RAINWATER HARVESTING

Rainwater harvesting refers to the collection and storage of rain from roofs or other surface areas for future use. This low-impact development (LID) technique stores rainwater that would otherwise be lost as runoff by being diverted into storm drains and streams. The captured water is generally stored in tanks or directed into structures that recharge groundwater. Rain barrels and cisterns are the most commonly used storage devices.

How does rain harvesting work?

Rainwater flows off a roof, through a downspout, and into a rain barrel or cistern where it is stored for future use.

Rain barrels are typically situated upslope or on a raised surface above the site where the water will be used. A spigot is located near the bottom of the barrel. When the spigot is turned on, water that has been stored flows via gravity out of the spigot, through a hose, and onto the site. Drip irrigation systems can be used so that water is released slowly over time.

Rain cisterns generally require an electric pump for distribution due to their large size and larger usage area. If at any point the maximum storage capacity of a barrel or cistern is reached, excess water will flow out of the storage unit through an overflow pipe. Open-bottom cisterns, which allow for the gradual infiltration of water into the ground, provide an alternative to regular rain cisterns.

Rain barrels

Rain barrels vary in size, but 55- and 80-gallon barrels are most commonly used. Because of their small storage capacity, rain barrels are used almost exclusively on residential sites. Most barrels are made of plastic. Water stored in rain barrels is typically used to irrigate lawns, landscapes, or gardens.

Rain cisterns

Rain cisterns are larger than rain barrels and vary greatly in size, from 200 to 10,000 gallons. Because they come in a variety of sizes, cisterns can be incorporated into both residential and commercial sites. Cisterns can be made from a variety of materials, including fiberglass, polyethylene, metal, or concrete. Certain materials allow the cistern to be partially or fully buried in the ground. Water stored in rain cisterns is often used for irrigation but has the potential for indoor reuse.

Stormwater Benefits

- ✓ Runoff quantity control
- ✓ Groundwater recharge

Additional Benefits

- ✓ Cost savings
- ✓ Reduction in public water supply usage
- ✓ Educational potential

Residential rain barrel

In-ground polyethylene cistern

CONTENTS

DESIGN COMPONENTS

Roof System

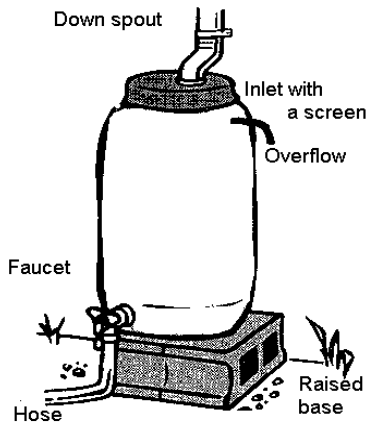
It is important to consider the material of the roof or catchment surface when installing rainwater harvesting components. Roof material, in addition to climatic conditions and the surrounding environment, can have a significant effect on the amount and quality of runoff. The following table lists some common roofing materials and the advantages and disadvantages of each.

Roof Material	Advantages	Disadvantages
Metal	• Suitable for potable and non-potable uses • Smooth surface allows for high quantity of runoff to be collected	• Roofs with copper flashings can cause discoloration of porcelain fixtures
Concrete/Clay Tiles	• Suitable for potable or non-potable uses	• Approximately 10% loss in quantity due to texture, inefficient flow, or evaporation • To reduce loss and prevent bacterial growth, tiles can be sealed or painted; increased chance toxins will leach from the paint or sealant
Composite or Asphalt Shingle	• Suitable for irrigation	• Presence of toxins prevents use in potable systems • Approximately 10% loss in quantity due to inefficient flow or evaporation
Slate	• Smooth surface ideal for rain harvesting (assuming no sealant used)	• High cost
Wood, Shingle, Tar, Gravel	• Suitable for irrigation	• Presence of toxins prevents use in potable systems

Adapted from **Texas Manual on Rainwater Harvesting**

Rain Barrels

Rain barrels are typically made of plastic with standard storage capacities of 55 or 80 gallons per barrel. Rain barrels can be made of wood, but these are often more expensive. Stored rainwater can be used to irrigate landscapes or to wash cars or windows.



Source: Missouri River Communities Network

Standard Rain Barrel Design

Additional Rain Barrel Components

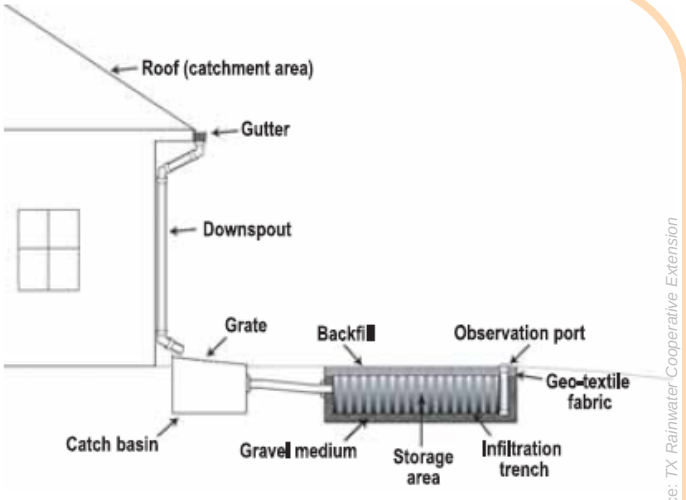
- **Downspout Filter**

  A downspout filter, sometimes called a leaf screen, is usually placed near the top of the downspout to prevent leaves and large debris from entering the barrel. The filter typically consists of a perforated collection container that prevents debris from passing through while allowing water to continue down the downspout. Most downspout filters require manual cleaning and should be checked regularly.

- **Downspout Diverter (optional)**
  A downspout diverter is a curved or jointed pipe that directs water from the downspout to the barrel when shrubbery or landscaping material prevents the barrel from being placed directly below the downspout. When the rain barrel has reached capacity, some diverters can direct excess water out of the downspout and onto the landscape, instead of relying on the barrel's overflow pipe.
- **Secure Cover**
  A secure but removable lid should be placed on top of the barrel to keep pests out but still allow easy access for cleaning.
- **Inlet Screen**
  A small screen is placed at the inlet of the barrel where water from the downspout enters the barrel. This screen reduces the amount of particulate matter entering the barrel. It also reduces the risk of mosquito breeding within the barrel.
- **Irrigation Hook-up (Spigot)**
  The irrigation hook-up allows for a hose to be attached to the barrel so that water can be distributed on the lawn, landscape, or garden. A drip irrigation system can be used so that water is released slowly over time.
- **Overflow Pipe**
  An overflow pipe, located near the top of the barrel, directs excess water out of the barrel. This water is often directed via hose to the landscape or to a nearby rain garden or bioretention area. In some cases, excess water is directed to a traditional stormwater conveyance system.
- **Linking Kit and Additional Barrel**
  A second barrel may be attached to the first barrel via a connecting hose to provide additional storage capacity. Overflow from the first barrel will be directed to the second.

Rain Cisterns

Rain cisterns vary in size and material. Storage capacity ranges from 200 gallons to 10,000 gallons. In-ground cisterns may be made of fiberglass, in-ground polyethylene, concrete, and ferro-cement. Above-ground cisterns can be made of any of the in-ground materials, plus regular polyethylene, metal, or wood.



Source: TX Rainwater Cooperative Extension

Rain Harvesting System with Open-Bottom Cistern

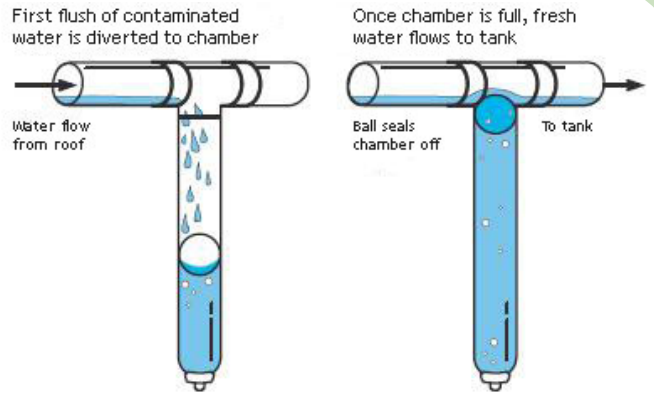
Open-Bottom Rain Cisterns

Open-bottom cisterns, sometimes called soil storage and infiltration systems, work much like regular underground cisterns in that they capture rain and direct it to underground tanks. Instead of storing water for reuse, however, open-bottom cisterns are designed so that water can pass through them into underground trenches where the water gradually infiltrates the ground. Because adequate infiltration is essential to the proper functioning of open-bottom cisterns, these systems should not be constructed in heavy clay soils. The most commonly used storage and infiltration system is a gravel trench with perforated pipe. Other systems include leaching chambers and polystyrene media trenches. More information about soil storage and infiltration systems may be found in the Texas Rainwater Cooperative Extension Rainwater Harvesting: Soil Storage and Infiltration System PDF.

Additional Cistern Components

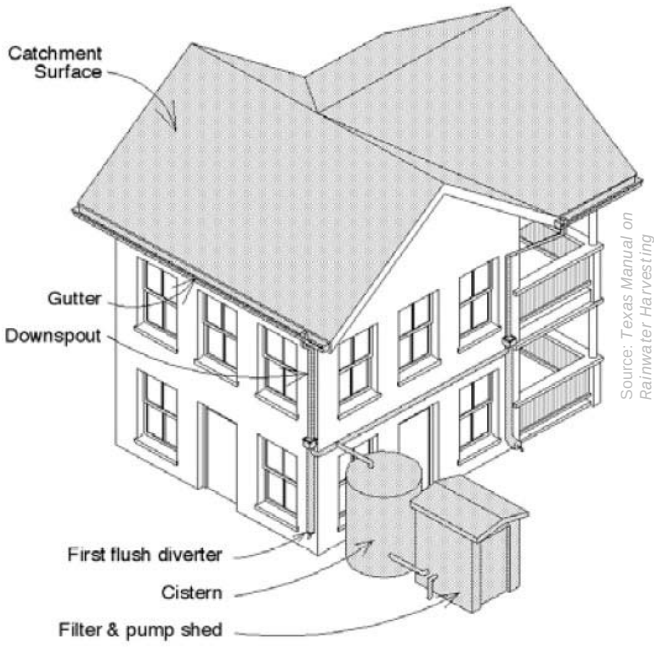
- **Downspout Filter**
  Same as rain barrel.
- **Secure Cover**
  Same as rain barrel.
- **Inlet Screen**
  Same as rain barrel.
- **Irrigation Hook-up (Spigot)**
  Same as rain barrel.
- **First-Flush Diverter (optional)**
  A first-flush diverter routes the first flow of water from the roof or catchment surface away from the cistern, removing contaminants, such as dust, pollen, and animal feces, that the leaf screen cannot filter. The most common type of first-flush diverter is the ball and seat system, which can be mounted within the downspout, on a post, wall, or stand, or underground, depending on the size and type of rain harvesting system being used.

  When rainfall starts, the initial flow is directed off the roof into the first-flush diverter, a small chamber holding a ball. As the chamber fills, the ball within the chamber floats upward. Once the ball reaches the top, it blocks the entrance. Any additional rainfall follows the regular path through the downspout and into the barrel. The contaminated water in the chamber is released after a rainfall by a slow-release valve. The first-flush water may be directed to a planting area.



Source: RainHarvesting.com

First-Flush Diverter
Ball-and-Seat System



Source: Texas Manual on Rainwater Harvesting

Rain Harvesting System with
Above-Ground Cistern

- **Extraction System**
  Water is extracted from the cistern for use via a traditional pump system or an on-demand pump-system. The traditional pump system utilizes a pump, pressure switch, and check-valve to draw water from the cistern, pressurize it, and store it in a pressure tank until it is needed. The on-demand pump combines a pump, motor, controller, and check-valve in one unit, eliminating the need for a pressure tank. On-demand tanks are designed to activate in response to a demand for water. It is important to ensure that whatever pump is used does not contaminate the water.
- **Overflow Pipe**
  Same as rain barrel.
- **Soak-away**
  A soak-away is dug next to the cistern to absorb any water that happens to spill out of the overflow pipe or over the top of the cistern. The soak-away may either be constructed by digging a hole in the ground and filling it with course stones or it may be a pre-made concrete or plastic system.

Integral Solutions Group
Spartanburg, South Carolina

In 2004, Integral Solutions Group (ISG) of Spartanburg, SC installed a rainwater harvesting system on the ISG site. With a rooftop area of about 18,000 square feet, the estimated harvesting potential of the ISG building is roughly 12,000 gallons of water for every one inch of rain. Based on this number and the amount of water needed to maintain their landscape, ISG decided to install a 20,000 gallon underground cistern. Although the system had a higher cost up-front, reduced water consumption has led to long-term savings. Since the cistern's installation, ISG has only had to rely on public water once, for only a few weeks during a period of drought. In addition, because water from the rooftop is stored instead of being directed to stormwater structures, the burden on the public stormwater system is reduced. Only minimal maintenance is required for the underground tank and pump. Thus far, ISG has been very satisfied with their rain harvesting system.

- **Filtration/Purification System (Optional)**
  A filtration system us necessary if the collected water is to be used as a potable water source. Several types of filter systems may be used. The most popular system is composed of two sediment filters and an ultraviolet (UV) light that first filters the water and then purifies it with the UV light. Other systems use ozone, reverse osmosis, or chlorination.
- **Manhole, Sump, and Drain**
  The manhole provides an entrance to the cistern so that the cistern may be periodically inspected and cleaned. The sump and drain remove the water so that such inspections and cleaning can take place.

"Design Components" adapted from the Texas Manual on Rainwater Harvesting **and** LID Center, Inc.

BENEFITS

Runoff Quantity Control

Rain barrels and cisterns can reduce stormwater runoff volume by storing water for later use. Without rainwater harvesting devices, rainwater flows off roofs and is directed to traditional stormwater conveyance systems. Rain barrels and cisterns temporarily store rainwater before using it to irrigate plants or wash cars. Such reuse reduces the size of, and need for, traditional stormwater conveyance systems and reduces the impact to water bodies.

Groundwater Recharge

Rainwater harvesting offers the potential stormwater management benefit of restoring groundwater supply. Stormwater runoff that would otherwise be directed to the traditional stormwater conveyance system can, instead, be used for irrigation. The use of captured stormwater on the landscape helps recharge groundwater, which in turn supplies drinking water and recharges surface water flow during periods of drought.

Cost Savings

Rain harvesting can potentially lower water bills because it is a safe source of water for irrigation and other non-potable uses. When rainwater is used to irrigate lawns or wash cars, less public water must be purchased. As a result, those who use rainwater harvesting may experience a reduction in their water bills.

Decreased Burden on Municipal Water

When homeowners or commercial businesses use stored rainwater for irrigation or as a potable water source, the demand for public water is reduced. This is especially beneficial to municipal water providers in drier seasons when water quantities are limited. In addition, because runoff quantity is reduced, there is less stress on municipal drainage systems during peak flow periods.

"Benefits" adapted from the Massachusetts Low Impact Development Toolkit

SITE CONSIDERATIONS

	Rain Barrel	Above-ground cistern	In-ground cistern
Dimensions (can vary somewhat)	Average 55 gallon barrel (3.3' tall x 1.9' diameter)	Smaller (205 gallons): 3.5' diameter, 5' high Larger (10,000 gallons): 13.5' high, 11' diameter	Smaller (325 gallons): 4' long x 4' wide x 4' high Larger (75,000 gallons): 76' long x 13' diameter
Soils	Drainage must be considered for overflow (drain to landscape, rain garden, bioretention cell, dry well)	Not typically a factor unless using an open-bottom cistern	Clay soils must be properly prepared before installation (adding a gravel foundation provides strength and drainage)
Slopes	Place up-slope or on raised surface so reuse can occur via gravity	Try to place up-slope so reuse can occur via gravity, but a pump is usually necessary for distribution	Try to place up-slope so reuse can occur via gravity, but a pump is usually necessary for distribution
Depth to water table	Not a factor	Not a factor	Higher water tables reduce the burial depth; 2,000-5,000 gallon cisterns generally accommodate a six-foot water table; larger cisterns (75,000 gallons) can accommodate a five-foot water table but must be secured
Depth to bedrock	Not a factor	Not a factor	Avoid placement close to bedrock; if unavoidable, blasting can be used to make hole
Proximity to foundation	Not a factor	Allow space for leakage to occur so that foundation will not be harmed	Allow space for leakage to occur so that foundation will not be harmed
Distance to septic tanks	Not a factor	Minimum of 100 feet recommended; locate cistern such that overflow does not enter septic system drainfield	Minimum of 100 feet recommended; place cistern up-slope so that septic or drainage field leakage will not infiltrate cistern water
Product material	Plastic Wood Metal	Fiberglass Polyethylene Wood Metal Concrete Ferro-cement	Fiberglass In-ground polyethylene Concrete Ferro-cement

Information adapted from LID Center, Inc., Texas Manual on Rainwater Harvesting

Residential Rain Barrels
North Kingstown, Rhode Island

This Rhode Island residence has incorporated two 54-gallon rain barrels on site to collect rainwater. Overflow from the first barrel is directed through a connecting hose to the second barrel, doubling the storage capacity for rainwater. Both barrels are located on raised platforms so that water can irrigate nearby plants with the help of gravity. Garden hoses are attached to each barrel's faucet so that the water can be used for irrigation. Soaker hoses, providing low-pressure and low-volume watering, can also be attached to the barrels. Soaker hoses reduce water loss due to wind and evaporation by watering plants close to the root zone.

MAINTENANCE

	Rain barrel or cistern
Roof catchment	Ensure no particulate matter is blocking the gutter or downspout
Gutters	Ensure there are no leaks or obstructions
Downspouts	Ensure there are no leaks or obstructions
Entrance of barrel/cistern	Ensure there are no leaks or obstructions
Barrel or cistern	Barrel: Check for leaks, especially at the top and seals Cistern: Check for leaks, ensure the inflow and outflow work properly, clean unit out during the dry part of the year
Runoff/overflow pipe	Check that the overflow is draining properly and in a non-erosive manner
Spigot	Ensure proper functioning
Cistern screen	Make sure the screen is clear of debris and has no major holes

*Cistern/barrel and all constituent parts should be inspected at least twice a year

Information adapted from LID Center, Inc.

BARREL OR CISTERN SIZE

Site	Recommendation
• **Typical home**	• **55- or 80-gallon rain barrel(s) recommended** • Locate areas around house where water will be reused (to irrigate landscape, wash cars, etc.) and place barrels at downspouts nearest these locations. • To increase storage capacity at each downspout, link two or more barrels together.
• **New home**	• **55- or 80-gallon rain barrel(s) recommended** • You may want to determine your harvesting potential while in the planning phase in order to design a system that maximizes reuse. See information below about calculating rain harvesting potential. Otherwise, follow recommendations for typical home.
• **Residential, commercial, or municipal sites with extensive irrigation needs or desire for indoor reuse** • **Multiple houses sharing harvested water**	• **Cistern recommended** • **To determine cistern size, you will want to know your:** o **Rainwater capture potential (water supply)** - Based on roof area and average annual amount of rainfall - Innovative Water Solutions† has a simple rainwater calculator to help you determine your annual capture potential o **Intended end use (water demand)** - Amount of harvested rainwater to be used for irrigation, indoor reuse, etc. - The online Rain Barrel Guide† has instructions on how to calculate your water demand using old water bills • For more information about sizing rain cisterns, please see Chapter Four of the Texas Manual on Rainwater Harvesting* †See "Additional Links" section of this fact sheet for html address.

*Remember: The volume of water that can be captured and stored (supply) must equal or exceed the volume of water used (demand). Cistern capacity should be capable of storing enough water to last through the longest expected interval without rain.

RAIN BARRELS

The small storage capacity of rain barrels (55-80 gallons) makes them ideal for single residences. Two or more barrels may be linked together to provide additional storage capacity.

RAIN CISTERNS

The large storage capacity of rain cisterns (200-75,000 gallons) makes them ideal for commercial sites or for sharing among multiple residential lots.

COST ESTIMATES

Rain Barrels

The following table presents cost estimates for typical pre-manufactured rain barrels and additional components. Cost of installing the rain barrel is not included.

Item	Cost Estimate
Rain Barrel	
50-60 gallon	$60-190
80-100 gallon	$150-300
Additional Components	
Downspout Filter	$20-60
Downspout Diverter (optional)	$20-40
Linking Kit for Additional Barrel (optional)	$13-20
Total Cost Estimate	**$80-420**

Residential Rain Cistern
Portland, Oregon

This 1,500-gallon cistern and all of the additional components cost less than $1,500. Additional components for this particular system include a pressurizing pump and pressure tank, plastic piping, two particulate filters, a first-flush diverter, and a water meter. Periodic cleaning of the gutters and cistern screens is necessary for maintaining the cistern. The tank is cleaned annually during the dry season.

Build-Your-Own Rain Barrel

The following table presents sample cost estimates for the parts and materials needed for building your own rain barrel. Please note that rain barrels can be constructed out of a variety of materials, so prices may vary considerably. Alternative supply lists, prices, and instructions for building your own rain barrel may be found online (See "Additional Links").

Item	Item Description	Cost per Barrel ($)	Total Cost ($)of Supplies
Barrel	55-gallon food grade drum	$18.00	$18.00
Mesh Screen*	Insect screening (roll)	$0.25*	$10.00*
½" Plastic Faucet	Acetal sink faucet (PVC)	$2.99	$2.99
Steel Washer	¾" Flat Steel washer	$0.43	$0.43
O-Ring*	#12 O-rings (10/bag)	$0.13*	$1.27*
Plastic Elbow	PVC schedule 40-90° elbow	$0.49	$0.49
Cable Tie*	24" Zip tie (10/bag, HVAC)	$0.47*	$4.67*
Plastic Drain Cover	Six-inch round grate	$2.99	$2.99
Downspout Flex Elbow	Plastic extension for downspout	n/a	$2.00-$8.00
Plug	#1 or #2 rubber stopper	$0.30	$0.30
Total		**$26.05**	**Approx. $43**

*denotes supplies that may be used for multiple barrels
Source: Cobb County, GA Water System (http://water.cobbcountyga.gov/pdf/rainbarrel_101707.pdf); instructions for building a rain barrel with these materials may be found at this site.

Rain Cisterns

The following are average costs for typical, new, pre-manufactured cisterns (for all use types, low-density residential to industrial) with costs for minimum and maximum size given. Prices may vary by manufacturer. Shipping costs and labor costs such as excavation, if required, are not included.

Rain Cisterns				
Material	**Cost: Small System**	**Cost: Large system**	**Pros**	**Cons**
Galvanized steel (above-ground)	$225 for 200 gallons	$950 for 2000 gallons	Lightweight; easy to relocate; attractive	Interior must be lined or coated to prevent corrosion
Above-ground polyethylene	$240 for 300 gallons	$900 for 2000 gallons	Readily available; relatively lightweight; long-lasting; various sizes, shapes; inexpensive and easy to relocate	Leakage fittings must be checked regularly; can deteriorate over time if not treated for UV radiation
In-ground polyethylene	$350 for 325 gallons	$1280 for 1700 gallons	Readily available; relatively lightweight; long-lasting; various sizes, shapes	Leakage fittings must be checked regularly; more expensive than above-ground tank because tank is more heavily reinforced; excavation required for installation
Fiberglass (above-ground or in-ground)	$660 for 350 gallons	$10,000 for 10,000 gallons	Lightweight; long-lasting; easily repaired; prevents algae growth and evaporation; rust resistant; durable	Higher initial costs; requires exterior coating
Ferro-Cement (above-ground or in-ground)	Cost of supplies varies by size of cistern: chicken wire; sand; cement; galvanized fencing wire; strong wooden poles; roofing sheet; PVC piping/valves. More information about ferro-cement tanks at the Tearfund International Learning Zone		Relatively inexpensive; durable; permanent	Potential to crack; recommend painting white to reflect sun, reduce evaporation, and keep water cool; excavation required for in-ground installation
Fiberglass/Steel Composite (above-ground or in-ground)	$300 for 300 gallons	$10,000 for 5,000 gallons	Interior steel shell provides strength while exterior fiberglass shell reduces risk of corrosion	Large composite tanks more expensive than large tanks made of other materials

TOTAL ESTIMATED COST: Extremely variable depending upon size, need and material.

Table adapted from Low Impact Development Center, Inc., Southface Energy Institute, Tearfund International Learning Zone rain harvesting information; polyethylene tank price estimates from 2008 Loomis Tank cost estimates

Additional Cistern Components	
Item	**Cost Estimate***
Downspout Filter	$20-60
First-Flush Diverter (optional)	$40-175
Extraction System	$200-600

* Cost estimates gathered from various online distributors, 2008

ADDITIONAL LINKS

1. The Texas Manual on Rainwater Harvesting
   (http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf)
   - ❖ Comprehensive guide to rainwater harvesting
   - ❖ Provides detailed information about system components, sizing, water quality, and cost estimations
2. Low-Impact Development Center, Inc., Rain Barrels and Cisterns
   (http://www.lid-stormwater.net/raincist_home.htm)
   - ❖ Provides information about sizing, construction, costs, and maintenance
3. Harvest H2O
   (http://www.harvesth2o.com/resources.shtml)
   - ❖ Provides numerous "how to" articles for rainwater harvesting, both with rain barrels and rain cisterns
   - ❖ Provides information on related topics, such as greywater use and rain gardens
4. RainHarvesting.com
   (http://www.rainharvesting.com.au/default.asp)
   - ❖ Provides product descriptions for many rainwater harvesting system components
5. Texas Rainwater Cooperative Extension: Soil storage and Infiltration Systems
   (http://agrilifebookstore.org/publications_details.cfm?whichpublication=2397)
   - ❖ Provides information about soil storage and infiltration systems (open-bottom cisterns)
6. Massachusetts Low Impact Development Toolkit
   (http://www.mapc.org/regional_planning/LID/PDFs/Cisterns_web.pdf)
   - ❖ Provides thorough overview or rain harvesting design, benefits, limitations, and cost
7. Innovative Water Solutions
   (http://www.watercache.com/standard.php?p=rh)
   - ❖ Rainwater calculator that helps determine your annual capture potential
   - ❖ Includes basic rain harvesting information
8. Rain Barrel Guide
   (http://rainbarrelguide.com/)
   - ❖ Provides instructions on how to calculate your water demand using old water bills
   - ❖ Includes general rain harvesting information
9. Southface Energy Institute
   (http://www.earthcrafthouse.com/documents/factsheets/27_rainwater-recovery-v2.pdf)
   - ❖ Rainwater harvesting fact sheet
   - ❖ Includes basic steps for setting up your own rain harvesting system
10. Tearfund International Learning Zone
    (http://tilz.tearfund.org/Publications/Footsteps+1-10/Footsteps+1/Ferro+cement+tank.htm)
    - ❖ Provides basic instructions for constructing your own ferro-cement tank

P.O. Box 2308
Greenville, South Carolina 29602
Office: (864) 250-0500
Fax: (864) 250-0788