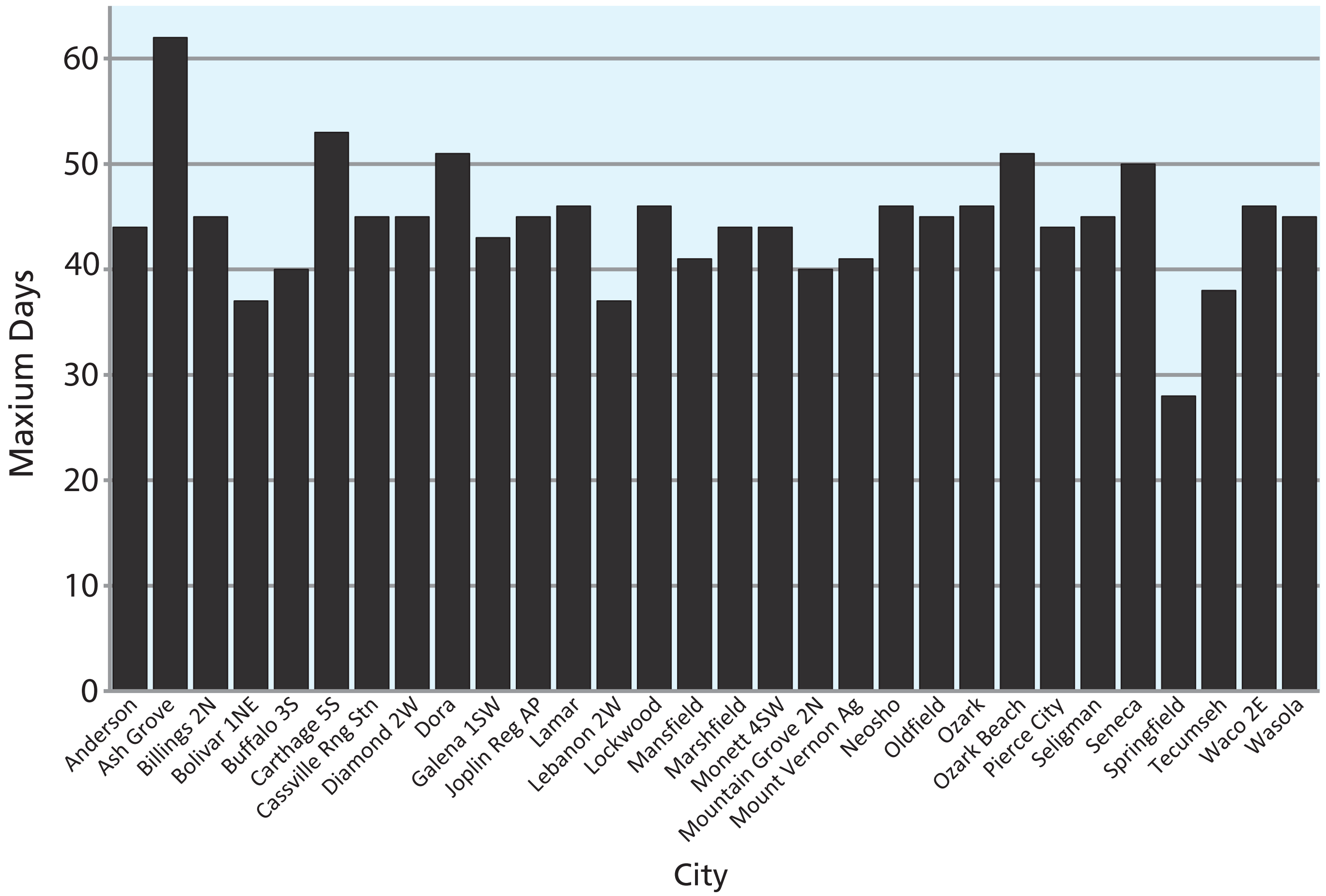


Figure 3 shows the maximum days with no precipitation in the period 1971 through 2000 at data collection points in southwest Missouri. As you can see, most recording locations in southwest Missouri fall within the 40 to 50 day time frame. Therefore, if enough water is needed to get the user through a period of drought, it is a good idea to plan for one-and-a half to two month's worth of reserve storage.

Before designing a rainwater harvesting system, the intended use and the amount of water desired or required to support that use need to be determined. If a predetermined amount of water is needed regardless of

Figure 3
Maximum Days Between Precipitation Events in Southwest Missouri



how often it rains (for flushing toilets, for example), the amount of water in storage will determine how many user days of water will be available. For periods extending beyond that available supply, an alternative source must be considered. For indoor uses, this back-up supply is typically a public water system. For these "dual" systems, there must always be a backflow prevention device or positive air gap between the rainwater system and the public water supply. Calculating the amount of water to be stored involves looking at daily use during the period of need and determining the longest average time between rains during that period. Costs can then be estimated for the type and volume of storage tanks and the associated piping, valves and, if needed, pumps.

Rainfall patterns need to be considered to provide an estimate of the amount of water that can be captured from a given collection surface over the intended use period. Southwest Missouri receives an average of about forty-three inches of rain per year. This is equivalent to about twenty-five gallons falling on every square foot of land surface every year. More rainfall tends to fall in the spring, when plants are growing, so harvested water for landscape watering is not needed as critically then. But in summer, when rainfall amounts slacken, plants need additional water and having rainwater in storage is very beneficial. The key is to implement enough storage of water during "wet" periods to provide a useful and beneficial resource during "dry" times. Depending on the level of use, the amount of rainwater in storage may or may not be able to sustain this use through periods without rainfall. In order to capture enough water to use throughout a typical dry period, a person should plan for at least one month's worth of storage.

Table 1
Typical Domestic Daily Per Capita Water Use
(Source: USEPA *Rainwater Harvesting Policies*, EPA-833-F-08-010, December 2008)

Use	Gallons per Capita	% of Daily Use
Showers	11.6	7.0
Dishwashers	1.0	0.6
Baths	1.2	0.8
Faucets	10.9	6.6
Clothes Washers	15.0	9.1
Toilets	18.5	11.2
Other Uses & Leaks	11.1	6.7
Subtotal	69.3	42.0
Outdoor Uses	95.7	58.0
Total	165	100

Table 2
Typical Domestic Daily Water Use for Office Buildings and Hotels (Source: USEPA)

Use	Office Bldg. (% of Daily Use)	Hotels (% of Daily Use)
Showers	-	27
Faucets	1	1
Kitchens	3	10
Toilets/Urinals	25	9
Laundry	-	14
Cooling	23	10
Outdoor Uses	38	10
Other Uses	10	19

Collection Surface (Roof)
In some parts of the world, such as small tropical islands where fresh groundwater is scarce or nonexistent, rainwater collection surfaces are made of concrete or plastic installed on hillsides. In southwest Missouri, the most logical choice for rainwater collection will usually be a roof. Depending on the amount of water desired or needed, sheds or garages may be easier to outfit with rainwater collection systems than homes or commercial buildings.

The most efficient roofs for rainwater collection have smooth, hard surfaces. Steel (stainless or galvanized) or painted aluminum roofs are often used and work very well. The Texas Rainwater Harvesting manual recommends Galvalume (trademark), a metal which is about 55% aluminum and 45% zinc alloy coated steel. Slate and tile roofs also work well, but are more expensive. Clay tile, asphalt and fiber cement shingles are more difficult to keep clean and may support the growth of mold and algae. Flat roofs tend to collect more dirt and debris than smooth, steep sided roofs. Light colored metal roofs are ideal, in that they deliver the greatest amount of water and also combat the heat island effect of urban areas.

For the purposes of anticipating roof runoff volumes, assume that one square foot of roof surface will produce about .6 gallons of runoff per one-inch rain (this amount will be reduced with higher slopes), or 60 gallons per 100 square feet of roof surface. Calculate the total roof area by summing up the individual roof sections. From this, it can easily be seen that a one-inch rain collected from 100 square feet of roof will easily overflow a 50-gallon rain barrel. Homeowners are often surprised to see how quickly their rain barrels fill, but a simple calculation shows why. Roof sections contributing water to a gutter are typically 200 square feet or larger. 200 square feet of roof will deliver enough water to fill two typical rain barrels during a single one-half inch rainfall event.

During years of average rainfall, it is possible to harvest about 25,000 gallons of water per year per 1,000 square feet of roof surface in southwest Missouri. The volume of water actually delivered by a roof is highly variable, however, depending on the surface, slope, gutter and downspout capacities and configuration of roof surfaces. Composite or asphalt shingles will reduce flows by about 10% compared to metal roofs. Furthermore, the "grit" on many shingles tends to wear off and clog gutters. During heavy rains, many roofs provide more runoff than gutters can handle, and they overflow. Gutters should be sized appropriate to the roof size and the amount of water to be collected. For roofs designed to deliver water suitable for drinking water purposes, non toxic roof and gutter materials must be used. Asphalt or composite shingles are not recommended for collecting water that will be ingested.

Gutters and Downspouts

Standard home and commercial gutters will work for most systems, but if water is to be used for drinking purposes, these materials must be non-toxic. Copper or zinc gutters and downspouts should not be used for collecting drinking water. Wooden gutters, due to roughness, rotting and adherence of soils and plant growth, are not recommended. Standard residential gutters will not work on larger buildings, where much more runoff is produced. Roof "valleys" concentrate flows, so to maximize rainwater collection the gutters may need to be expanded in the areas receiving direct runoff from valleys.

Leaves sitting in gutters can produce acidic water that can leach solder or toxic metals from gutters. Leaf guards are very helpful in keeping gutters mostly clean and free of leaves. They allow water to seep into the gutter, but keep leaves out. However, this will also cut down on the total amount of water that can be collected. Strainer baskets placed in drop outlets to the downspout will also help to keep leaves and debris out of the collection systems. If the water is to be used for drinking, serious efforts must be taken to keep dirt and leaves and debris out of the collection system, but the water will still need to be filtered and disinfected.

Storage Containers (Barrels, Tanks, Cisterns)

Rain barrels can be made of about anything that will hold water, but they should not have contained any toxic materials prior to being used to store rainwater. They should be opaque or dark colored to prevent the entry of sunlight, which will stimulate the growth of algae. Dark colored polypropylene containers or food grade barrels are often used. Rain barrels can be placed on stands or platforms to provide increased pressure at the outlet. About 2.3 pounds of pressure per square inch (psi) is added for every foot of elevation from the top of the barrel (or water surface) to ground level. Openings into the barrel must be protected with fine mesh screens to prevent the entrance of mosquitoes and the hatching of larvae in the barrel. Since most rain barrels have only crude inlet filters, the barrel will probably need to be cleaned out at least once per season, as dirt and organic material will tend to accumulate in the bottom, eventually filling to the level of the lower "spigot" or drain point.

Most rain barrels do not provide sufficient water for extended droughts. It is common to use all the water in a rain barrel over a few days or weeks during the summer, while droughts could continue for several weeks or months. The easiest way to provide additional water in storage is to add barrels. It is a simple matter to hook several barrels together in series, with one overflowing into the next. The last barrel can be used first, and the water in it will tend to be the cleanest. As the drought continues, barrels closer to the immediate downspout source can be used.

Water tanks provide more storage than barrels. The storage tank is often the most expensive and important component of a harvesting system. It must be sized carefully in consideration of the intended end use. If the intent is to have sufficient water between infrequent rainfall events, the storage tank must be sized large enough to sustain regular use activities between these events. In other words, the system designer must carefully plan the amount of storage for a "design drought."

Tanks can be of many sizes, shapes and materials, but it is important that any above ground storage container be opaque rather than translucent. Admitting light into the container will stimulate the growth of algae, which can lead to clogging problems or, if the water is intended for human consumption, tastes and odors. If tanks have been used previously for petroleum or other hazardous or toxic materials they must be thoroughly cleaned before reusing in a rainwater system.

Cisterns are large tanks that are typically buried underground. Considerations are the expense of excavation and having enough room for the installation on the property. Installing the tank underground prevents freezing, keeps the water cool in summer (average ground temperature) and prevents access to algae-inducing sunlight, but the water must be pumped or lifted to a higher elevation for use. Cistern tanks can be made of plastic, fiberglass, coated steel or concrete. Buried tanks should be heavy enough to overcome buoyancy forces when empty, or else weighted or "ballasted." Lightweight tanks made of materials such as plastic need to be designed or weighted to minimize the potential for "floating" out of the ground when empty or nearly empty.

Cistern tanks need to be watertight and have smooth internal surfaces, so they can be easily cleaned. If intended for drinking water, cisterns should carry the NSF (National Sanitation Foundation) certification label. Tank inlet pipes should be turned or deflected so that inflowing water doesn't stir up sediment on the bottom of the cistern. Manholes on cisterns need to be sealed to prevent surface contamination. Most codes require that access manholes extend at least four inches above grade (ground level) to prevent the entrance of surface water. Cisterns used for drinking water should always be disinfected after opening for maintenance or repair. The Texas Manual suggests that a cistern containing enough water for a three-month supply is adequate for most home use. Water can be purchased to fill the cistern during droughts, if necessary, and water in the cistern can be made available via a hand operated pump in the event of power failure.

Rainwater storage tanks can also be placed above ground. Placing tanks on roofs, for example, provides enough water pressure for irrigation or fire fighting. As mentioned earlier, about 2.3 pounds per square inch (psi) of pressure is added for every foot of water elevation above the ground. A water surface ten feet above the ground would provide over 20 psi, sufficient pressure for most irrigation systems. If tanks are located above ground and outside, the possibility of freezing weather must be considered. Pipes coming out of tanks are especially vulnerable to freezing, and either must the protected (e.g., heat tape), or the tanks drained during freezing weather.

A system designer must also consider the considerable mass of water, which weighs eight and one-third pounds per gallon. A 300 gallon-tank will contain well over a ton of water, so large tanks should be installed on level, sturdy foundations and mounted securely. Raised platforms for tanks to provide system pressure must be properly engineered and constructed to bear the heavy load. Above ground tanks made of plastic should also be located in shady areas or be U.V. resistant to prevent degradation and cracking of the tank materials.

First Flush Devices

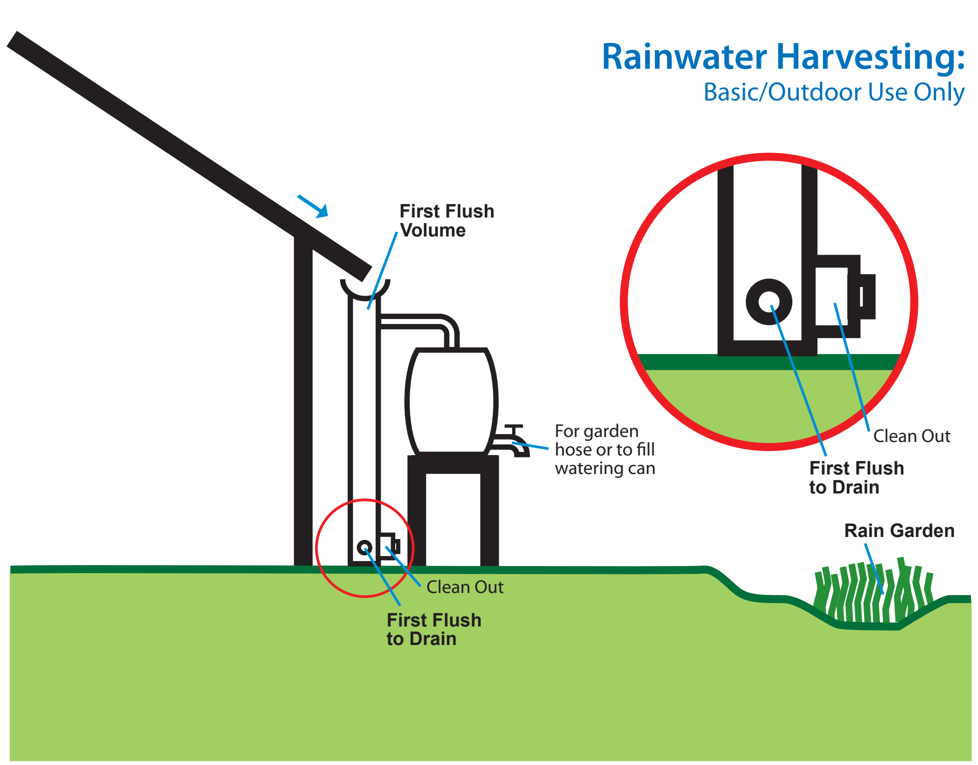
Even with simple rain barrel systems, homeowners often install some type of "first-flush" device to prevent buildup of residue in the barrel and nuisance conditions such as discoloration or odors. These devices can either be manually operated, or can be passive. A manual device could be a simple flap diverter in a downspout that allows the owner to by-pass the first flush of roof runoff at the beginning of a rain event. Downspouts can also be manually moved over the top opening of the rain barrel after the first flush.

The Texas Rainwater Harvesting Manual recommends diverting at least the first 10 gallons of runoff from each 1,000 square feet of collection surface. But the amount to be diverted is highly dependent on local conditions, with the Texas Manual suggesting 13 to 50 gallons per 1,000 square feet depending on the presence of trees, dust, bird droppings or local air pollution. The higher the potential for debris or pollutants to be on the roof or in the gutters, the more desirable the diversion of the first flush and the larger the diverted volume that should be considered. Owners may need to fine tune the first-flush diverter after the harvesting system has been in use for a few seasons.

Commercial roof washers are available with screens and detention storage volume to provide some cleaning of water before it goes into a tank or cistern. Passive first-flush diverters are beneficial in that building owners or occupants don't have to do anything to physically separate the first-flush flows. One type of diverter is simply a large diameter (6 inches or more on a 4-inch gutter, e.g.) vertical pipe under the downspout to contain the first flush. Near the top of the pipe, cleaner water overflows to the storage tank (see Figure 4). It is a simple matter to calculate the pipe diameter and length needed to contain the desired first flush volume. A 6-inch diameter standpipe will hold one gallon of water for every 8 inches of pipe. A small "weep hole" or "trickle drain" at the bottom of the pipe allows water to seep out slowly after storm events. All first-flush devices should be drained to remove water and accumulated residue between storm events.

Some manufacturers make a diverter that fits directly on the downspout. The downspout pipe is cut to insert the diverter, which is technically not a "first flush" device but does divert leaves and sticks and debris from the tank. This works on the principle that most flow inside the downspout occurs on the inner walls of the pipe, not down the middle (sustained high flows will begin to fall into the middle of the pipe). This "surface flow" is intercepted by a shelf along the inside edge of the diverter which moves water out of the downspout and into the storage tank. Leaves and debris will tend to fall through the open, downwardly sloping middle part of the diverter to the downspout outlet and splash block below.

Figure 4
Rain Barrel with First Flush Device and Clean-Out
(note that First Flush is directed to Rain Garden)



Pumps and Filters

Pumps are necessary if pressure is needed in the system. For irrigation, at least 20 psi is recommended. The Texas Manual recommends that pumps be rated or listed for potable water and that they be able to deliver at least 35 psi (typical city water is 40-60 psi). Pumps providing sufficient pressures are necessary if the water is going to be used for flushing toilets or urinals, or supply water heaters or washing machines. Pumping is also normally required for buried tanks or cisterns simply to raise water to a usable elevation.

Filters are required on systems where cleaner water is needed, such as for toilet flushing or drinking water. Filters of many types are available, with pore sizes of 3-5 microns typically used to remove most suspended matter. Filters to be used with drinking water should carry the NSF (National Sanitation Foundation) certification for potable water use. If the water is to be disinfected, it is critical that it receive adequate prior filtration. Suspended organic matter, for example, can reduce the disinfection effectiveness of chlorine or other chemicals. If ultraviolet (UV) light is used to disinfect, the water must be very clear so the light can shine effectively through it, as cloudy water could shield microbes from the killing UV rays. Filters are therefore recommended upstream of UV disinfection units. Where activated carbon filters are used on drinking water systems, these may be placed downstream of chlorine or ozone disinfection systems.

Figure 5
Rainwater Harvested for Multiple Home Uses

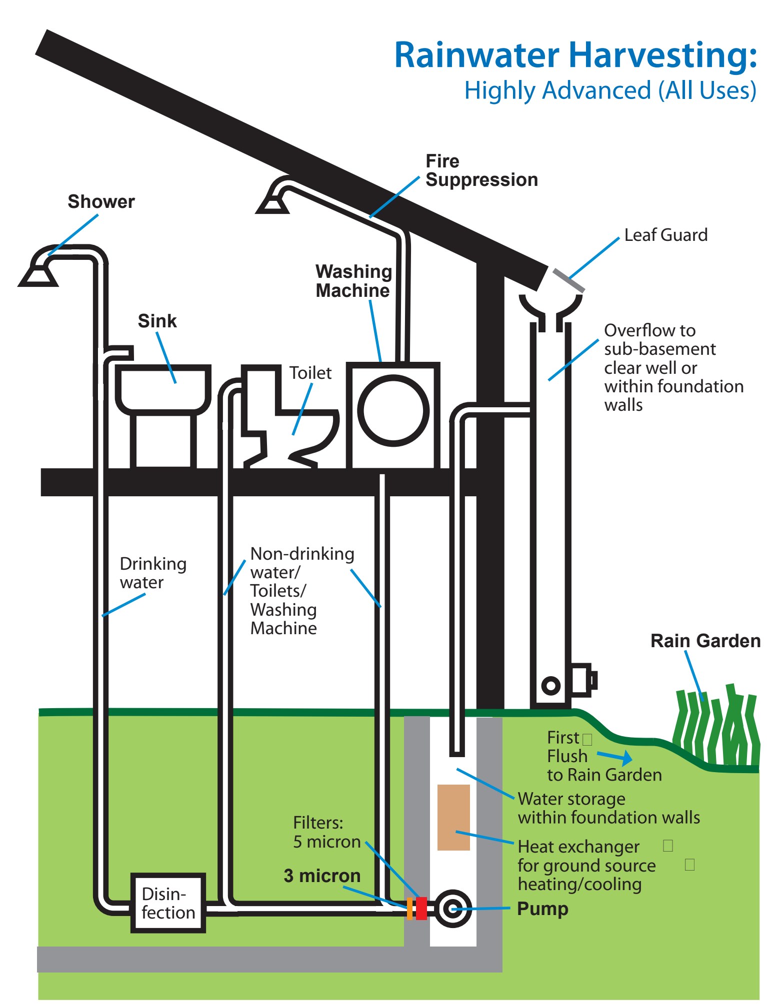


Figure 5 shows a hypothetical highly advanced harvesting system where the water is intended for all home uses, including drinking water, fire suppression and even ground source heating and cooling.

Codes, Regulations and Health Issues

Nationwide, rainwater harvesting is for the most part unaddressed in regulations and codes. No national standards for the design and installation of rainwater harvesting systems currently exist in the United States. Neither the Uniform Plumbing Code (UPC), nor the International Plumbing Code (IPC), directly addresses the use of harvested rainwater. The International Green Construction Code (IGCC) does address rainwater harvesting and is being adopted by an increasing number of cities. The IGCC code is easy for cities to adopt and use because it dovetails nicely with the existing IPC. However, existing, traditional codes and regulations in many cities still produce impediments to rainwater harvesting. "Older" plumbing codes have been identified as a common barrier to wider implementation of harvesting systems nationwide.

Anyone who intends to use harvested rainwater for any purpose beyond watering or cleaning outside the building must pay attention to local codes or regulations. This will almost invariably affect a system located in a city, most of which have adopted building and plumbing codes. Where harvested rainwater is addressed in codes at all, it is often lumped with "reclaimed water." It is important to note that harvested rainwater is not the same thing as reclaimed water. Reclaimed water is by definition wastewater which has been treated to remove impurities. But because rainwater is not specifically addressed in the code, engineers typically design systems to conform with Appendix J of the Uniform Plumbing Code, which deals with reclaimed water.

Some states, such as Kentucky and Texas, encourage rainwater harvesting and have passed laws dealing with the practice. The Texas Rainwater Harvesting Evaluation Committee in November 2006 made these recommendations: 1) the state should encourage the use of harvested rainwater for non-potable indoor uses; 2) the state should encourage the use of harvesting systems for non-potable uses in conjunction with public water supplies, and 3) a certification program for rainwater harvesting system installers should be developed. Many local jurisdictions have either adopted building codes dealing with rainwater harvesting or are considering them. Tucson was the first city in the U.S. to require harvested rainwater for landscape watering. In June 2010, a code went into effect in Tucson requiring 50% of a commercial property's irrigation water to be supplied by rainwater.

The city of Portland, Oregon, recommends rainwater for non-potable uses like landscape irrigation, hose bibs, toilets and urinals. Rainwater used for outdoor irrigation only is not covered by the Portland code. Multi-family residential structures are allowed to use rainwater for irrigation purposes only. Rainwater systems for drinking water uses at individual homes are allowed only through an individual appeals process. Non-residential buildings may use harvested rainwater for irrigation and non-potable indoor uses such as toilet flushing. However, water for this use must first be filtered and disinfected. This is not the case with codes in other cities. San Francisco allows rainwater to be used for toilet flushing without being treated to potable standards (filtration and disinfection). The city of Springfield is currently amending local codes to allow for wider uses of harvested rainwater.

One concern with using non-potable harvested rainwater in buildings is the potential for cross connection with the public water supply. For this reason, any pipes carrying harvested rainwater that are brought into a building, for example for toilet flushing, need to be clearly marked or labeled to show that this water is not for drinking purposes. The Texas Manual recommends that pipes containing rainwater be painted bright orange with black lettering, saying, "Rainwater—Do Not Drink." These words should be clearly visible and stamped at two foot intervals throughout the length of the pipe. Any future owners or plumbers can easily see that these pipes should not be tapped into for "drinking" water uses, for example at a sink, shower or water fountain. More commonly, codes call for rainwater to be carried in pipes painted purple with signs at points-of-use indicating the water is not intended for human consumption.

Health codes and regulations also impact the use of harvested rainwater. Studies have shown that using harvested rainwater for non-potable uses like toilet and urinal flushing pose very low health risks to users. A study in Germany indicated that the risk of *E. coli* contact with humans from toilet flushing with rainwater was virtually non-existent. The authors of the study suggested that disinfection was therefore unnecessary for rainwater dedicated to non-potable uses.

On the other hand, some studies have shown that using harvested rainwater for drinking water purposes could pose health risks, although little information is available on the potential for microbial pathogens to be present. Investigators have found pathogenic *Salmonella*, *Legionella* and *Aeromonas* organisms in some systems using non-disinfected rainwater. Birds and small mammals on roofs or in gutters are implicated as potential sources of these organisms. Overall, the existing literature, though limited, indicates that the microbial quality of harvested rainwater should be considered potentially poor until further assessments can be undertaken. For this reason, filtration and disinfection should always be provided on drinking water systems.

Table 3
Minimum Quality and Treatment Options for Stormwater Reuse
(Source: USEPA *Rainwater Harvesting Policies*, 2008))

Use	Minimum Water Quality Guidelines	Suggested Treatment Options
Potable Indoor Uses	Total Coliforms—0 Fecal Coliforms—0 Protozoan Cysts—0 Viruses—0 Turbidity: < 1 NTU	Pre-filtration; first flush diverter Cartridge filtration—3 micron sediment filter, w/ 3 micron activated carbon filter Disinfection—chlorine residual of 0.2 ppm or UV disinfection
Non-Potable Indoor Uses	Total Coliforms <500 cfu (colony forming units) per 100 mL. Fecal Coliforms < 100 cfu per mL.	Pre-filtration; first flush diverter Cartridge filtration—5 micron sediment filter Disinfection—chlorination with household bleach or UV disinfection
Outdoor Uses	N/A	Pre-filtration; first flush diverter

Like other surface sources, rainwater will normally contain bacterial densities above the standards for drinking water unless properly filtered and disinfected. The Texas Manual suggests that total coliform levels for untreated, non-potable water should be less than 500 colony forming units per 100 milliliters, and fecal coliform less than 100. For potable uses of harvested rainwater, the Texas Manual suggests a point-of-use limit of 0 total coliform, 0 fecal coliform, 0 protozoans, 0 virus, and less than 1 NTU turbidity. The Texas Manual further recommends water should be tested at least quarterly. The table above provides USEPA recommended minimum water quality guidelines and treatment options for stormwater reuse.

Stringent rules will most likely apply in southwest Missouri if there is intent to use harvested rainwater for drinking purposes, even at the household scale. There is a good chance that the local authority will not allow harvested rainwater to be used for drinking purposes. If allowed, approved filtration and disinfection equipment will need to be utilized specifically to treat the water to drinking water quality standards. The quality of the water should be tested routinely, at least annually, as recommended for any individual drinking water supply, for example from private wells.

For many potential applications, harvested rainwater remains in a "gray" area. Specific codes for rainwater harvesting systems need to be developed in most jurisdictions. Promoters of rainwater harvesting say that code writing bodies need to adapt to the realities of today's emphasis on "green" building, and separately consider the unique attributes of rainwater harvesting systems. Jurisdictions commonly need to evaluate the potential of using lesser requirements for non-potable uses such as toilet flushing. Codes should establish acceptable uses for harvested rainwater and the appropriate treatment requirements for those particular uses.

Cases Studies

Discovery Center in Downtown Springfield

A hands-on education center, a LEED gold certified expansion project in 2006. Uses two 4200 gallon cisterns, visible to visitors, collecting rainwater from two different roof sections. Used to irrigate green roof plants and provide water for toilet flushing. Filtration of harvested rainwater with overflow to city storm drain. Make-up valve automatically brings city water into the system for use in restrooms, if harvested rainwater insufficient. Since building has been in operation in 2006, no major problems have been encountered. Filters and circulation pumps will be replaced as needed.

Watershed Center at Valley Water Mill Park, north Springfield

A 1500 gallon cistern, mounted just past entrance door and so very visible to public, collects runoff from largest section of roof. (Other roof sections flow down rain chains to rain garden or will flow over a "living wall"). Cistern water is used for flushing toilets and urinals. Valves automatically sense low water in cistern and switch to city water if water in cistern is insufficient. This water has no disinfection.

Green Circle Development

Runoff from 100% of the roof is directed into a 14,000 gallon buried cistern. Pipes inside the building are painted blue for education and identification purposes. The vegetated "green roof" also contributes water, but carries some fine sediment into the tank. The cistern has to be cleaned every few years. The water is used for toilet flushing and is connected to several irrigation spigots. Two backflow preventers protect the municipal water supply. The cistern combined with dual flush toilets, waterless urinals and sensored skinks saves about 70% of annual water consumption in the building.

Cycles Unlimited

Two roof downspouts are directed into a 3,650 gallon below ground cistern. From the cistern, water is piped through a modified PVC pipe with a standard paper inline filter, then though a "whole house filter system." The harvested rainwater is used to flush toilets in the restroom and also provides water to outside spigots. The owner changes filters four times per year.

Local Vendors

Habitat for Humanity ReStore sells 55-gallon food grade barrels of white or blue plastic for about $15. Spigot kits and diverter kits cost about $16. Barrel connectors (for overflowing water from one barrel to the next), atriums (strainer baskets fitting into the barrel inlet), and spade bits (for drilling proper sized holes in barrels) are also available.

Wickman's Garden Village, Habitat for Humanity ReStore, and Smiling Sun LLC carry systems that qualify for the instant rebate for Greene County residents. Rebates are provided by the City of Springfield, City Utilities, and Greene County Resource Management Department.

Race Brothers, West Kearney Street in Springfield; 55-gallon food grade barrels, made of white or blue plastic, for about $15. Spigot kits for barrels and diverters kits for about $16. Barrel connectors (for overflowing from one barrel to next), atriums (strainer baskets fitting into barrel inelt), and spade bits (for drilling proper sized holes in barrels) are also available.

SoMo Supply, West Kearney in Springfield; 45-gallon barrels, spigots and two-way hose diverters in kits for about $80. (Kits manufactured by Allied Precision, Elburn, Ill. 60119).

Other Sources for Water

Rainwater is not the only water alternative available to homes or businesses. There are several different "kinds" of sources to keep in mind. A home or business might have none, or might have all of these potentially available. It is important to consider which, if any, make sense for a particular setting or use. The requirements or regulations typically become more difficult from number 1 to number 4, depending on the intended final use.

1) **Condensate Water**: The most common type is condensate from air conditioning systems. On a humid summer day, a typical air conditioning system for a home can produce about ten gallons of condensate. This water usually either drips onto the ground or into a drain inside the building. This is clean water, basically produced through a process similar to distillation. In most homes, however, not enough water is produced this way to justify the expense of capturing and reusing it. However, if condensate water can be easily and cheaply conveyed into a rain barrel or cistern, there is no reason not to do this. On a commercial and industrial scale, condensate water can be a significant source, and can often be simply added to harvested rainwater to supplement this supply.

2) **Foundation Drain Water**: Many structures have subsurface drains around the perimeters of foundations to collect excess water and convey it away from the building. This is water which has been in contact with soil, so is typically of lesser quality than harvested rainwater, though it may have received some filtration through the soil. Capturing and reusing this water would typically be more difficult and expensive than harvesting condensate water or rainwater because it would have to be pumped from below ground. Depending on the final use, it may also need filtration and/or disinfection.

3) **Stormwater**: In urban areas, stormwater is often collected in detention facilities to be slowly released into local waterways, in an effort to prevent downstream flooding and/or improve water quality. Stormwater, because it has been in contact with soil and potentially contaminated urban surfaces (think of oil dripping from cars on parking lots), is usually of lesser quality than harvested rainwater. However, this water could still be beneficially reused, for example in landscape watering. There are constraints on the reuse of stormwater. Using it for non-potable indoor uses would in most cases be more difficult and complicated than using rainwater.

4) **"Gray Water" or "Black Water."**: Gray Water is by definition untreated wastewater that has not been in direct contact with human wastes. In other words, it is water coming from showers and laundries and sinks, which contains soap and dirt and bacteria but no human wastes. It does not include wastewater from kitchen sinks with garbage disposals or dishwashers, which contains a high organic load of food debris. The reuse of Gray Water in the home setting is often a "gray area" in terms of building codes and regulations. In most cases, Gray Water must receive the same type of wastewater treatment as Black Water. As stated earlier, it is best to check with local regulatory authorities about restrictions on the reuse of Gray Water. "Black water" is wastewater that contains human waste, typically from toilets and urinals. Reusing this water is the most difficult of the types mentioned, and requires special equipment and often stringent requirements to meet all codes and regulations. For this reason, most wastewater is not recycled for reuse in southwest Missouri. An exception is the treated effluent from the Southwest Wastewater Treatment Plant in Springfield, which is used as cooling water for the Southwest Power Plant.

Summary

The rainwater harvesting industry is beginning to grow again. New marketing opportunities for products and systems and services related to rainwater harvesting are opening up. It is important to remember that while this is an age-old technology, the systems of the future will need to be designed and operated more carefully to avoid contamination and cross connections and other problems. It is not the same world as it was for our grandparents and great-grandparents. But as water issues loom larger in the future, harvesting rainwater could take on added significance. In light of these circumstances, national, state and local ordinances and codes need to be updated to allow this technology to take its rightful place in our palette of available water sources. Missouri and most communities in southwest Missouri have not yet addressed this issue to any extent.

There is no reason not to harvest rainwater, at least for watering plants, landscapes and gardens. This can save on water bills and reduce pressure on the public water supply. But if rainwater is being considered for other applications, such as flushing toilets or providing drinking water for household use, it is very important to discuss this idea with local governing authorities. Putting in an "illegal" system may cause problems in the future, such as when trying to sell a home or business. But local governing authorities can also be contacted about any "rules" precluding the use of harvested rainwater. And people interested in the practice can work with these authorities to remove any roadblocks to the use of harvested water that no longer make sense.

Acknowledgments

Funding for this manual was provided by USDA-NRCS through a Conservation Innovation Grant.

The author(s) wish to thank the following people for their input into the making of this booklet: Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

WATERSHED PRESS