HARVESTING
RAINWATER

GUIDE TO WATER-EFFICIENT LANDSCAPING

GUIDE TO WATER-EFFICIENT LANDSCAPING

CITY OF TUCSON

TUCSON WATER

Water Smart

DO YOUR PART, BE WATER SMART

NOTES:

TUCSON WATER

City of Tucson Water
Harvesting Rainwater Guide to Water-Efficient Landscaping

September 2013

First Edition by
Patricia H. Water fall, Extension Agent – retired
Pima County Cooperative Extension, Low 4 program

Second Edition by
Christina Bickelmann, Water Conservation Specialiast,
Arizona Department of Water Resources, TAMA

Revised by
City of Albuquerque

Edited by
Daniel Ransom, Water Conservation Program Manager
Tucson Water Public Information & Conservation Office

Prepared for the
City of Tucson Water Department

Copies are available from
City of Tucson Water Conservation/Public Information Office
PO Box 27210, Tucson, AZ 85726-7210
(520) 791-4331
tucsonaz.gov/water/publications

ACKNOWLEDGEMENTS

In large part, this publication duplicates a rainwater harvesting guide published by the Arizona Department of Water Resources (ADWR) in September 1998. Titled *Harvesting Rainwater for Landscape Use*, it was prepared by Patricia H. Waterfall, Extension Agent with the Pima County Cooperative Extension Low 4 Program, with editorial assistance from Joe Gell, Editor, Water Resources Research Center, University of Arizona; Dale Devitt, Professor, Soil and Water, University of Nevada/Reno; and Christina Bickelmann, Water Conservation Specialist, Arizona Department of Water Resources, Tucson Active Management Area. Silvia Rayces prepared the artwork.

The guide was then revised and reformatted to accommodate the needs of the City of Albuquerque. We are grateful to ADWR and the City of Albuquerque for allowing us to borrow freely from their publications.

We would like to acknowledge and thank the Arizona Cooperative Extension, college of Agriculture and Life Sciences, and the University of Arizona for granting permission to adapt their publication "*Harvesting Rainwater for Landscape Use*" (http:cals.arizona.edu/pubs/water/az1344.pdf) for use in this "*Harvesting Rainwater Guide to Water-Efficient Landscaping.*"

REBATES:

City of Tucson Water customers
can call (520) 791-4331 for
information about incentive programs.
tucsonaz.gov/water/rebate

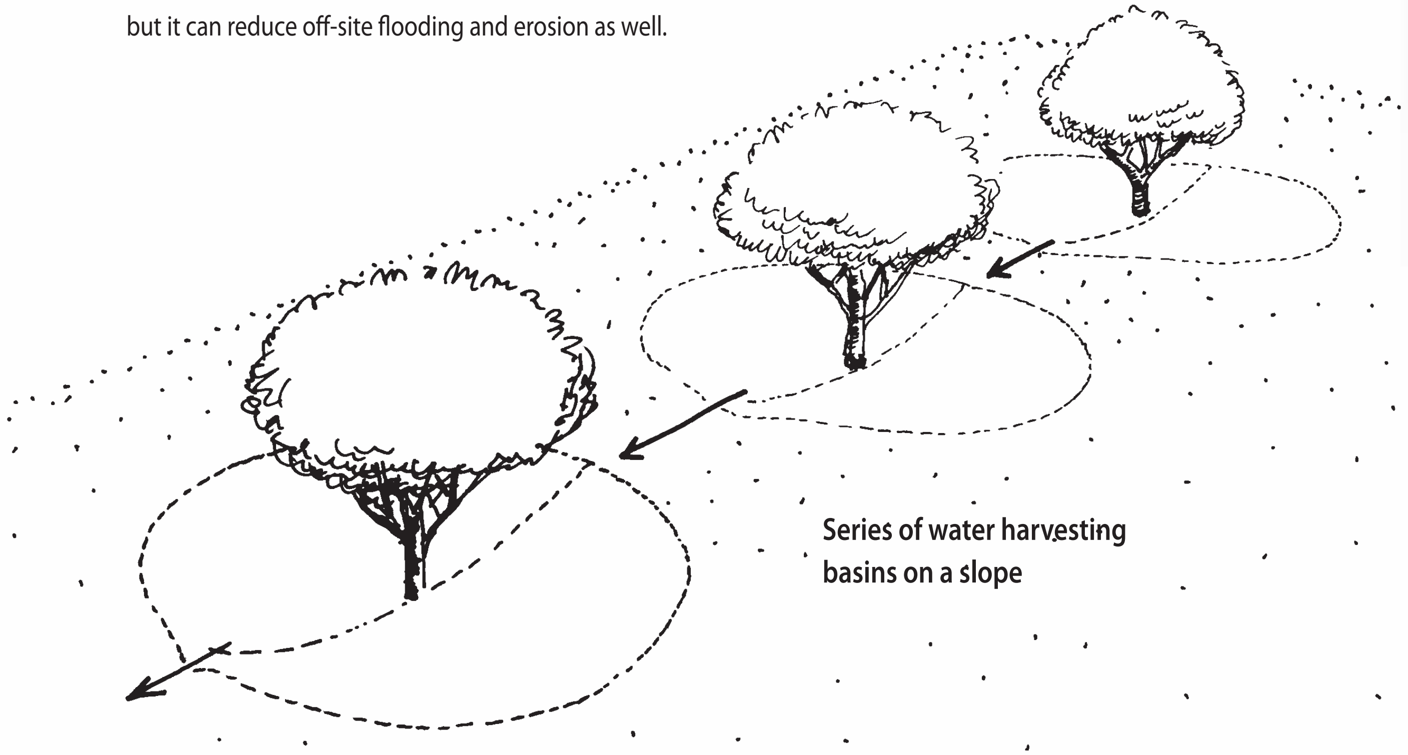
TABLE OF CONTENTS

INTRODUCTION

In the arid Southwest, rainfall is scarce and frequently erratic. These conditions require that we us water as efficiently as possible, and take full advantage of what little rain we do receive to help meet our water needs.

Rainwater harvesting is the capture, diversion, and storage of rainwater for landscape irrigation and other uses. Although rainwater can serve as a source of potable water, this guide focuses on landscape uses because they: 1) account for a significant percentage of total water demand; 2) are less essential and therefore more easily reduced than water used for other purposes; and 3) need not meet stringent drinking water standards. In many communities, landscaping accounts for 30 to 50 percent of total water use; in Tucson, about 40 percent of drinking water is used on landscapes.

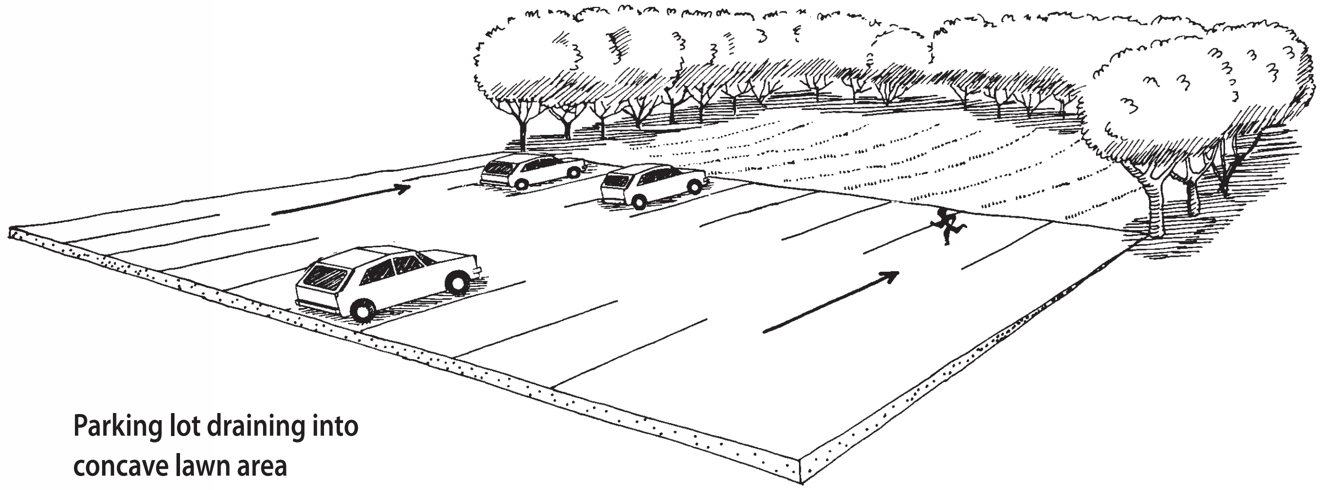
Rainwater harvesting can reduce the use of drinking water for landscape irrigation. Coupled with the use of native and desert-adapted plants, rainwater harvesting is an effective water conservation tool because it provides "free" water that is not from the municipal supply. Rainwater harvesting not only reduces dependence on ground water and the amount of money spent on water, but it can reduce off-site flooding and erosion as well.



Series of water harvesting basins on a slope

Rainwater is the best source of water for plants because it is free of salts and other minerals that can be harmful to root growth. When collected, rainwater percolates into the soil forcing salts down and away from the root zone. This allows for greater root growth and water uptake, which increases the drought tolerance of plants.

Rainwater harvesting can be incorporated into large-scale landscapes such as parks, schools, commercial sites, parking lots, and apartment complexes as well as small-scale residential landscapes. Limitations of rainwater harvesting systems are few and are easily met by good planning and design. There are many rainwater-harvesting opportunities on developed sites and even very small yards can benefit from rainwater harvesting. In addition, rainwater harvesting can easily be planned into a new landscape during the design phase. Therefore, whether your landscape is large or small, the principles outlined in this manual apply.



Parking lot draining into concave lawn area

RAINWATER HARVESTING SYSTEM COMPONENTS

All rainwater harvesting systems have three main components: the supply *(Rainfall)*, the demand *(Plant Water Requirement)*, and the system that moves water to the plants *(Water Collection and Distribution System)*. Rainwater harvesting systems can be divided into Simple and Complex systems. In general, simple systems immediately distribute rainwater to planted areas, whereas complex systems store some or all of the rainwater in a container for later use.

Rainfall

Rainwater "runoff" refers to rainwater that flows off a surface. If the surface is impermeable, runoff occurs immediately. If the surface is permeable, runoff will not occur until the surface is saturated. Runoff can be harvested *(captured)* and used immediately to water plants or can be stored for later use. The amount of rain received, its duration and intensity all affect how much water is available for harvesting. The timing of the rainfall is also important. If only one rainfall occurs, water percolates into the dry soil until it becomes saturated. If a second rainfall occurs soon after the first, more water may run off because the soil is already wet.

Plant Water Requirements

The type of plants selected, their age and size, and how closely together they are planted all affect how much water is required to maintain a healthy landscape. Because rainfall is scarce in arid regions, it is best to select plants with low water-use requirements and to limit planting densities to reduce overall water need. Native plants are well adapted to seasonal, short-lived water supplies, and most desert-adapted plants can tolerate drought, making them good choices for landscape planting.

Water Collection and Distribution Systems

Most people can design a rainwater collection and distribution system to meet the needs of their existing site. Designing a system into new construction allows one to be more elaborate and thorough in capturing and routing rainwater. In the case of very simple collection and distribution systems, the payback period may be almost immediate.

SIMPLE RAINWATER HARVESTING SYSTEMS

A simple rainwater harvesting system usually consists of a catchment, a distribution system, and a landscape holding area, which is a concave or planted area with an earthen berm or other border to retain water for immediate use by the plants. A good example of a simple rainwater harvesting system is water dripping from the edge of a roof to a planted area or diversion channel located directly below the drip edge. Gravity moves the water to where it can be used.

Catchments

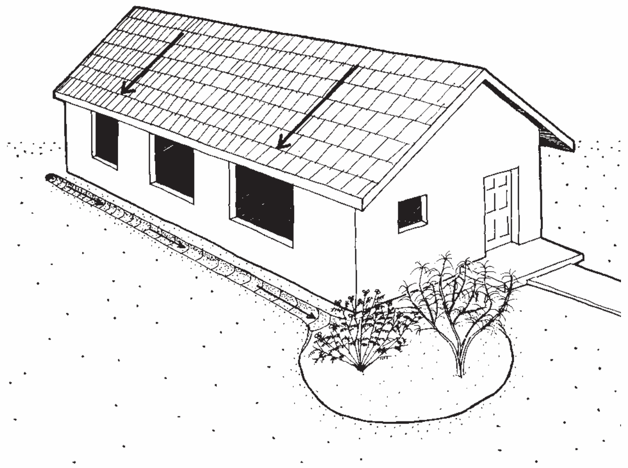
A catchment is any area from which water can be collected, which includes roofs, paved areas, and the soil surface. The best catchments have hard, smooth surfaces, such as concrete or metal roofing material. The amount of harvested rainwater depends on the size, surface texture, and slope of the catchment area.

Distribution Systems

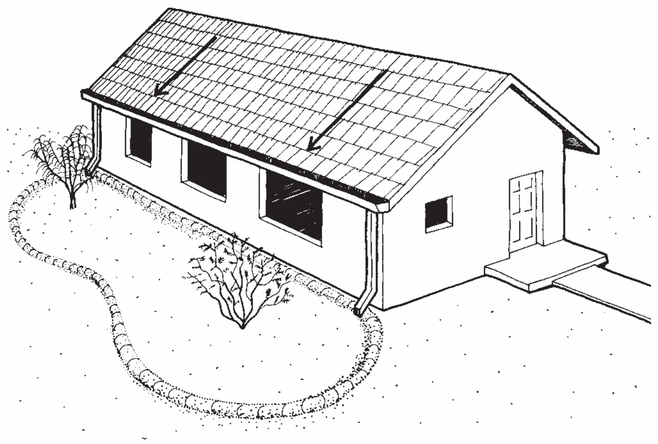
These systems connect catchments to the landscape holding areas. Distribution systems direct water flow and can be simple or sophisticated.

For example:

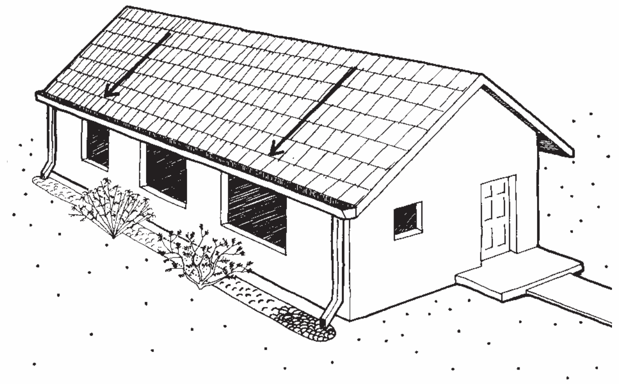
- Gutters and downspouts direct roof water to a holding area, and gently sloped sidewalks distribute rainwater to a planted area.
- Hillsides provide a perfect situation for moving water from a catchment to a holding area.



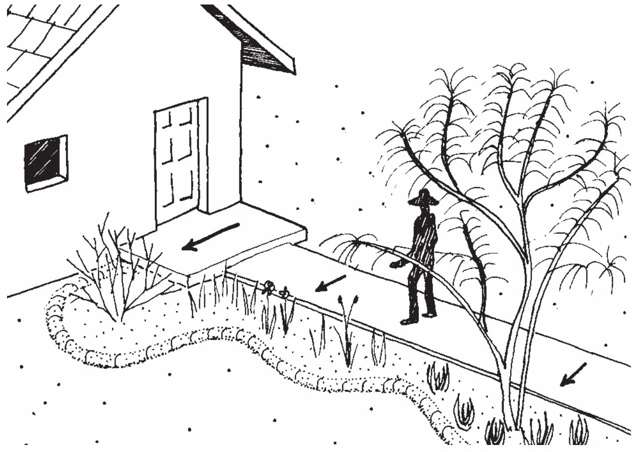
Simple system – roof catchment, channel, and planted landscape-holding area



Simple system – roof catchment, gutters, and bermed landscape-holding area



Simple system – roof catchment, gutters, downspouts, and French drain



Simple system – sidewalk catchment and bermed landscape holding area

- Channels, ditches, and swales *(shallow depressions)* all can be used to direct water. *(If desired, these features can be lined with plastic or some other impermeable material to increase their effectiveness and to eliminate infiltration in areas where it is not wanted.)*
- Elaborate open channel distribution systems may require gates and diverters to direct water from one area to another.
- Standard or perforated pipes, and drip irrigation systems can be designed to distribute water.
- Curb cutouts can channel street or parking lot water to planted areas. If gravity flow is not possible, a small pump may be required to move the water.

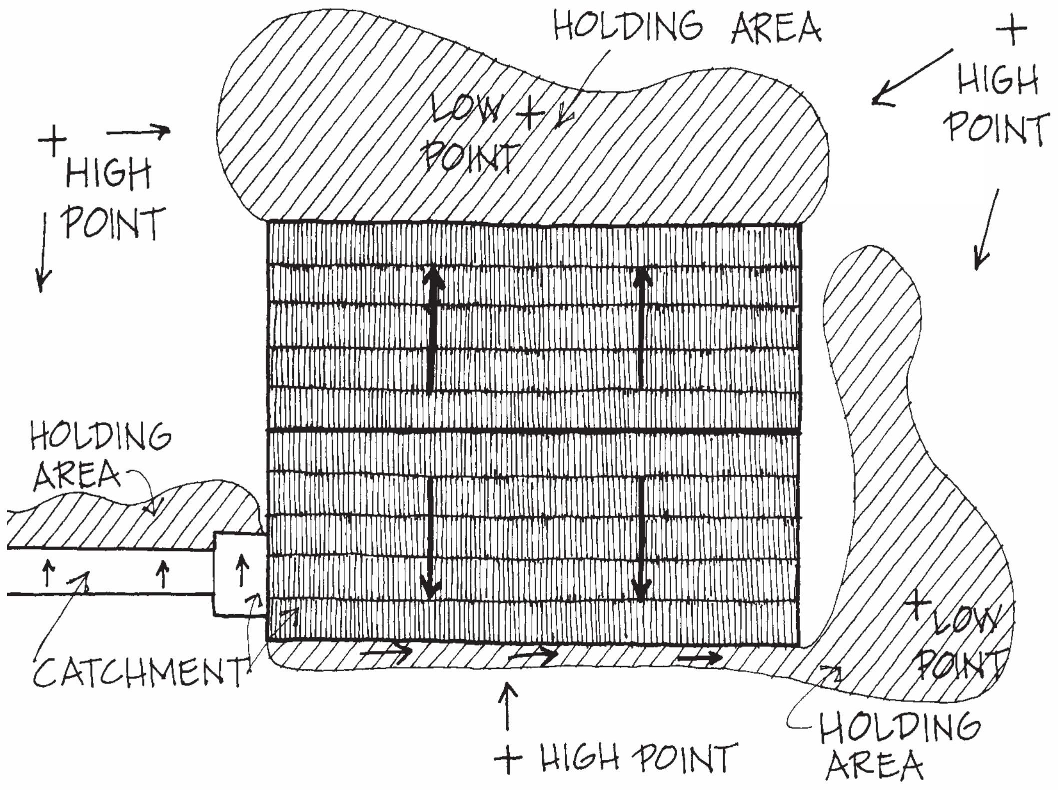
Landscape Holding Areas (Earthworks)

Water harvesting earthworks are landscape features that direct and capture the flow of water. These areas store water in the soil for direct use by the plants. A basin is a mulched depression dug into the earth and used to capture rainfall. Concave depressions planted with grass or plants serve as landscape holding areas. These areas contain the water, increase water penetration into the soil, and reduce flooding and erosion. Depressed areas can be dug out, and the extra soil used to form a berm around the depression. Berms are designed to capture rainwater as it runs down a sloped area and are laid perpendicular to the slope of the landscape. Typically, berms are built in a crescent shape and compacted to keep them from eroding. With the addition of berms, moats, or soil terracing, flat areas also can hold water. One holding area or a series of holding areas can be designed to fill and then flow into adjacent holding areas through spillways *(outlets for surplus water)*.

Step #1 *Site Analysis*

Design the Collection and Distribution System. By observing your landscape during a rain, its drainage patterns can be identified and used. Use these drainage patterns and gravity flow to move water from catchments to planted areas.

- If you are harvesting rainwater from a roof, extend gutter/downspouts to reach planted areas or provide a path or drainage to move the water where it is needed
- Take advantage of hardscapes to catch rainwater and redistribute it to planted areas
- The placement and slope of new paving can be designed to increase runoff
- Soil can also serve as a catchment by grading the surface to increase and direct runoff

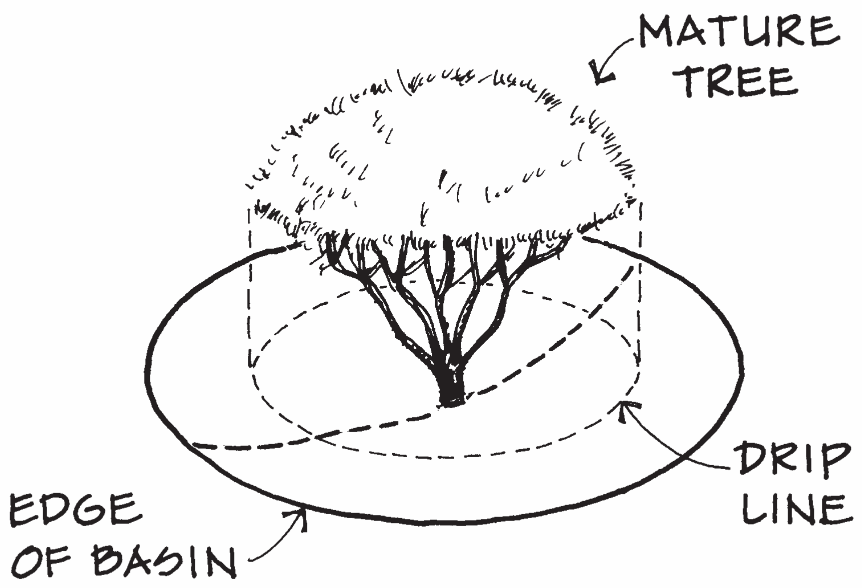


Site plan showing drainage patterns and landscape holding areas (aerial view)

Step #2 *Design Landscape Holding Areas*

Next, locate and size your landscape holding areas.

- Locate landscape depressions that can hold water or create new depressions where you want to locate new plants. *(To avoid structural or pest problems, locate holding areas 10 feet away from building foundations.)*
- Rather than digging a basin around existing plants, construct berms or moats on the surface to avoid damaging roots. Do not mound soil at the base of trees or other plants. Holding areas around existing plants should extend beyond the “drip line” to accommodate and encourage extensive root systems. Plants with a well-developed root system have a greater tolerance for drought because the roots have a larger area to find water.
- For new plantings, locate the plants at the upper edge of concave holding areas to encourage extensive rooting and to avoid extended flooding.
- For both existing and new landscapes, you may want to connect several holding areas with spillways or channels to distribute water throughout the site.



Tree dripline and basin edge

Step #3 *Select Plant Material*

Proper plant selection is a major factor in the success of a rainwater-harvesting project. Native and desert-adapted plants are usually the best choices. Some plants cannot survive in the actual water detention area if the soil is saturated for a long period, so careful plant selection for these low-lying areas is important.

- Select plants that can withstand prolonged drought and prolonged inundation, such as native plants or adapted plants. If you intend to plant in the bottom of large deep basins, low-water use native riparian trees may be the most appropriate plant choice.
- To take advantage of water free falling from roof downspouts *(canales)*, plant large rigid plants where the water falls or hang a large chain from the downspout to the ground to disperse and slow the water.
- Provide a basin to hold the water for the plants and to slow it down. It may be necessary to place rocks or other hard material under the downspout to break the water's fall and prevent erosion.
- If you are working with a sloped site, large, connected, descending holding areas can be constructed for additional plants.
- Seeding is another alternative for planting holding basins. Select seed mixes containing native or desert-adapted wildflowers, grasses, and herbaceous plants. Perennial grasses are particularly valuable for holding the soil and preventing erosion and soil loss.
- Take care not to compact soils in landscape holding areas; this inhibits the movement of water through the soil. If the soil is compacted, loosen it by tilling. If the soil is sandy, you may wish to add composted organic matter to the soil to increase its moisture holding potential.
- After planting, apply a 2 - 4 inch layer of mulch to reduce evaporation.

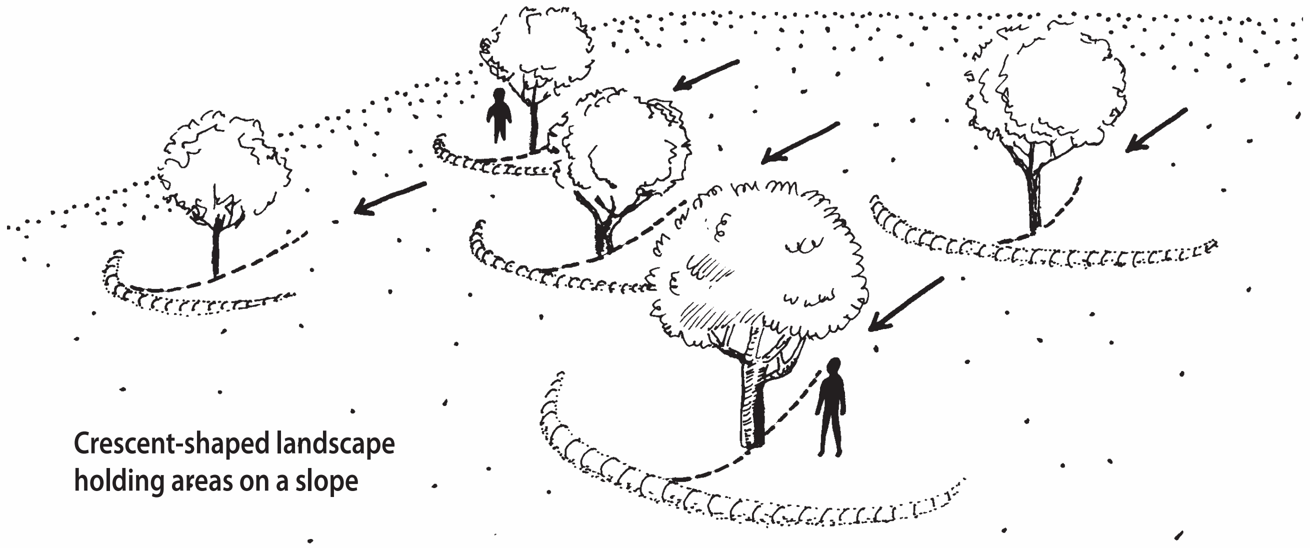
CONSTRUCTION HINT: *Call Arizona Blue Stake (800) 782-5348 before you dig to locate utility lines on your property.*

HARVESTING RAINWATER TO REDUCE FLOODING AND EROSION

Rain falling on impermeable surfaces generates runoff. In sufficient volumes, runoff is a powerfully erosive force, scouring away bare soil and creating pockmarked roads. Because roofs, roads, and parking lots are impermeable surfaces, in urban areas even moderate rainfall produces large amounts of runoff. Controlling runoff to prevent flooding and erosion is a major public expense.

Rainwater harvesting can reduce these problems:

- Crescent-shaped berms constructed around the base of a plant are useful for slowing and holding water on slopes.
- French drains *(holes or trenches filled with gravel)* can also hold water for plant use.
- Permeable paving materials, such as gravel, crushed stone, and open or permeable paving blocks, stabilize soil on steep slopes and allow water to infiltrate into the soil to irrigate trees and other plant with large, extensive root systems.
- Another option on steep slopes is terrace grading to form stair step-like shelves. By slowing runoff and allowing it to soak into the ground, rainwater harvesting can turn a problem into an asset.

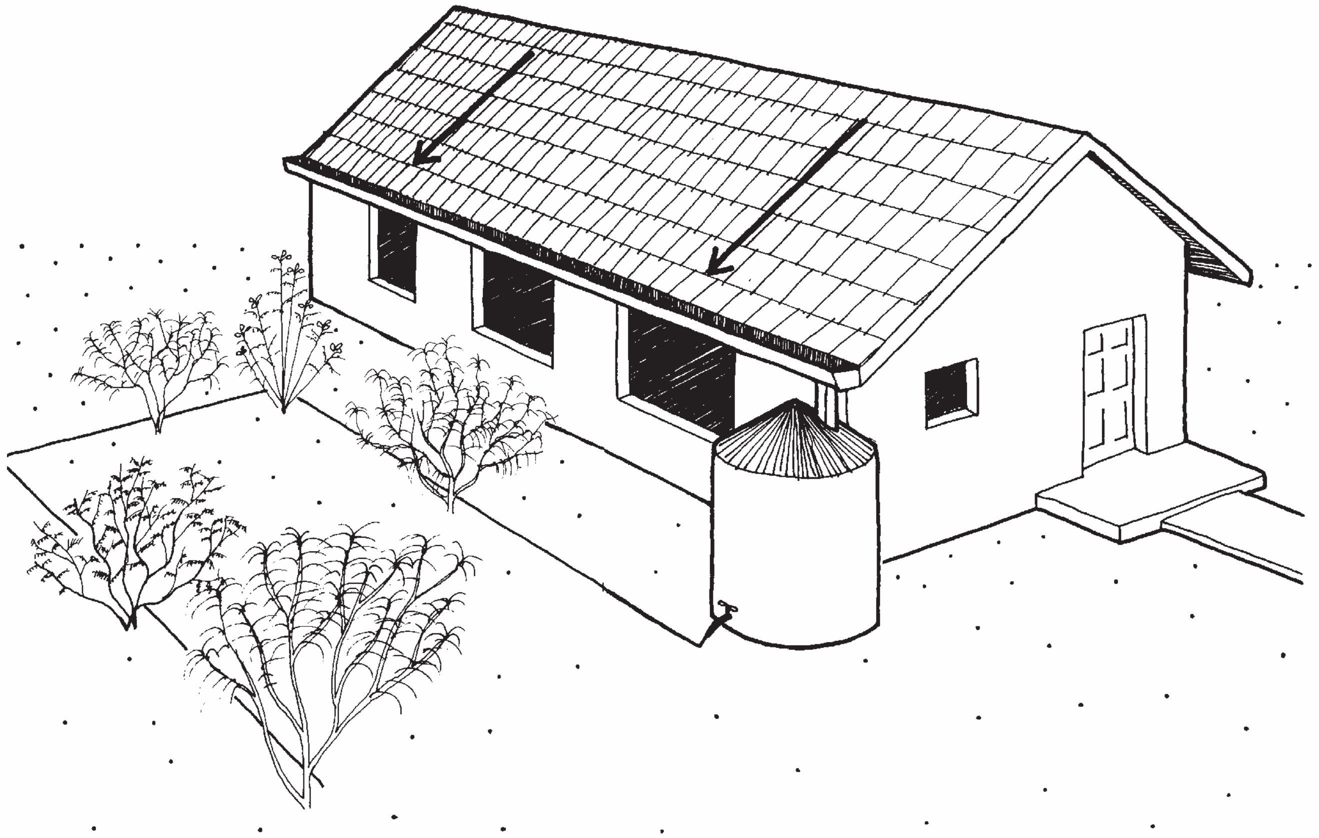


Crescent-shaped landscape holding areas on a slope

Rainwater harvesting cannot provide a completely reliable source of irrigation water because it depends on the weather, and the weather is not dependable. To maximize the benefits of rainwater harvesting, storage can be built into the system to provide water between rainfall events. Arizona's rainy season, for example, usually begins in mid-summer and runs through the fall, with drier periods in between. During the summer "monsoons", a heavy rain may produce more water than is needed by a landscape. *(Plants are well watered once their root zones have been thoroughly wetted; at this point water may begin to run off or stand on the surface.)* A complex rainwater harvesting system stores this excess water for later use.

A frequently asked question is whether a complex rainwater harvesting system can collect and store enough water in an average year to provide sufficient irrigation for an entire landscape. The answer depends on whether the amount of harvested rainwater *(the supply)* and the water needed for landscape irrigation *(the demand)* are in balance. Storage capacity plays a big role in this equation by making water available to plants in the dry seasons when rainfall alone is insufficient.

Rainfall harvesting systems that include storage result in both larger water savings and higher construction costs. These complex systems are more appropriate for larger facilities or for areas where municipal or other water supplies are not available, and they may require professional assistance to design and construct. With such a system the cost of storage, which includes not only the storage container but also excavation costs, pumps and wiring, as well as additional maintenance requirements is a major consideration. The investment payback period may be several years, which means that one's personal commitment to a "water conservation ethic" may come into play in determining whether such an investment makes sense. Most people choose to use a smaller container and harvest less than the total landscape requirement. Another option is to reduce water demand by reducing planting areas or plant densities, or by replacing high-water use plants with medium or low-water use ones. This reduces the supply required and the space required to store it and is therefore, less expensive.



Complex rainwater harvesting system with roof catchment, gutter, downspout, storage, and drip distribution system

ELEMENTS OF A COMPLEX RAINWATER HARVESTING SYSTEM

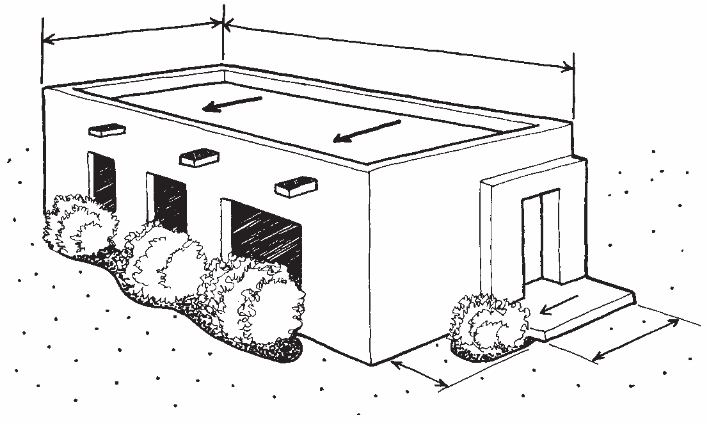
Complex rainwater harvesting systems include catchments, conveyance systems *(to connect catchments to storage containers)*, storage, and distribution systems *(to direct water where it is needed)*. Each of these elements is discussed below.

Catchments

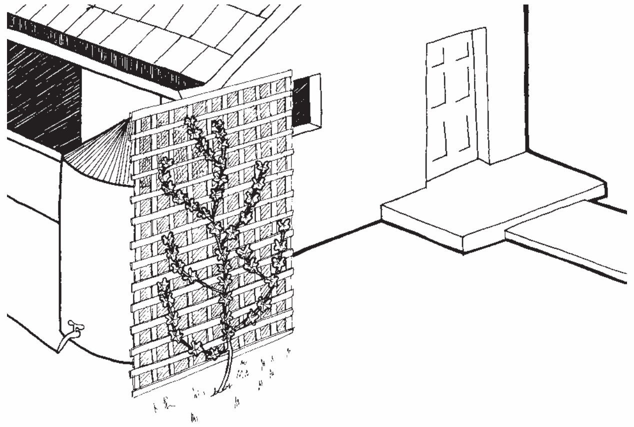
The amount of water or "yield" that a catchment will provide depends on its size and surface texture. This is an important consideration with a complex system. Concrete, asphalt, or brick paving and smooth-surfaced roofing materials provide high yields. Bare soil surfaces provide harvests of medium yield, with compacted clayey soils yielding the most. Planted areas, such as grass or groundcover areas, offer the lowest yields because the plants hold the water longer, thereby allowing it to infiltrate into the soil.

Conveyance Systems

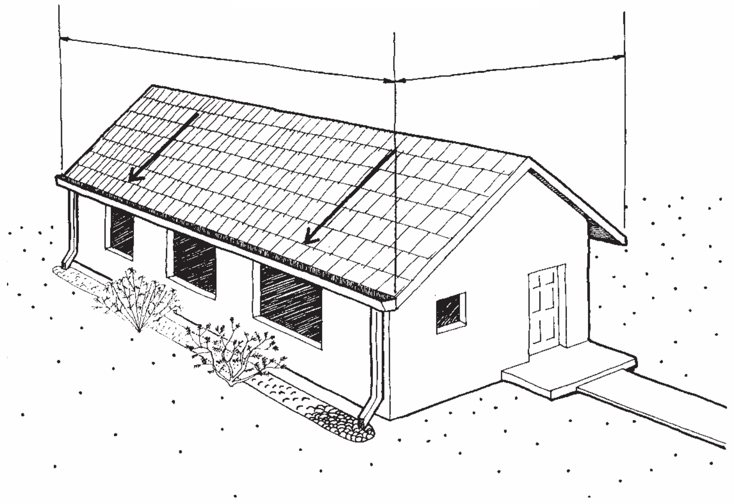
These systems direct the water from the catchment area to the storage container. With a roof catchment system, either canales *(from which water free-falls to a storage container)* or gutters and downspouts are the means of conveyance. Gutters should be properly sized to collect as much rainfall as possible. *(See Appendix E for guidelines on gutters and downspouts.)*



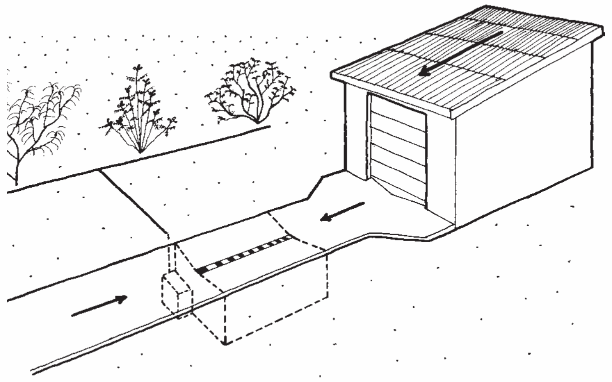
Catchment area of flat roof = length x width



Vine used to screen storage tank



Catchment area of sloped roof (both sides) = length x width



Roof catchment with sloping driveway, French drain, and underground storage

Filters

Storage allows full use of excess rainfall by making water available when it is needed. Before the water is stored, however, it should be filtered to remove particles and debris. The degree of filtration necessary depends on the size of the distribution tubing and emission devices *(drip systems would require more and finer filtering than water distributed through a hose)*. Filters can be in-line or a leaf screen can be placed over the gutter at the top of the downspout. Always cover the storage container to prevent mosquito and algae growth and to keep out debris.

Many people divert the first part of the rainfall to eliminate debris from the harvested water. The initial rain "washes" debris off the roof; the later rainfall, which is free of debris and dust, is then collected and stored. The simplest roof-washing system consists of a standpipe and a gutter downspout located ahead of the cistern. The standpipe is usually 6 – 8 inch PVC equipped with a valve and cleanout at the bottom. Once the first part of the rainfall fills the standpipe, the rest flows to the downspout connected to the cistern. After the rainfall, the standpipe is drained in preparation for the next rain event. Roof-washing systems should be designed so that at least 10 gallons of water are diverted to the system for every 1,000 square feet of collection area. Several types of commercial roof washers are also available.

Storage

Storage containers can be located under or above ground and made of polyethylene, fiberglass, wood, concrete, or metal. Underground containers are more expensive because of the cost of soil excavation and removal. Pumping water out of the container adds to their cost. Ease of maintenance should also be considered. Swimming pools, stock tanks, septic tanks, ferrocement culverts, concrete block, poured-in-place concrete, or building rock can be used for underground storage.

ELEMENTS OF A COMPLEX RAINWATER HARVESTING SYSTEM

Examples of aboveground containers include 55-gallon plastic or steel drums, barrels, tanks, and cisterns. Buildings or tanks made of concrete block, stone, plastic bags filled with sand, or rammed earth also can be used. Costs depend on the system, degree of filtration, and the distance between the container and place of use.

Locate storage near or at the end of downspouts. If storage is unsightly, it can be designed into the landscape in an unobtrusive place or hidden with a structure, screen, and/or plants. In all cases, storage should be located close to the area of use and placed at an elevated level to take advantage of gravity flow. Ideally, on a sloped lot the storage area is located at the high end of the property to facilitate gravity flow. Another option is to locate several smaller cisterns near where water is required because they are easier to handle and camouflage. If the landscaped area is extensive, several tanks can be connected to increase storage capacity. In the event that rainfall exceeds storage capacity, alternative storage for the extra water must be found. A concave planted area would be ideal because it allows rainwater to slowly percolate into the soil. Storage container inlets and overflow outlets should be the same size.

Distribution

The distribution system directs the water from the storage container to landscaped areas. The distribution device can be a garden hose, constructed channels, pipes, perforated pipes, or a manual drip system. Gates and diverters can be used to control flow rate and direction. A manual or electric ball valve located near the bottom of the storage container can assist gravity-fed irrigation. In the absence of gravity flow, an electric pump hooked to a garden hose can be used. Distribution of water through an automatic drip irrigation system requires extra effort to work effectively. A pump will be required to provide enough pressure to operate a typical drip irrigation system. Ensure your pump will turn off automatically when there is no water in the tank.

Irrigation System & Backflow Prevention Requirements

Use of an irrigation system that is pressurized with any kind of pump must have a reduced pressure principle assembly (RPA) installed at the service connection to protect the public water system from potential contamination. Visit tucsonaz.gov/water/backflow or contact the City of Tucson Water Department Section at (520) 791-2650 for more information on backflow installation requirements for the use of Alternative Water Sources; Rainwater Harvesters equipped with pumps.

Storage Container Safety

Storage units should be covered, secure from children, and clearly labeled as unfit for drinking. If containers are elevated, a strong foundation should be used. Containers should be opaque and if possible, shielded from direct sunlight to discourage the growth of algae and bacteria. Regular inspection and maintenance are essential.

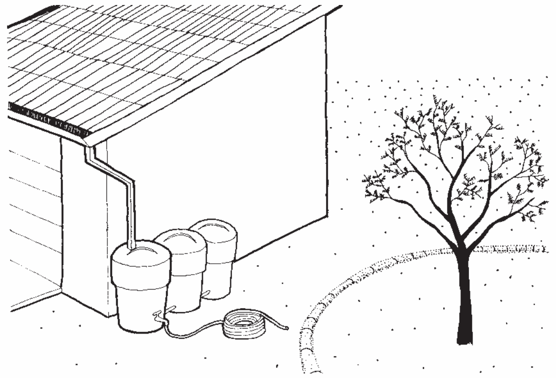
COMPLEX RAINWATER HARVESTING SYSTEM DESIGN & CONSTRUCTION

If you are designing a complex rainwater harvesting system one that includes storage to provide rainwater in between rainfall events advance planning, coupled with a few simple calculations, will result in a more functional and efficient system. The steps involved in designing a complex rainwater harvesting system include site analysis, calculation, design, and construction. If the project is a complicated one, either because of its size or because it includes numerous catchments and planting areas, divide the site into sub-drainage areas and repeat the following steps for each sub-area. As a final step, field-test the system.

Step #1 *Site Analysis*

- Whether you are designing a new landscape or working with an existing one, draw your site and all the site elements to scale.
- Plot the existing drainage flow patterns by observing your property during a rain.
- Show the direction of the water flow with arrows, and indicate high and low areas on your plan.
- Look for catchments such as paved areas, roof surfaces, and bare earth.
- Identify areas that require irrigation and sites near those areas where above or underground storage can be located.

Although the final design will depend on the outcome of your supply and demand calculations *(page 16)*, consider how you are going to move water from the catchment to the holding area or storage container. Rely on gravity to move water whenever you can. Consider too how you are going to move the water through the site from one landscaped area to another. Again, if the site is too large or the system too complicated, divide the site into sub-drainage areas.



Roof catchment with multiple storage cans connected to a hose adjacent to a landscape holding area

Step #2 *Calculations*

First, calculate the monthly Supply *(rainfall harvest potential)* and the monthly Demand *(plant water requirement)* for a year. Next, calculate the monthly Storage/Supplemental Water Requirement.

Calculate Supply

The following equation for calculating supply will provide the amount of water (in gallons) that can be harvested from a catchment *(see Example 1)*.

SUPPLY (gallons)	=	INCHES OF RAINFALL	x	0.623	x	CATCHMENT AREA (sq/ft)	x	RUNOFF COEFFICIENT

Multiply rainfall in inches *(See Appendix A)* by 0.623 to convert inches to gallons per square foot, and multiply the result by the area of catchment in square feet (ft^2). *(For example, a 10′ x 20′ roof is 200 ft^2. For a sloped roof, measure the area covered by the entire roof, which is usually the length and width of the building.)* Multiply this figure by the "runoff coefficient" *(See Appendix C)* to obtain the rainfall that can be harvested from a particular surface. The "High" number in the table corresponds to a less absorbent surface, and the "Low" number corresponds to a more absorbent surface.

Example 1: Calculating Supply

Eva wants to build a rainwater harvesting system for her home in Tucson. From Appendix A, she enters the monthly rainfall for each month on the Supply Worksheet *(see sample on next page)*. Then she multiplies the inches of rainfall by 0.623 to convert inches to gallons per square foot.

Eva has an "L"-shaped house with asphalt shingle roofing that she plans to use as her primary catchment area. To simplify measurements, she divides the house into two rectangular sections, A and B. The eave-to-eave measurements for section A are 45′ x 25′, and for section B are 20′ x 25′:

Section A 45′ x 25′ = 1,125 ft^2
Section B 20′ x 25′ = 500 ft^2
Total 1,625 ft^2

Eva has 1,625 square feet of catchment area. She enters this value in Column C, and then multiplies the gallons per square foot in Column B by the square footage in Column C to determine the total gallons of rainfall each month. Since the asphalt shingle roof will not shed all of the rainfall, Eva finds the appropriate catchment coefficient (0.9) in Appendix C and enters it in Column E.

Multiplying Column D by Column E provides the net harvestable rainfall for the month.

To assist in the calculations for supply and demand, blank worksheets are provided in appendix F. A sample supply worksheet using Tucson rainfall is provided *(below)* to show how monthly rainfall amounts are calculated based on 1,625 ft^2 of roof area *(see example 1)*.

SAMPLE SUPPLY WORKSHEET

	A	B	C	D	E	F
Follow the lettered instructions for each month	From Appendix A enter the rainfall amount in inches for each month	Multiply "A" by 0.623 to convert inches to gallons per square foot	Enter the square footage of the catchment surface	Multiply "B" by "C" This is the gross gallons of rainfall per month	Enter the runoff coefficient for your catchment surface	Multiply "D" by "E" This is the total monthly yield of harvested rainwater in gallons
January	0.99	0.617	1,625	1,002	0.90	902
February	0.88	0.548	1,625	891	0.90	802
March	0.81	0.505	1,625	820	0.90	738
April	0.28	0.174	1,625	283	0.90	255
May	0.24	0.150	1,625	243	0.90	219
June	0.24	0.150	1,625	243	0.90	219
July	2.07	1.290	1,625	2,096	0.90	1,886
August	2.30	1.433	1,625	2,328	0.90	2,096
September	1.45	0.903	1,625	1,468	0.90	1,321
October	1.21	0.754	1,625	1,225	0.90	1,102
November	0.67	0.417	1,625	678	0.90	610
December	1.03	0.642	1,625	1,043	0.90	938
Totals	**12.17**			**12,321**		**11,089**

CALCULATING DEMAND

Calculate Demand

The demand equation tells how much water is required for a given landscaped area. Two methods are available for determining landscape demand: Method 1 can be used for either new or established landscapes; Method 2 can be used for established landscapes only.

CALCULATING DEMAND, METHOD 1:

This method for calculating demand is based on monthly evapotranspiration (ET) information. *(Appendix B provides ET information for different regions in Arizona.)* ET is multiplied by the "Plant Water Use Coefficient," which represents the percentage of ET needed by the plant. *(See Appendix D for information on plant factors. In the example that follows, the plants require approximately 20 percent of ET.)* Irrigated area refers to how much area is planted.

Example 2: Calculating Demand

NEW OR ESTABLISHED LANDSCAPE, METHOD 1:

Eva's landscape has a small lawn area served by a sprinkler system and about 1,200 square feet of densely planted low water use trees, shrubs, and flowers. To avoid the expense of installing an electric pump, Eva wants her rainwater project to operate by gravity flow. Since the sprinkler system cannot be operated by gravity flow, she decides to limit the use of her rainwater system to irrigation of her flowers, trees, and shrubs.

1. Using the Demand Worksheet *(see sample on next page)*, Eva calculates the potential water needs *(demand)* for her rainwater-irrigated area. From Appendix B, she enters the evapotranspiration rate for the Tucson area into Column A.
2. She multiplies Column A by 0.623 to convert inches to gallons per square foot and enters the result in Column B.
3. Since Eva's landscape is primarily low water use plants, she uses a plant factor of 0.2 *(See Appendix D)*. She enters this value in Column C.
4. She then multiplies B by C to get the estimated gallons of water her plants will require. She enters the result in Column D.
5. In Column E, she enters the total square feet of landscaping she hopes to water with her rainwater system.
6. Lastly, she multiplies Column D by Column E to determine how much water her landscape will need for each month.

Now that the supply and demand have been calculated for each month, Eva can determine the maximum storage needs for her system. Although containers of any size will reduce Eva's dependence on municipal water, to capitalize on the available rainfall she should have enough storage to accommodate her cumulative water storage needs *(see Sample Worksheet on page 22)*.

What is Evapotranspiration?

Evapotranspiration (ET) is the combined loss of water from the soil due to evaporation and plant transpiration. It is usually expressed in inches. To keep a plant healthy, water must be replenished in relation to the ET rate.

Weather and plant types are the primary factors that determine ET. On the weather side, temperature, wind, solar radiation, and humidity are the important variables.

ET usually is calculated for alfalfa, a heavy water use crop. Since most plants do not use as much water as alfalfa, the ET rate is multiplied by a plant coefficient that adjusts the ET rate for the types of plants you are growing.

SAMPLE DEMAND WORKSHEET (METHOD 1)

	A	B	C	D	E	F
Follow the lettered instructions for each month	From Appendix B enter the ET amount in inches for each month	Multiply "A" by 0.623 to convert inches to gallons per square foot	From Appendix D enter the appropriate plant water use coefficient	Multiply "B" by "C" to obtain plant water needs in gallons	Enter the total square footage of landscaping	Multiply "D" by "E" This is your total landscaping demand in gallons
January	2.52	1.57	0.20	0.31	1,200	377
February	3.19	1.99	0.20	0.40	1,200	477
March	5.07	3.16	0.20	0.63	1,200	758
April	6.82	4.25	0.20	0.85	1,200	1,020
May	8.61	5.36	0.20	1.07	1,200	1,287
June	9.59	5.97	0.20	1.19	1,200	1,434
July	8.95	5.58	0.20	1.12	1,200	1,338
August	7.75	4.83	0.20	0.97	1,200	1,159
September	6.68	4.16	0.20	0.83	1,200	999
October	4.96	3.09	0.20	0.62	1,200	742
November	3.02	1.88	0.20	0.38	1,200	452
December	2.16	1.35	0.20	0.27	1,200	323
Totals	**69.32**			**8.64**		**10,365**

CALCULATING DEMAND

CALCULATING DEMAND, METHOD 2:

This method estimates landscape water demand based on actual water use, as measured by your monthly water bills. With this method, we assume that most water used during the months of December through February is indoor use, and that very little landscape watering occurs. *(If you irrigate your landscape more than occasionally during these months, use Method 1.)* Most utilities measure water in ccf (1 ccf = 100 cubic feet). To use this method, combine the water use amounts for December, January, and February and divide by 3 to determine your average indoor water use. In the worksheet that follows, the average winter monthly use is 9 ccf. Because we can assume that indoor use remains relatively stable throughout the year, simply subtract the average winter monthly use from each month's total use to obtain a rough estimate of monthly landscape water use. To convert ccf to gallons, multiply ccf by 748. A blank worksheet is provided in Appendix F to calculate monthly demand using Method 2.

SAMPLE DEMAND WORKSHEET (METHOD 2)

Month	Monthly Use *(CCF)*	Average Winter Use *(CCF)*	Landscape Use *(CCF)*	Convert CCF to Gallons	Landscape Use *(Gallons)*
January	7	9	0	748	0
February	11	9	2	748	1,496
March	13	9	4	748	2,992
April	15	9	6	748	4,488
May	18	9	9	748	6,732
June	19	9	10	748	7,480
July	18	9	9	748	6,732
August	15	9	6	748	4,488
September	14	9	5	748	3,740
October	12	9	3	748	2,244
November	10	9	1	748	748
December	9	9	0	748	0

CALCULATING CUMULATIVE STORAGE & SUPPLEMENTAL USE

CALCULATE CUMULATIVE STORAGE/SUPPLEMENTAL WATER REQUIREMENT

Once you've calculated the potential water supply from harvested rainwater and your landscape water demand, use a "checkbook" method to determine your monthly harvested rainwater balance and the amount of supplemental water *(municipal or other source)* needed to meet any shortfall in stored rainwater. The calculations in the sample worksheet that follows are based on the sample supply and demand calculations presented earlier *(see sample worksheets on pages 17 and 19),* which in turn are based on the supply and demand scenario presented in Examples 1 and 2. For the sake of simplicity, the calculations in this worksheet are performed on a monthly basis. In reality, the amount of water available fluctuates daily.

The "Cumulative Storage" column in this worksheet is cumulative and refers to what is actually available in storage. A given month's storage is obtained by adding the previous month's storage to the current month's yield, minus the current month's demand. If the remainder is positive, it is placed in the Cumulative Storage column for the current month. This number is then added to the next month's yield to provide for the next month's demand. If the remainder is negative, that is, if the demand is greater than the supply of stored water, this number is placed in the Supplemental Use column to indicate the amount of supplemental water needed to satisfy irrigation water demand for that month.

The worksheets are for determining potential storage capacity; they are not for weather prediction. Weather may vary from the average at any time. Each site presents its own set of supply and demand amounts. Some water harvesting systems may always provide enough harvested water; some may provide only part of the demand. Remember that the supply will fluctuate from year to year depending on the weather and on which month the rainfall occurs. Demand may increase when the weather is hotter than normal.

CALCULATING CUMULATIVE STORAGE & SUPPLEMENTAL USE

SAMPLE STORAGE/SUPPLEMENTAL USE WORKSHEET

Month	Yield	Demand Storage	Cumulative Storage *(yield-demand)*	Supplemental Use
Year 1 January	902	377	525	0
February	802	477	850	0
March	738	758	830	0
April	255	1,020	65	0
May	219	1,287	0	1,003
June	219	1,434	0	1,215
July	1,886	1,338	548	0
August	2,096	1,159	1,485	0
September	1,321	999	1,807	0
October	1,102	742	2,168	0
November	610	452	2,327	0
December	938	323	2,942	0
Year 2 January	902	377	3,468	0
February	802	477	3,792	0
March	738	758	3,772	0
April	255	1,020	3,008	0
May	219	1,287	1,939	0
June	219	1,434	724	0
July	1,886	1,338	1,272	0
August	2,096	1,159	2,209	0
September	1,321	999	2,531	0
October	1,102	742	2,892	0
November	610	452	3,051	0
December	938	323	3,666	0

As shown in the preceding worksheet, Eva's landscape demand during the summer months in May and June of the first year will require the use of a supplemental water supply with a 3800-gallon tank. A smaller tank would require additional supplemental water. The supply of rainwater exceeds demand during the winter months when evapotranspiration rates are low, so this water can be saved for the "leaner" spring and early summer months.

BALANCING SUPPLY AND DEMAND

Every site presents its own unique set of water supply and demand amounts. Some water harvesting systems may always provide enough harvested rainwater to meet demand, while others may provide only part of the demand. Remember that the supply will fluctuate from year to year depending on the weather and in which month rainfall occurs. Demand may increase when the weather is hotter than normal, and will increase as the landscape ages and plants grow larger. Demand will also be high during the period of time when new plants are being established.

If, after determining the available supply and demand, it turns out that the supply of harvested rainwater falls short of meeting irrigation demands, you can balance your rainwater-harvesting checkbook by either increasing the supply or by reducing the demand.

Options for increasing the supply include the following:

- Increase the catchment area
- Use municipal or some other source of water

Options for reducing demand include the following:

- Reduce the amount of landscaped area
- Reduce the plant density
- Replace high-water use plants with lower-water use plants
- Use mulch to reduce surface evaporation

Step #3 *Final Design and Construction*

Use your site analysis and supply and demand calculations to size and locate catchment areas. If possible, size the catchment to accommodate the maximum landscape water requirement. If you cannot do this, you may want to reduce plant water demand by either lowering planting density or by selecting lower water use plants. Roofs or shade structures can be designed or retrofitted to maximize the size of the catchment area. If you are planning a new landscape, create one that can live on the amount of rainwater harvested from the existing roof catchment. This can be accomplished through careful plant selection and by controlling the number of plants used. For the most efficient use of harvested rainwater, group plants with similar water requirements together. Remember that new plantings, even native plants, require special care and will need supplemental irrigation during the establishment period. This period can range from one to three years. *(Use the supply and demand calculations to determine the amount of water needed for new plantings.)* Use gutters and downspouts to convey the water from the roof to the storage area. *(Consult Appendix E for tips on selecting and installing gutters and downspouts.)*

Size storage container(s) large enough to hold your calculated supply. Provide for distribution to all planted areas. Locate storage close to plants needing water and higher than the planted area to take advantage of gravity flow. Pipes, hoses, channels, and drip systems can distribute water where it is needed. If you do not have gravity flow or if you are distributing through a drip system, you will need to use a small pump to move the water through the lines. Select drip irrigation system filters with 200 mesh screens. The screens should be cleaned regularly.

BALANCING SUPPLY AND DEMAND

System Maintenance

Developing a rainwater harvesting system is an on-going process that can be improved and expanded over time. Once the initial construction is complete, it will be necessary to "field test" your system during rain events. Determine whether the water is moving where you want it, or whether you are losing water. Also, determine if the holding areas are doing a good job of containing the water. Make changes to your system as required. As time goes on you may discover additional areas where water can be harvested or channeled. A rainwater harvesting system should be inspected before each rainy season and ideally after every rain event to keep the system operating at optimum performance.

MAINTENANCE CHECKLIST

- Keep holding areas free of debris
- Control and prevent erosion; block erosion trails
- Clean and repair channels
- Clean and repair dikes, berms, and moats
- Keep gutters and downspouts free of debris
- Flush debris from the bottom of storage containers
- Clean and maintain filters, including drip filters
- Expand the watering basins as plants grow

Monitor Water Use

Once your system is operating, it is recommended that you monitor landscape water use so you will know just how much water you are saving. If you have constructed rainwater-harvesting basins in an existing landscape, use last year's water bills to compare your pre-harvesting and post-harvesting water use. If you are adding new plants to a rainwater harvesting area, the water savings begin as soon as they are in the ground, and the savings continue every time they are irrigated with harvested rainwater!

APPENDIX A: RAINFALL DATA FOR ARIZONA CITIES AND TOWNS

INCHES OF AVERAGE MONTHLY RAINFALL DATA FOR ARIZONA CITIES AND TOWNS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Bullhead	0.95	0.99	0.93	0.17	0.08	0.01	0.29	0.68	0.44	0.37	0.41	0.52	**5.84**
Casa Grande	0.77	0.83	0.99	0.28	0.19	0.10	0.80	1.97	0.82	0.77	0.74	0.96	**9.22**
Chandler	1.10	0.99	0.94	0.32	0.17	0.15	0.50	0.62	0.53	0.84	0.67	0.76	**7.59**
Douglas	0.75	0.64	0.46	0.20	0.33	0.63	3.14	2.88	1.63	1.30	0.74	1.06	**13.76**
Flagstaff	2.18	2.56	2.62	1.29	0.80	0.43	2.40	2.89	2.12	1.93	1.86	1.83	**22.91**
Gila Bend	0.62	0.87	0.72	0.20	0.15	0.04	0.76	1.20	0.53	0.52	0.56	0.84	**7.01**
Holbrook	0.71	0.66	0.72	0.37	0.38	0.20	1.17	1.51	1.18	1.07	0.66	0.57	**9.20**
Kingman	1.23	1.10	1.31	0.47	0.31	0.19	0.98	1.41	0.66	0.81	0.71	0.82	**10.00**
Marana	1.09	1.25	0.79	0.46	0.17	0.14	1.38	2.17	0.55	0.73	0.44	1.15	**10.32**
Mesa	1.01	0.99	1.19	0.33	0.17	0.06	0.89	1.14	0.89	0.81	0.77	0.98	**9.23**
Nogales	1.31	1.09	1.00	0.49	0.32	0.54	4.27	4.24	1.68	1.84	0.78	1.47	**19.03**
Page	0.61	0.48	0.66	0.50	0.40	0.14	0.58	0.69	0.66	0.99	0.56	0.48	**6.75**
Parker	0.87	0.70	0.65	0.17	0.09	0.02	0.27	0.61	0.57	0.32	0.33	0.57	**5.17**
Payson	2.33	2.34	2.68	1.15	0.66	0.37	2.42	2.97	1.81	1.89	1.70	1.75	**22.07**
Phoenix	0.83	0.77	1.07	0.25	0.16	0.09	0.99	0.94	0.75	0.79	0.73	0.92	**8.29**
Pinetop	2.00	1.90	1.63	0.88	0.83	0.72	2.82	3.72	2.59	1.84	1.74	1.93	**22.60**
Prescott	1.58	1.87	1.91	0.76	0.64	0.40	2.87	3.28	2.07	1.28	1.25	1.28	**19.19**
Safford	0.74	0.78	0.61	0.22	0.27	0.31	1.45	1.72	1.12	1.10	0.56	0.91	**9.79**
Scottsdale	1.01	1.06	0.96	0.35	0.17	0.11	0.99	1.05	0.87	0.97	0.88	0.99	**9.41**
Sierra Vista	1.19	0.65	0.44	0.36	0.26	0.38	3.01	3.85	1.29	1.16	0.45	0.98	**14.02**
Springerville	0.50	0.50	0.49	0.27	0.45	0.53	2.52	3.11	1.49	1.08	0.57	0.48	**11.99**
Tempe	1.01	1.04	1.15	0.25	0.21	0.07	0.89	1.20	0.86	0.85	0.80	1.03	**9.36**
Tuba City	0.55	0.52	0.59	0.27	0.32	0.17	0.66	0.69	0.98	0.85	0.43	0.32	**6.35**
Tucson	0.99	0.88	0.81	0.28	0.24	0.24	2.07	2.30	1.45	1.21	0.67	1.03	**12.17**
Wilcox	1.11	0.95	0.68	0.25	0.35	0.40	2.36	2.59	1.27	1.36	0.73	1.30	**13.35**
Williams	2.08	2.37	2.32	1.00	0.80	0.48	2.54	3.01	1.73	1.77	1.75	1.52	**21.37**
Yuma	0.38	0.28	0.27	0.09	0.05	0.02	0.23	0.61	0.26	0.26	0.14	0.42	**3.01**

Precipitation

Normal for Period 1971 – 2000 (National Weather Service)

APPENDIX B: EVAPOTRANSPIRATION FOR ARIZONA CITIES AND TOWNS

AVERAGE EVAPOTRANSPIRATION (ET) FOR ARIZONA CITIES AND TOWNS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Annual**
Bullhead	2.92	3.48	5.68	7.56	9.78	9.97	9.24	8.35	6.63	5.33	3.67	3.30	**75.91**
Casa Grande	2.31	3.16	5.17	7.24	9.55	10.28	10.00	8.75	7.00	5.18	3.00	2.14	**73.78**
Chandler	2.38	2.87	4.66	6.38	8.71	9.39	9.02	8.28	6.60	4.59	2.75	2.24	**67.87**
Douglas	3.16	3.58	5.07	6.68	8.67	9.72	8.10	7.31	6.58	5.41	3.64	2.82	**70.74**
Flagstaff	1.61	1.74	2.85	4.24	5.79	7.09	6.46	5.63	4.64	3.21	2.13	1.74	**47.13**
Gila Bend	2.66	3.26	4.75	6.99	9.24	10.18	9.78	8.76	6.95	5.40	3.36	2.48	**73.81**
Holbrook	1.48	2.15	3.27	4.83	6.87	8.09	8.10	7.20	5.81	4.06	2.34	1.48	**55.69**
Kingman	2.82	3.37	4.40	6.03	7.87	9.40	9.56	8.44	6.89	4.96	3.53	2.48	**69.74**
Marana	3.16	3.72	5.70	7.44	9.72	10.59	9.53	8.26	7.28	5.94	3.97	2.79	**78.10**
Mesa	2.38	2.87	4.66	6.38	8.71	9.39	9.02	8.28	6.60	4.59	2.75	2.24	**67.87**
Nogales	3.16	3.68	4.62	6.25	8.10	9.07	7.98	7.31	6.47	5.30	3.53	2.71	**68.19**
Page	1.58	2.25	3.73	5.81	8.10	9.72	9.45	8.44	6.58	4.51	2.45	1.48	**64.10**
Parker	2.83	3.51	5.69	8.07	10.34	11.12	10.85	9.59	7.70	5.81	3.64	2.26	**81.41**
Payson	2.04	2.35	3.16	4.73	6.64	8.21	7.87	6.53	5.70	3.95	2.66	1.92	**55.77**
Phoenix	2.38	2.87	4.66	6.38	8.71	9.39	9.02	8.28	6.60	4.59	2.75	2.24	**67.87**
Pinetop	1.58	1.95	2.82	4.19	5.63	6.47	6.08	5.07	4.40	3.61	2.34	1.47	**45.59**
Prescott	1.89	2.86	3.73	5.38	6.08	9.07	8.67	6.98	6.68	4.51	2.99	2.15	**60.99**
Safford	2.69	3.41	5.48	7.52	9.63	10.31	9.18	7.42	6.35	6.08	3.24	2.38	**73.69**
Scottsdale	2.38	2.87	4.66	6.38	8.71	9.39	9.02	8.28	6.60	4.59	2.75	2.24	**67.87**
Sierra Vista	2.80	3.21	4.60	6.21	7.97	9.04	7.74	7.07	6.21	4.37	3.17	2.58	**64.97**
Springerville	1.48	1.95	2.82	4.07	5.29	6.46	6.08	5.52	4.40	3.61	2.01	1.36	**45.07**
Tempe	2.38	2.87	4.66	6.38	8.71	9.39	9.02	8.28	6.60	4.59	2.75	2.24	**67.87**
Tuba City	1.36	1.95	3.27	4.62	6.98	8.42	8.10	7.31	6.03	4.06	2.23	1.25	**55.58**
Tucson	2.52	3.19	5.07	6.82	8.61	9.59	8.95	7.75	6.68	4.96	3.02	2.16	**69.32**
Wilcox	2.45	3.04	4.96	6.66	8.26	9.23	8.35	6.94	5.99	4.77	3.09	2.19	**65.93**
Williams	1.36	1.65	2.82	4.07	5.30	7.12	6.75	5.63	4.94	3.61	2.00	1.70	**46.96**
Yuma	3.27	3.79	5.67	7.24	9.16	10.21	10.50	9.67	7.92	5.87	3.80	3.10	**80.20**

Standardized Reference Evapotranspiration

Yuma, Bullhead, Tucson, Phoenix computed by ASMET
Nogales, Prescott, Kingman, Williams, Payson estimated using Yitayew*
Flagstaff: computed from local weather data

Yitayew, M. 1990. Reference Evapotranspiration Estimates for Arizona. Tech.
I Bull.266. Agr.Exp.Stn.Col. of Agr. University of Arizona

APPENDIX C: RUNOFF COEFFICIENTS

ROOF	**HIGH**	**LOW**
Metal, gravel asphalt shingle, fiberglass mineral paper	0.95	0.90
PAVING		
Concrete, asphalt	1.00	0.90
GRAVEL	0.70	0.25
SOIL		
Flat, bare	0.75	0.20
Flat, heavy soil	0.60	0.10
LAWN		
Flat, sandy soil	0.10	0.05
Flat, heavy soil	0.17	0.13

APPENDIX D: PLANT WATER USE COEFFICIENTS

The Plant Water Use Coefficient represents the water needs of a particular plant relative to the rate of evapotranspiration (ET). Thus, a low-water use plant requires only 20 percent of ET, but a high-water use plant requires 75 percent of ET. Supplemental water must be supplied in areas where a plant's water use requirement *(demand)* exceeds the amount of water available from precipitation *(supply)*. If you are unsure of a plant's water use requirement, consult "Landscape Plants for the Arizona Desert" guide to growing more than 200 low-water-use plants.

PLANT TYPE	**PERCENTAGE**
Low Water Use	0.20
Medium Water Use	0.50
High Water Use	0.75

APPENDIX E: GUIDELINES FOR RAIN GUTTERS AND DOWNSPOUTS

Gutters and downspouts are key components for the system for distributing rainwater to plants. They should be properly sized and durable, but they should also be attractive and well suited to the building they are used on.

The following are general guidelines for the use of gutters and downspouts. Particular applications may vary, depending on the type of gutter selected and any special considerations, such as snow load or roof type. Consult a company that specializes in gutter design and installation for more information.

Gutters

- Select gutters that are at least five-inches wide.
- Select galvanized steel *(29-gauge minimum)* or aluminum *(0.025-inch minimum)* gutters.
- To enhance flow, slope sectional gutters 1/16 of an inch per one foot of gutter; slope seamless gutters 1/16 of an inch per 10-feet.
- If a straight run of gutter exceeds 40-feet, use an expansion joint at the connection.
- Keep the front of the gutter ½-inch lower than the back.
- Provide gutter hangers at least every three-foot. Space hangers every one-foot in areas of heavy snow load.
- Select elbows in 45, 60, 75, or 90-degree sizes.

Downspouts

- Space downspouts from 20 to 50 feet apart.
- Provide one square inch of downspout area for every 100 square feet of roof area. A two-inch by three-inch downspout will accommodate 600 to 700 square feet; a three-inch by four-inch downspout will accommodate up to 1,200 square feet.
- Do not exceed 45-degree angle bends.
- Select downspouts in configurations: square, round, and corrugated round, depending on your needs. Both gutters and downspouts come in a variety of maintenance-free finishes.
- Use four-inch diameter pipe to convey water to the storage container or filter.

APPENDIX F: SUPPLY AND DEMAND WORKSHEETS

WORKSHEET #1: SUPPLY CALCULATIONS

	A	B	C	D	E	F
Follow the lettered instructions for each month	From Appendix A enter the rainfall amount in inches for each month	Multiply "A" by 0.623 to convert inches to gallons per square foot	Enter the square footage of the catchment surface	Multiply "B" by "C" This is the gross gallons of rainfall per month	Enter the runoff coefficient for your catchment surface	Multiply "D" by "E" This is the total monthly yield of harvested rainwater in gallons
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Totals						

WORKSHEET #2: DEMAND CALCULATIONS (METHOD 1)

	A	B	C	D	E	F
Follow the lettered instructions for each month	From Appendix B enter the ET amount in inches for each month	Multiply "A" by 0.623 to convert inches to gallons per square foot	From Appendix D enter the appropriate plant water use coefficient	Multiply "B" by "C" to obtain plant water needs in gallons	Enter the total square footage of landscaping	Multiply "D" by "E" This is your total landscaping demand in gallons
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Totals						

WORKSHEET #3: DEMAND CALCULATIONS (METHOD 2)

Month	**Monthly Use** *(CCF)*	**Average Winter Use** *(CCF)*	**Landscape Use** *(CCF)*	**Convert CCF to Gallons**	**Landscape Use** *(Gallons)*
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					

WORKSHEET #4: STORAGE/MUNICIPAL USE CALCULATIONS

Month	**Yield**	**Demand Storage**	**Cumulative Storage** *(yield-demand)*	**Supplemental Use**
Year 1 January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
Year 2 January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				

APPENDIX G: WHERE TO GO FOR MORE INFORMATION

Publications

Landscape Plants for the Arizona Desert, by AMWUA Regional Water Conservation Committee. Ironwood Press, 2004.

Rainwater Harvesting for Drylands Volume 1 Guiding Principles, by Brad Lancaster. Rainsource Press, 2006.

Rainwater Harvesting for Drylands Volume 2 Water-Harvesting Earthworks, by Brad Lancaster. Rainsource Press, 2008.

Residential Gray Water Information Guide, by Justin Cupp and C. Alan Nichols. City of Tucson, 2011.

Other Rainwater Harvesting Guides

Harvesting Rainwater for Landscape Use, by Patricia H. Waterfall. Arizona Department of Water Resources, 2006.

Texas Guide to Rainwater Harvesting, Second Edition, by Wendy Price Todd and Gail Vittori. Texas Water Development Board, 1997.

Water Harvesting Guidance Manual, by Ann Audrey Phillips. City of Tucson, Department of Transportation, Stormwater Management Section, 2005.

Organizations

American Rainwater Catchment Systems Association
arcsa.org

NOTES:

NOTES:

NOTES:

Water Smart

DO YOUR PART, BE WATER SMART

☎ (520) 791-4331
(520) 791-2639 TDD

tucsonaz.gov/water/rebate

youtube.com/tucsonwater

Scan

For materials in an accessible format or in a language other than English, call Tucson Water.

TUCSON WATER

CITY OF TUCSON

Printed on recycled paper