ALABAMA COOPERATIVE Extension SYSTEM
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UNP-26

Rainwater Harvesting for Irrigation Water

While worldwide water consumption is rising at double the rate of the population, the amount of freshwater remains at only 2.5 percent of the world's water resources. Rainfall replenishes much of the water we use; however, it is predicted that by 2025, eighteen countries will use more water than can be replenished (Credit Suisse, 2007; Clark, 2007). Climate changes occur annually, often, and in different regions of the world. Various regions will experience floods, droughts, earthquakes, or tornadoes at any one time. While little can be done about these climatic events, we can reduce their impact through planning and preparedness. Builders in California are required to adhere to building codes and build structures that can withstand low-level earthquakes. Dams and levees help prevent flooding. Rainwater collection, and storage can also reduce the impacts of drought, storm water runoff, and peak flow levels as well as reliance on ground and surface water, also lower nonpoint source pollution, allow groundwater to recharge, and promote water conservation and sustainable practices (LaBranche et al., 2007; Hicks, 2008).

Water can be conserved through proper xeriscaping (landscaping) and by choosing the ideal native plants for desired locations. The collection of storm water from parking lots and other surfaces, storage in basins, swales or other watersheds, and distribution to plant beds by predesigned French drains, berms, curbs, spillways, depressions, microbasins, and aprons will also conserve water and reduce runoff and its associated problems (Mechell, 2008; Philips, 2005; Waterfall, 2006).

Rainwater harvesting, whether it is from parking lots or rooftops, is the collection and storage of rainwater. Collected rainwater is used for domestic purposes and irrigation. In some countries, it is the only source of potable water. Rainwater is usually collected from rooftops, greenhouses, pool covers and other relatively clean surfaces. This stored water can be used for irrigation, flushing toilets, or washing cars; however, it is nonpotable and requires extensive treatment for use as tap water. Potable water purification requirements vary with state and local ordinances and must be inspected by local authorities.

Water harvesting systems can range from a simple barrel at the end of the downspout to multiple tanks buried in the ground with numerous pumps and controls. Regardless of whether you want a little water for your spring flowers or a lot for your crops, both you and your environment will benefit from harvesting rainwater. A small 10 X 10-foot surface will collect 40 to 60 gallons of water from 1 inch of rainfall. Simple nonpotable rainwater harvesting systems for your landscape, garden, or even commercial crops can be designed and installed by any homeowner or crop producer.

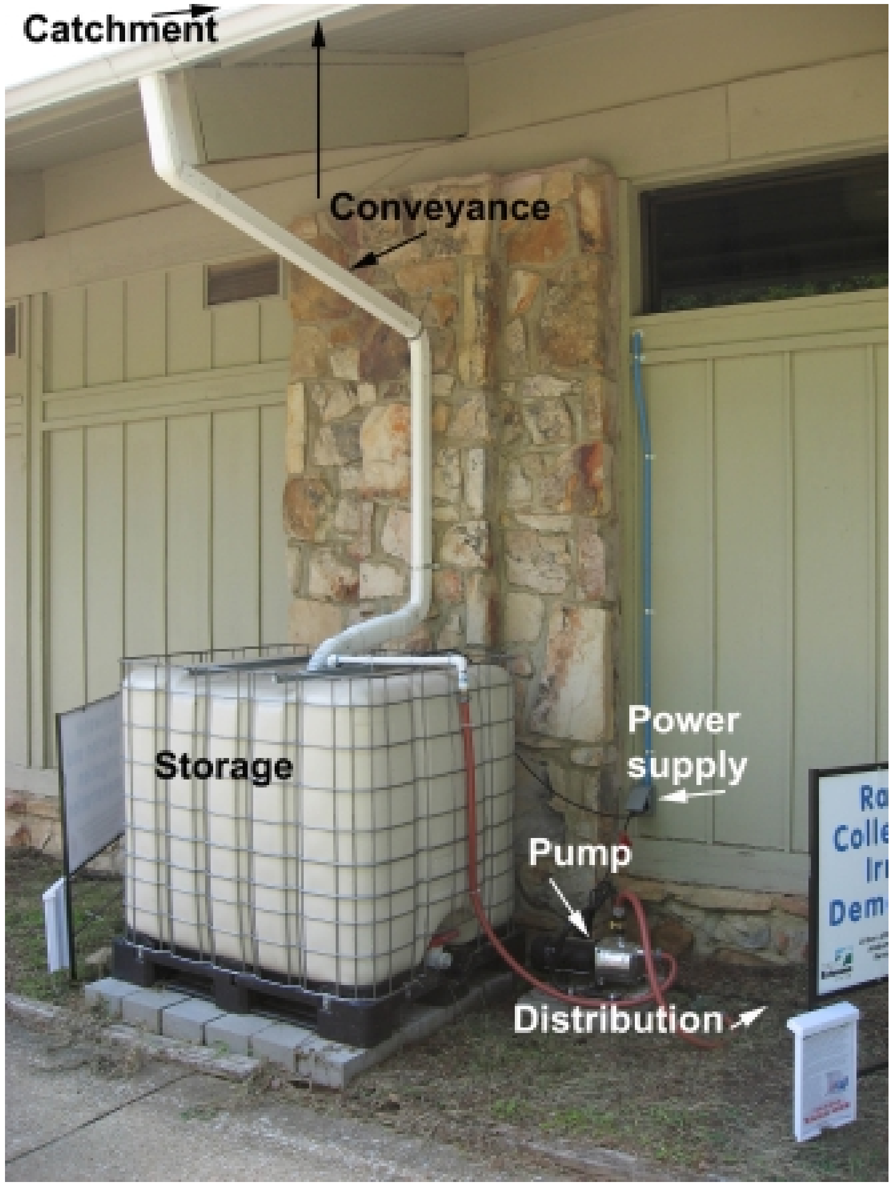

Figure 1. The catchment system is made up of a water catching surface, a conveyance system to get the water to storage, a storage container, and a method of redistribution.

Components of a Harvesting System

The system is made up of components that catch, convey, clean, store, and distribute water (Figure 1). The actual materials and methods used will vary with the catchment surface, the location and size of storage containers, and how the water will be used.

Catchment

Surfaces that can be used include roofs, greenhouses, clean and tight pool covers, and some patios and decks. Most roofing materials are acceptable for water collection. Roofing materials that contain asphalt or that have lead flashing (galvanized metal or sheet metal) should not be used if you plan to purify your water for in-home tap water. Aluminum is the best for rooftop rainwater harvesting.

Conveyance

Gutters typically collect the water from your roof or elevated deck and move it to downspouts. Downspouts can be used to deliver water to a storage tank. If your tank is above ground, you may need to remove you original downspouts. There should be a least one downspout for every 50 feet of gutter run and 1 square inch of downspout diameter per 100 square feet of roof area (2 X 3-inch downspout will support 600 square feet of roof area).

If you only have one storage tank, all of the downspouts will need to be connected to a 4-inch line that runs to the tank. Sharp bends in the line that lead to the storage tank should be avoided. You may just prefer to put a rain barrel or other container under each downspout.

Other types of catchment, such as pool covers or other surfaces, can be used but will require construction of a collection/conveyance system or a small sump pump that can be used to transfer the water to a tank. Structures, such as a quonset-shaped greenhouse, will require a gutter system at the hip board or at the lower roofline if the greenhouse has a peaked or rounded roof with vertical sides. You can purchase flexible downspouts, gutter extensions, drainage pipe, and connectors at most stores carrying plumbing and landscaping materials.

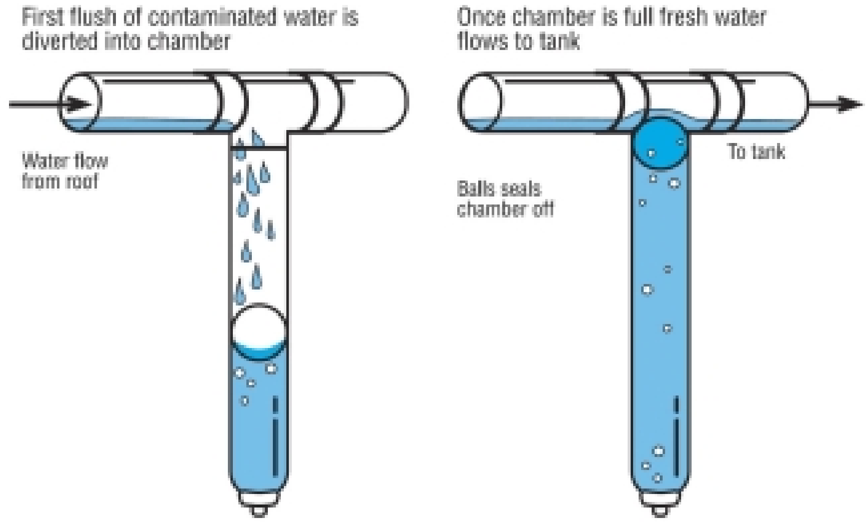

Figure 2. A first flush diverter removes the initial flush of water from the catchment surface so it does not end up in the storage tank. The size of the diverter tube should be proportionate to the catchment surface.

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Cleaning the Water

Dust, bird droppings, and tree droppings such as acorns, samaras, branches, or leaves can accumulate on the roof and other catchment surfaces between rain events. A first flush diverter (Figure 2) is a pipe that tees off the main line, catches the first flush of water, and has a plug or trickle drain on the bottom. Once this pipe fills up with the initial dirty water, the remaining water bypasses the pipe and runs directly to the storage container. The plug at the end of the first flush diverter should be removed and the pipe drained after each rainfall event or, if there is a trickle tube, the water will slowly clear from the tube.

Diverter tubes should redirect 0.1 to 0.5 gallons of water per 10 square feet of roof surface. For example, if you have 100 square feet of catchment surface and want to redirect 0.1 gallons of water per 10 square feet of roof, you will need to divert 10 gallons of flush water. This would require a 6-inch PVC line 6.8 feet long. The calculation is as shown in the box below.

Other downspout filters called a "leaf beater," "leaf eater," or "roof washer," depending on the source, can be placed in the downspout (Figure 3, next page) above the first flush diverter. The purpose is to remove large objects like

Volume = π x r^2 X length of tube

Length of tube = volume/(π X r^2)

10 gallons = 2,310 cubic inches of water (1 cubic inch = .004329 gallons). You must convert gallons into cubic inches to put all units in inches.

π = 3.142

r^2 = the radius of the pipe squared (a 6-inch PVC pipe has a radius of 3 or 9 inches squared)

2,310 cubic inches = 3.142 X 9 square inches X length of tube (inches)

2,310/(3.142 X 9) = 81.7 inches or 6.8 feet of 6-inch PVC pipe leaves and acorns from the water source prior to entering the first flush diverter. If your gutters are covered, a roof washer will probably be unnecessary. If you use trickle or drip irrigation, you should put in an inline filter after the pump (Figure 4). This will remove sediment that clogs trickle tubes and drip lines. The filter's screen size should be at least a 200 mesh. Remember, the larger the mesh size, the finer the screen.

If rainwater enters the tank at the manway or top hole, the end of the downspout should be covered with 1/4-inch or smaller hardware cloth or a screened basket (Figure 5) should be placed in the manway entrance to reduce the amount of organic matter that enters the tank. The hardware cloth should be connected in a way that allows for easy removal for cleaning out debris. Other options include roof washers that screen the water prior to it entering the collection tank.

Figure 3. The leaf beater and first flush diverter (left) as a unit and installed into a home catchment system (center). The leaf beater removes leaves and large objects from the water flow before the water enters the first flush diverter (right).

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Figure 4. An inline filter can reduce sediment that will clog trickle and drip irrigation lines. The valve at the bottom allows you to drain sediment and the plastic casing screws off to give you access to the screen filter.

Water Use

Before discussing storage, it is appropriate to determine how you will use your water and how much you will need to store. This is a difficult concept because everyone's lot size and landscape content is different. The size of your catchment area and your irrigation methods will also be important in estimating tank size. Your water needs may vary with weather conditions, plant water requirements, soil type, sun or shade conditions, exposure to sun-

Figure 5. A screened basket in the manway hole will prevent a lot of organic matter and mosquitoes from entering the tank.

north, south, east, or west side of a structure, and variety or cultivar. In drought conditions, categorize your plants into groups based on water requirements. Plants such as gardenias, azaleas, rhododendrons, annuals, vegetables, and fruit trees have high water requirements for survival and/or fruit or vegetable production. You may also want to group your most valuable plants. Priorities should include trees that define your landscape, heir-loom plants that cannot be replaced, and mature plants that are massed and of the same size (Waterfall, 2004).

Irrigation for approximately 2,000 square feet will require about 2,000 gallons per month or more to maintain when using conservative irrigation methods (drip-and-trickle-type irrigation). Typical landscapes do not exceed 1,000 square feet of plants (excluding bed space with no plants). However, if you plan to use the system to maintain a lawn or turf, you will have a much larger landscape area and need a larger tank.

Commercial or garden crops such as vegetables, fruits, or nursery plants are most often watered with trickle or drip hoses. Rows totaling 2,000 feet in length would require 2,000 gallons or more per week if providing about 1 inch of water per week.

You can determine what the anticipated monthly rainfall should be for your area by going online to http://www.city-data.com/city/Huntsville-Alabama.html and replacing Huntsville-Alabama with your city and state. Be careful not to remove the dash between city and state. Knowing how much rainfall is anticipated will help you calculate how much it contributes to your water needs. For example, if you need to water a crop 1 inch per week in June and the average rainfall was 5 inches for that month, you probably will not need to water. Your storage needs for that month will be zero. Of course, all 5 inches could have been from a single rain event, but that is rare. Subtract the water needs (-gallons) from the rainfall amounts (+gallons), and that will provide you with the balance amount of water you will need to store (Table 1). Based on this information, you will need a minimum 5,300-gallon tank. This is determined from the "Balance" figure shown for May, after which the water in the tank was depleted during the months of June, July, August, and September. The minimum tank size is obtained by taking the largest balance and subtracting the smallest balance from it [if the smallest balance is negative, that means that you add it]. For example using Table 1 data, the formula would be:

5,241 - (-75) = 5,316

therefore, a minimum 5,300-gallon tank would be needed.

Storage

Storage tanks can be made of almost any nontoxic material; however, be cautious about what was stored in them. You can use "never-used" lined fuel tanks, precast fiberglass, polyethylene, or even concrete, such as septic tanks (Figure 6). Large polyethylene tanks with wire frames are used for sugar derivatives, are inexpensive, and can be rinsed and reused for water storage.

If you plan to bury the tank, be sure it is built for in-ground use. The tank inlet and outlet should be designed so that minimal

Figure 6. Large polyethylene tanks in various shapes and sizes can be used for storage of water, as long as the material and prior contents were nontoxic. Above ground tanks should be painted black or green.

sediment in the bottom of the tank is disturbed. You can purchase calming inlets that disperse the water in an upward direction. Large buried tanks should have a manhole, a vent, a cleanout sump pump, and an overflow pipe. Aboveground tanks should have a drain at the bottom and an overflow pipe if the water line coming into the tank is tightly fit.

Aboveground tanks should be purchased in dark green or black to prevent light penetration, or they should be painted a dark color prior to installation. If in-ground tanks are completely covered, tank color is not an issue.

Table 1.
Water Collection From Rainfall and Water Use by Irrigation (based on a 500-square-foot collection surface and 2,000 square feet of vegetable crops grown from March through mid-November)

Month	Rain (inches)	+ Gallons from Rain[1,2]	- Gallons from Irrigation[3]	Balance
January	3.6	1,060	0	1,060
February	3.3	972	0	2,032
March	4.36	1,284	250	3,066
April	3.98	1,172	1,000	3,238
May	5.1	1,502	1,000	5,241
June	1.61	474	2,000	3,715
July	2.34	689	2,000	2,404
August	4.03	1,187	2,000	1,591
September	1.26	371	2,000	-38
October	3.27	963	1,000	-75
November	2.78	819	500	244
December	1.74	512	0	756

[1]*Rainfall (inches) x catchment surface (square feet) x 0.62 x percent collection efficiency=gallons collected.* Collection efficiency is affected by leaks, wind, rainfall rate, etc. During a slow gentle rain, with no leaks in the system, collection efficiency is about 95 percent. During a very fast, heavy rain, the efficiency would be closer to 60-75 percent because gutters overflow and gutter covers are overrun with water.

[2]The total collected has not had first flush diverter water deducted. Generally the first 5 gallons/100 sq ft of catchment area, of each rain event, is roof wash water that is flushed.

[3]This takes into account that the actual rainfall events contribute to the irrigation needs of the plants. However, rainfall is rarely spaced evenly throughout a month and irrigation may be needed all four weeks. Also, the late summer months have a higher evapotranspiration rate and require longer, more frequent watering.

Tank placement depends on space and resources. It is very expensive to bury a tank, and in many locations where it is rocky or the ground water is high, it is not feasible. There are many tank sizes and shapes that can be hidden by shrubbery or placed near the house wall.

Metal, fiberglass, and concrete storage tanks will tolerate cold and warm temperatures. However, plastic tanks come in several grades and polymers. Tanks constructed using homopolymers should not be used for water catchment tanks (Schultz, 2008). Check with your vendor to be sure the tank is made of high-density polyethylene. This material will tolerate greater temperature extremes. Lesser grades of polymer tanks will become brittle and crack as water freezes and thaws and if temperatures are extremely cold. All tanks, regardless of type, should have a domed top or an overflow pipe below the top of the tank to provide head space and to allow for the expansion of water as it freezes.

The size of your tank can be determined by considering several factors:

- Space available
- Resources/desire to bury the tank
- Roof size
- Use/need

If space is not a limiting factor, the primary concern should be how much water you will need and when (Table 1). If you collect water from a large roof surface, 1,500 to 2,000 square feet for example, you will fill a 1,500-gallon tank with a 2-inch rainfall. If you are collecting water for in-home use, outdoor use, or for commercial crops, you will need a 5,000-gallon or larger tank. If you have been purchasing water to irrigate your landscape or crops, you can average your winter bills, typically December, January, and February to determine household use. Since water meters and bills report water use in cubic feet, multiply this number by 748 to get gallons. Subtract the winter average from your monthly bills to determine monthly outdoor water use (Table 2, next page). Tank size requirements will depend on rainfall recharge rates.

For nonpotable, toilet flushing, determine the number of household members and the flush volume of your toilets. Generally, each person flushes five times a day, and a typical tank uses 1.6 gallons. In a four-person home, water use for flushing is about 32 gallons a day or 960 gallons a month. Using Table 1 as an example of how much raninwater can be collected monthly, put 960 in each row of the -gallons column. A 1,700 gallon tank would provide enough water for year-round flushing. If you have the resources to bury large tanks, they should be placed close to the water source. However, this may require extensive plumbing to the production site for crop producers.

Distribution

Unless your collection tank is 20 to 30 feet above where you will be watering, you will need a pump to distribute the water from the tank to your landscape or crops. There are several pumps that work well with this system. One-quarter to one and one-half horsepower irrigation pumps will provide enough pressure for most drip and trickle systems (Figures 7 and 8). "Irrigation," "lawn," or "shallow well" pumps can be used without bladder tanks. A tether switch can be placed in the tanks to turn off the pump when the water level is low (Figure 8). If your tank is not close to an electrical source, a gasoline-powered pump can be used.

When connecting the pump to the tank, the plumbing can include a floating filter located at the end of the pump's suction hose. This will reduce the amount of soil sediment sucked into the pump and inline filters. You can also use a foot valve at the bottom of the outflow line if it is placed a few inches above the bottom of the tank; however, you will still need an inline filter.

Pressure tanks hold a set volume of water that is pumped into the bladder. When the valve is opened, pressure pushes out the water. A pressure-sensitive pump should be used with a pressure tank. A pressure-sensitive pump turns on when pressure decline is detected. It shuts off when a specific pressure is reached. Most pressure-sensitive

Table 2.
Sample Monthly Demand for Water Use if You Pay to Irrigate Water

Sample Monthly Demand			
Large Garden/Small commercial Crop Production Average Winter Use = 8.9 CCF[1], Household Size = 4			
Month	**Monthly Use**	**Average Winter Use**	**Landscape Use**
January	6,732	6,679	0
February	5,986	6,679	0
March	7,945	6,679	1,266
April	8,361	6,679	1,682
May	8,520	6,679	1,841
June	10,620	6,679	3,941
July	14,560	6,679	7,881
August	16,521	6,679	9,842
September	12,330	6,679	5,651
October	10,253	6,679	3,574
November	8,694	6,679	2,015
December	7,320	6,679	0

[1] CCF=100 Cubic Feet of Water. Water bills usually report usage in 100 cubic feet units. One hundred cubic feet of water equals 748 gallons.

Figure 7. This 1.5 hp pump is used to irrigate shiitake mushrooms and 1/2 acre of organic vegetables using a mist system and soaker hoses.

Figure 8. A 1 hp pump (left) will provide enough water to irrigate a home landscape and garden if trickle and drip irrigation are used. The pipe on the right has a foot valve at the bottom (closest end to you) and the black cylindrical-shaped object is a tether float switch. The black cord (attached to the tether float switch) at the far end of the pipe plugs into an outlet and the pump plugs into this cord. When the black float drops vertically due to lack of water, it will turn off the power to the pump.

pumps are not submersible, and they are more expensive. However, pressure tanks must be protected from freezing temperatures and placed in a structure. Pressure or bladder tanks are more commonly used under the house when catchment water supplements toilet water.

An inline pump controller is an optional part that is screwed directly onto the existing pump and water line. It will detect pressure changes and turns on the pump when pressure is low. Some units can even detect if the tank is out of water and will turn off the pump so it will not burn out (Pushard, 2004).

Pump size requirements are based on volume of water needed at any one time, pressure requirements, distance the water must travel (run), and the rise required to get the water out of tank and to the irrigation site. Most manufacturers provide this information on the box or in the pump instruction book.

Figure 9. These small mist heads reduce the water pressure and volume needed to keep the shiitake mushroom logs moist throughout the year.

Irrigation

Your method of irrigation will determine pump size and other distribution equipment needed. If you plan to hand water with a hose, a smaller pump can be used. Irrigation of lawns and large areas with sprinklers will require larger pumps, depending on the sprinkler head and distance and slope the water must traverse. Trickle and drip irrigation are the most efficient systems for beds and crop production (Figure 9).

These systems will require the installation of a pressure regulator and an inline filter (Figure 4). The shiitake mushroom logs shown in Figure 9 have a mister head at the top of each riser; this provides a fine mist to wet the burlap and increase the humidity under the burlap.

Cost of the System

We have constructed a small, tank system for under $400 (see Figure 1) and 1,500-gallon systems for commercial crops that cost about $3,000, not including the irrigation lines. Your system costs will depend on whether you need some or all of the following:

- Gutters
- Downspouts
- Tank
  - Above ground or in-ground
  - Size
  - Tank material (polyethylene, fiberglass, metal, concrete)
- Pump
  - Rise of land to irrigation site
  - Lift (if water must be raised out of the tank)
  - Run (greater distances reduce pressure)
  - Pressure tank
- Filtration
  - Leaf collection
  - First flush diverter
  - Insect screens
  - Inline filters
  - Floating filter
- Plumbing-pipes and fittings
- Irrigation supplies

System Design

There are several steps involved in creating a suitable rainwater collection system. There are also numerous solutions and methods you can use to create a system.

For best results, consider the following steps:

1. Ensure that the catchment surface is suitable for collecting quality rainwater.
2. Ensure roof gutters are installed to the appropriate standards according to the regulation fall and number of outlets.
3. Install a fireproof mesh or gutter cover system to prevent leaves and debris from blocking outlets.
4. Fit gutter outlets under the roof gutter to prevent sludge buildup.
5. Fit rain head to gutters to divert leaves and debris. Use a screen with less than 1 millimeter apertures to reduce mosquito infestations.
6. Fit insect proof screens to all pipes that hold water and all pipes and openings to and from the tank.
7. Fit appropriately sized first flush water diverters. Diverter tubes should redirect 0.1 to 0.5 gallons per 10 square feet of roof surface.
8. Select an appropriate tank based on collection area, rainfall, water use, and climate.
9. Choose a pump that provides sufficient pressure for desired lift, rise, and run of the water lines and type of irrigation system.
10. Draw water from the highest point in the tank possible. Floating outflow filtration systems will do this best.
11. Ensure the system is maintained. Service gutters, rain heads, water diverters, tanks, and pumps regularly.
12. Insulate and protect all water lines and pumps from freezing temperatures.
13. Check local ordinances and tax laws to see if you can get tax credits or rebates for installation of your system.

(Adapted with permission from Rain Harvesting Pty Ltd. www.rainharvesting.com)

Product Suppliers

There are numerous suppliers available via the Internet for construction materials. Note that local suppliers can also be a good resource for construction materials.

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Resources

The following publications provide extensive details about the information presented here and can be obtained online:

Virginia Rainwater Harvesting Manual
http://www.cabellbrandcenter.org/Virginia%20Rainwater%20Harvesting%20Manual.pdf

Rainwater Harvesting
http://rainwaterharvesting.tamu.edu/publications.html

The Texas Manual on Rainwater Harvesting (3rd ed.)
http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf

Harvesting Rainwater For Landscape Use
http://cals.arizona.edu/pubs/water/az1344.pdf

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Questions regarding rainwater collection should be directed to your county Extension agent.

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