Rainwater Harvesting

SUPPLY FROM THE SKY

A PUBLICATION OF THE CITY OF ALBUQUERQUE

LETTER FROM THE MAYOR

Dear Neighbor,

On behalf of the City of Albuquerque, I am pleased and excited to present *Rainwater Harvesting: Supply from the Sky*. This guide was developed by the City's Water Conservation Office to assist city residents and businesses in the campaign to save water.

Achieving our community's ambitious water conservation goals will not come easily. Doing so will require that we as a community adopt a "water ethic," and that all of us make conservation part of our daily lives. I believe this guide can help in that regard because rainwater harvesting, by its very nature, reconnects people to the environment they live in. It teaches natural limits while showing that human ingenuity can stretch those limits through improvements in efficiency and overall water management. Indeed, rainwater harvesting is the perfect combination of supply-side and demand-side management techniques, increasing the supply of water while simultaneously promoting demand-side reductions. Perhaps most importantly, rainwater harvesting fosters an awareness of one's personal water use and of the amount of water available from rainfall alone. And, it's something anyone can do.

So read this guide, share it with your friends and neighbors, and let us know what you think about it. But above all, use it to take advantage of the "supply from the sky." If each of us does just a little to act on the advice contained within these pages, we will have taken a big step toward ensuring an adequate water supply for our community today and in the future.

Sincerely,

Jim Baca

Jim Baca, Mayor
City of Albuquerque

"Achieving the higher savings will require that the City effectively reach out and engage large segments of the public in a shared mission to save water. In that regard, Albuquerque will need to establish a water ethic that ripples throughout the entire community, one that can fuel the program to go above and beyond what has been done elsewhere."

From:
Water Conservation Rates and Strategy Analysis, March 1995

ACKNOWLEDGEMENTS

CITY OF ALBUQUERQUE
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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 art-work. We are grateful to ADWR for allowing us to borrow freely from their publication.

This guide was revised to incorporate New Mexico-specific data and reformatted to accommodate the needs of the City of Albuquerque. Draft production was handled by Kevin Bean, of K.M. Bean Environmental Consulting; Doug Bennett, Albuquerque's Irrigation Conservation Manager; and Eva Khoury, an Intern with the Water Resources Division of the Albuquerque Public Works Department. Technical assistance was provided by Andrew Selby of the Mayor's Office, and by Kay Lang of the Albuquerque Environmental Health Department. Cooney, Watson & Associates handled final production. Final design was provided by Ken Wilson Design.

TO ORDER:

Albuquerque residents may order this document from the City's Water Conservation Office, P.O. Box 1293, Albuquerque, NM 87103.
505-768-3655 (phone), 505-768-3629 (fax), 768-2477 (TTY) or Relay NM 1-800-659-8331. (www address: http://www.cabq.gov/resources.)

If you live outside of Albuquerque, please contact the Office of the State Engineer, Water Use and Conservation Bureau, P.O. Box 25102, Santa Fe, N.M. 87504-5102. Orders may also be placed by phone at 1-800-WATERNM.

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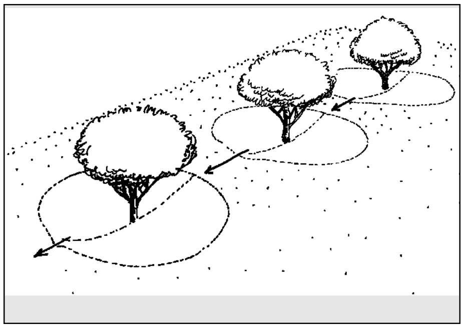
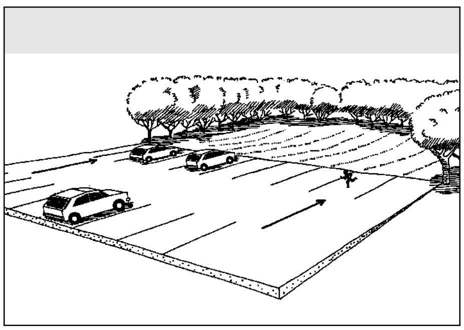


Series of water harvesting basins on a slope.



Parking lot draining into concave lawn area.

IMPORTANT NOTES

1. This Guide applies to landscape uses of harvested water only. The use of rainwater for drinking is beyond the scope of this publication.

2. Before you start, check with your local building, zoning and environment departments to determine what plumbing requirements, height and local restrictions, neighborhood covenants, or other regulations or guidelines might apply to your project.

In the arid Southwest rainfall is scarce and frequently erratic. These conditions require that water be used as efficiently as possible, and that we 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 Albuquerque, about 15 billion gallons of water a year are used for landscape irrigation.

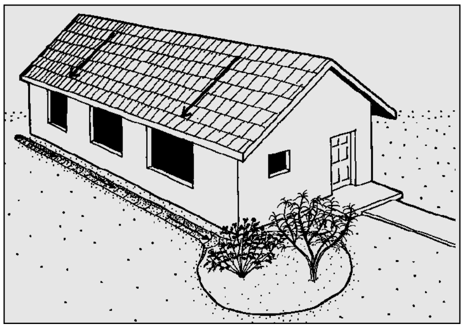
Rainwater harvesting can reduce the use of drinking water for landscape irrigation. Coupled with the use of native and desert-adapted plants, rainwater harvesting is an effective water conservation tool because it provides "free" water that is not from the municipal supply. Water harvesting not only reduces dependence on groundwater and the amount of money spent on water, but it can reduce off-site flooding and erosion as well. If large amounts of water are held in highly permeable areas (areas where water penetrates the soil quickly and easily), some water may percolate to the water table.

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, 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. The limitations of water harvesting systems are few and are easily met by good planning and design. There are many water harvesting opportunities on developed sites, and even small yards can benefit from water harvesting. And, water harvesting can easily be planned into a new landscape during the design phase. So whether your landscape is large or small, the principles outlined in this manual apply.

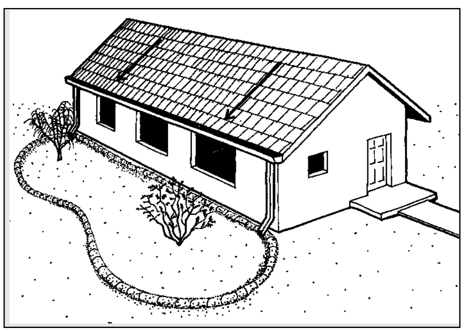
RAINWATER HARVESTING SYSTEM COMPONENTS

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). Water 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.



Simple system—roof catchment, channel, and planted landscape holding area.

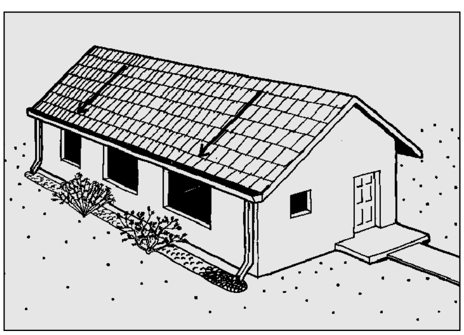
Rainfall. Rainwater "runoff" refers to rainwater that flows off a surface. If the surface is impermeable, runoff occurs immediately. If the surface is permeable, runoff will not occur until the surface is saturated. Runoff can be harvested (captured) and used immediately to water plants or stored for 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.



Simple system—roof catchment, gutters, and bermed landscape holding area.

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.

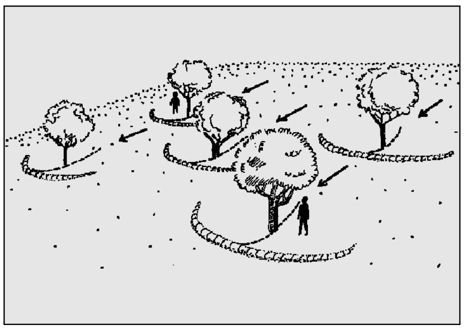
Water Collection and Distribution Systems. Most people can design a rainwater collection and distribution system to meet the needs of their existing site. Designing a system into new construction allows one to be more elaborate and thorough in capturing and routing rainwater. In the case of very simple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



Simple system—roof catchment, gutters, downspouts, and french drain.

SIMPLE RAINWATER HARVESTING SYSTEMS

A simple water 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 water 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. In some cases, small containers are used to hold water for later use.



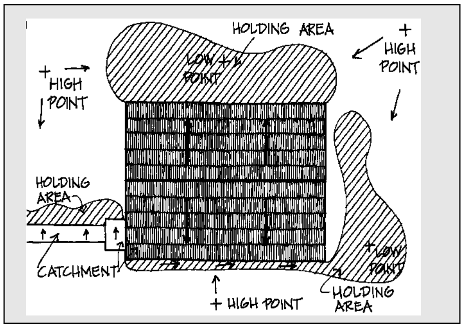
Crescent-shaped landscape holding areas on a slope.

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 water harvested depends on the size, surface texture, and slope of the catchment area.

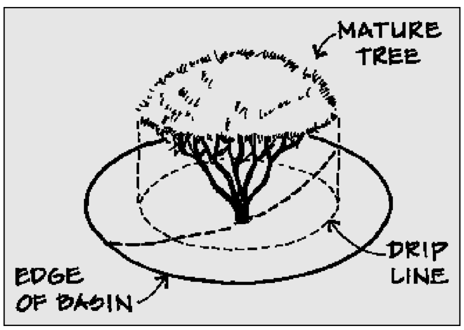
Distribution Systems. These systems connect catchments to the landscape holding areas. Distribution systems direct water flow, and can be simple or sophisticated. For example, gutters and downspouts direct roof water to a holding area, and gently sloped sidewalks distribute water to a planted area. Hillsides provide a perfect situation for moving water from a catchment to a 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 isn't 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. These areas store water in the soil for direct use by the plants. Concave depressions planted with grass or plants serve as landscape holding areas. These areas contain 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. 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).

SIMPLE RAINW ATER HARVESTING SYSTEM DESIGN & CONSTRUCTION



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



Tree dripline and basin edge.

FREE XERISCAPE GUIDE

The City of Albuquerque and the New Mexico Office of the State Engineer offer a free, full-color How-to Guide to Xeriscaping that contains many examples of low-water use, drought-tolerant plants. To request your copy, call 768-3655 (Albuquerque residents), or 1-800-WATERNM (all others).

Step #1. Design the Collection and Distribution System.

By observing your landscape during a rain, you can locate the existing drainage patterns on your site. Use these drainage patterns and gravity flow to move water from catchments to planted areas.

If you are harvesting rainwater from a roof, extend downspouts to reach planted areas or provide a path, drainage, or hose to move the water where it is needed. Take advantage of existing sloped paving to catch water and redistribute it to planted areas. The placement and slope of new paving can be designed to increase runoff. If sidewalks, terraces, or driveways are not yet constructed, slope them 2 percent (1/4 inch per foot) toward planting areas and use the runoff for irrigation. Soil can also serve as a catchment by grading the surface to increase and direct runoff.

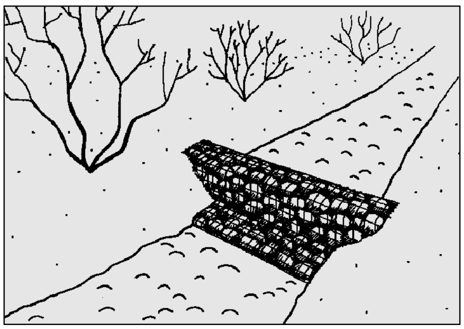
Step #2. Design Landscape Holding Areas.

Next, locate and size your landscape holding areas. Locate landscape depressions that can hold water or create new depressions where you want to locate plants. (To avoid structural or pest problems, locate holding areas at least 10 feet from any structures.) Rather than digging a basin around existing plants, construct level 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.

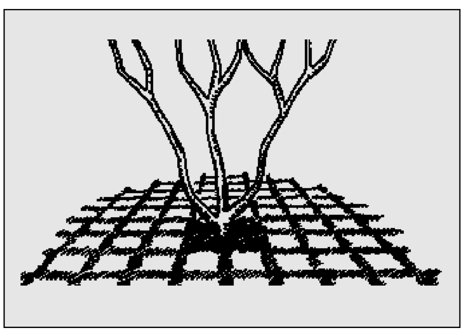
Step #3. Select Plant Material.

Proper plant selection is a major factor in the success of a water 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 of time, so careful plant selection for these low-lying areas is important. Select plants that can withstand prolonged drought and prolonged inundation, such as native 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.

SIMPLE RAINWATER HARVESTING SYSTEM DESIGN AND CONSTRUCTION



Gabion in a stream bed.



Permeable paving blocks with grass.

STOP!

Call 1-800-321-ALERT (2537) before you dig to locate utility lines on your property. This will minimize the potential for line breaks, and could save your life.

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 also 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're 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 too sandy and will not hold water for any length of time, you may wish to add composted organic matter to the soil to increase its moisture-holding potential. (This is not necessary with native or desert-adapted plants.) After planting, apply a 1.5 - 2 inch layer of mulch to reduce evaporation (but realize organic mulches may float).

HARVESTING WATER 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.

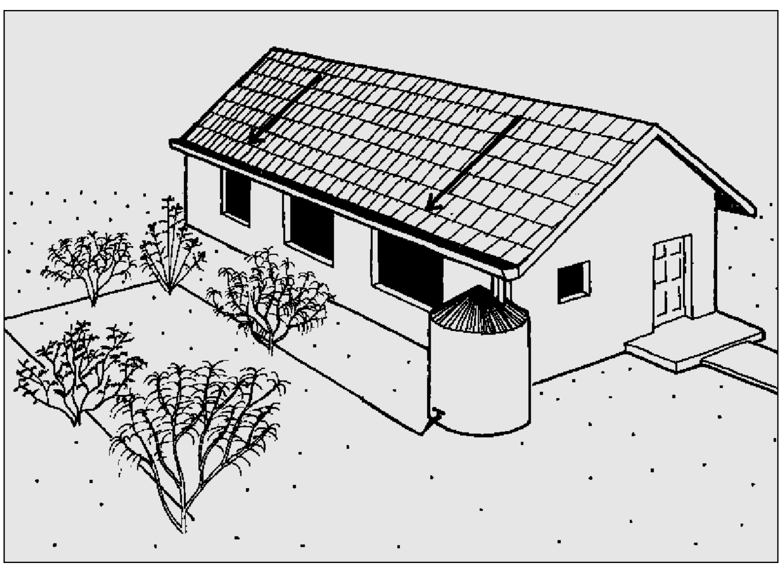
Water harvesting can reduce these problems. Crescent-shaped berms constructed around the base of a plant are useful for slowing and holding water on slopes. Gabions (a stationary grouping of large rocks encased in a wire mesh) are widely used to contain water and reduce erosion. French drains (holes 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 plants with large, extensive root systems. Another option on steep slopes is terrace grading to form stairstep-like shelves. By slowing runoff and allowing it to soak into the ground, rainwater harvesting can turn a problem into an asset.

COMPLEX RAINWATER HARVESTING SYSTEMS

Water 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. New Mexico'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 rootzones have been thoroughly wetted: at this point water may begin to run off or stand on the surface.) With a complex water harvesting system this excess water is stored for later use.

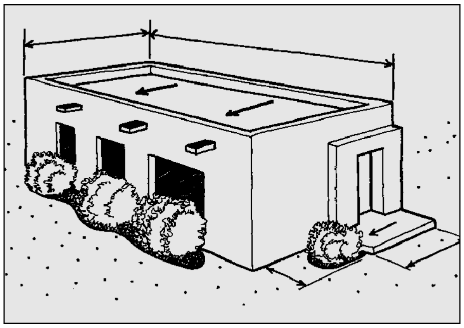
A frequently-asked question is whether a complex water harvesting system can collect and store enough water in an average year to provide sufficient irrigation for an entire landscape. The answer is yes, so long as the amount of water harvested (the supply) and the water needed for landscape irrigation (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.

Rainwater 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 the storage container, 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. For most people, the appropriate choice is to 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.

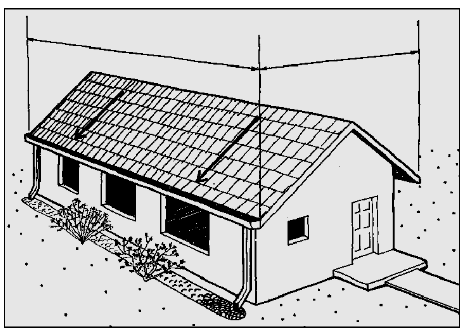


Complex water harvesting system with roof catchment, gutter, downspout, storage, and drip distribution system.

ELEMENTS OF A COMPLEX RAINWATER HARVESTING SYSTEM



Catchment area of flat roof = Length x width



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

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.

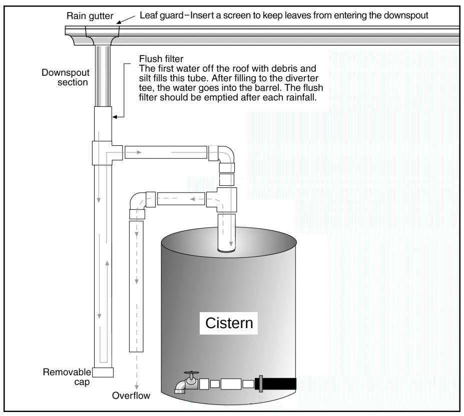
Catchments. The amount of water or "yield" that a catchment will provide depends on its size and surface texture. Concrete, asphalt, or brick paving and smooth-surfaced roofing materials provide high yields. Bare soil surfaces provide harvests of medium yield, with compacted clay soils yielding the most. 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. (This is not necessarily a problem, depending on whether you want to use the collected water directly or store it for later use.)

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 VI for guidelines on gutters and downspouts.)

TABLE–1
ANNUAL APPROXIMATE SUPPLY FROM ROOF CATCHMENT

Inches/ Rainfall	Gallons/ Square Foot
0	0
1	0.6
2	1.3
3	1.9
4	2.5
5	3.1
6	3.7
7	4.4
8	5.0
9	5.6
10	6.2
11	6.8
12	7.5
13	8.1
14	8.7
15	9.3

ELEMENTS OF A COMPLEX RAINWATER HARVESTING SYSTEM

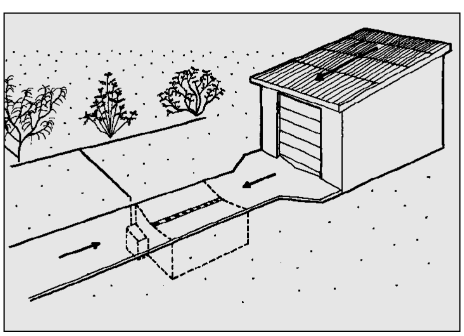


Roofwasher system

TABLE–2
CALCULATING ROOFWASHER SYSTEM CAPACITY

Pipe Diameter

4 inches	= 0.65 gallons/foot
6 inches	= 1.47 gallons/foot
8 inches	= 2.61 gallons/foot



Roof catchment with sloping driveway, french drain, and underground storage.

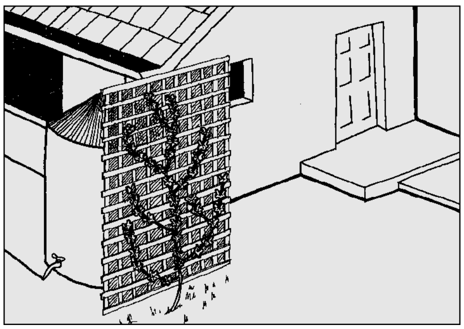
Storage. Storage allows full use of excess rainfall by making water available when it is needed. Before the water is stored, however, it should be filtered to remove particles and debris. The degree of filtration necessary depends on the size of the distribution tubing and emission devices (drip systems 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 containers can be located under or aboveground, and made of polyethylene, fiberglass, wood, concrete, or metal. Underground containers are more expensive due to the cost of soil excavation and removal. Pumping water out of these containers adds to their cost. Ease of maintenance should also be considered. Swimming pools, stock tanks, septic tanks, ferrocement culverts, concrete blocks, poured-in-place concrete, or building rocks can be used for underground storage.

Examples of aboveground containers include 55-gallon plastic or steel drums, barrels, tanks, cisterns, stock tanks, fiberglass fishponds, and swimming pools. 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 distance between the container and place of use. Look under "Tanks," "Feed Dealers," "Septic Tanks," or "Swimming Pools" in the Yellow Pages to locate storage containers. Salvaged 55-gallon drums may be available from local businesses, but should you choose to use them, take care to use only those drums that are free of any toxic residues.

ELEMENTS OF A COMPLEX RAINWATER HARVESTING SYSTEM



Vine used to screen storage tank.

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 (cleaning) are essential.

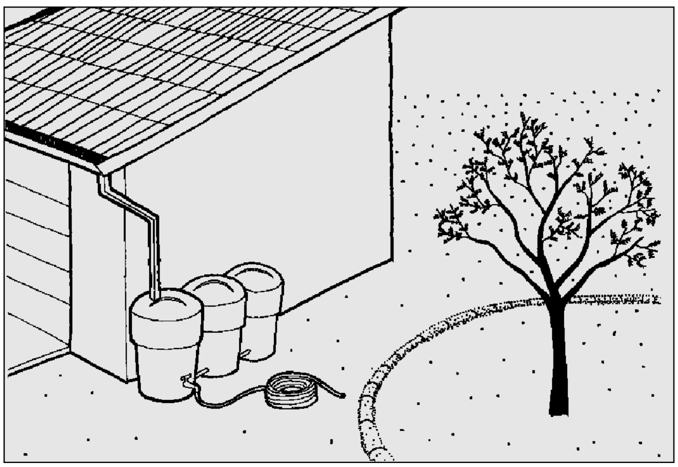
Locate storage near or at the end of downspouts. If storage is unsightly, it can be designed into the landscape in an unobtrusive place or hidden with a structure, screen, and/or plants. In all cases, storage should be located close to the area of use and placed at an elevated level to take advantage 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 is 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 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 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.

To continue using a drip or other integrated distribution system in the event of a rainwater shortfall, and to avoid the need for dual systems, provisions should be made for adding water to your container or distribution system from an auxiliary source. Connection of the distribution system to a municipal or private water supply requires the use of an "air gap" or other approved backflow prevention device. If such a source is unavailable, ensure your pump will turn off automatically when there is no water in the tank. *These integrated distribution systems can be rather complex: check your local plumbing and building codes to ensure your system is in compliance.*

COMPLEX RAINWATER HARVESTING SYSTEM DESIGN & CONSTRUCTION

If you are designing a complex water 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 water 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.



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

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 existing drainage flow patterns by observing your property during a rain. Show the direction of 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.

Next, 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 (see below), 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 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.

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/Municipal 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.

$$\text{SUPPLY (in gallons)} = \text{Inches of Rainfall} \times .623 \times \text{Catchment Area (square feet)} \times \text{Runoff Coefficient}$$

CALCULATING SUPPLY

Multiply rainfall in inches (see Appendix I) by .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 III) to obtain the available supply. (The runoff coefficient is the percentage of total 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.)

RAINFALL TABLES

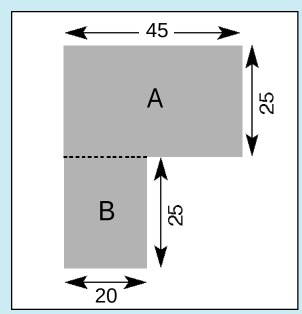
Monthly average rainfall amounts for 39 different locations in New Mexico are listed in Appendix I on page 18.

EXAMPLE 1: CALCULATING SUPPLY

Eva wants to build a rainwater harvesting system for her home in Albuquerque. From Appendix I, she enters the 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, then multiplies the gallons per SF in Column B by the square footage in Column C to determine the total gallons of rainfall each month. Since the asphalt shingle roof won't shed all of the rainfall, Eva finds the appropriate runoff coefficient (0.9) in Appendix II and enters it in Column E.

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

SAMPLE SUPPLY WORKSHEET

	A	B	C	D	E	F
Follow the lettered instructions for each month.	From Appendix I 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.	From Appendix II enter the runoff coefficient for your catchment surface.	Multiply "D" by "E." This is the total monthly yield of harvested water in gallons.
January	0.39	0.243	1,625	395	0.9	355
February	0.40	0.249	1,625	405	0.9	365
March	0.48	0.299	1,625	486	0.9	437
April	0.50	0.312	1,625	507	0.9	456
May	0.61	0.380	1,625	618	0.9	556
June	0.65	0.405	1,625	658	0.9	592
July	1.31	0.816	1,625	1,326	0.9	1,193
August	1.52	0.947	1,625	1,539	0.9	1,385
September	1.02	0.635	1,625	1,032	0.9	929
October	0.81	0.504	1,625	819	0.9	737
November	0.48	0.299	1,625	486	0.9	437
December	0.49	0.305	1,625	496	0.9	446
Annual Totals	8.66			8,767		7,888

SAMPLE DEMAND WORKSHEET (METHOD 1)

	A	B	C	D	E	F
Follow the lettered instructions for each month.	From Appendix III enter the ET amount in inches for each month.	From Appendix IV enter the plant demand according to its water needs.	Multiply "A" by "B" to obtain plant water needs in inches.	Multiply "C" by 0.623 to convert inches to gallons per square foot.	Enter the total square footage of landscaping.	Multiply "E" by "D." This is your total landscaping demand in gallons.
January	0.38	0.50	0.19	0.12	1,200	142
February	0.64	0.50	0.32	0.20	1,200	239
March	1.44	0.50	0.72	0.45	1,200	538
April	2.76	0.50	1.38	0.86	1,200	1,032
May	4.58	0.50	2.29	1.43	1,200	1,712
June	6.37	0.50	3.18	1.98	1,200	2,381
July	7.17	0.50	3.58	2.23	1,200	2,680
August	6.43	0.50	3.21	2.00	1,200	2,404
September	4.42	0.50	2.21	1.38	1,200	1,652
October	2.52	0.50	1.26	0.78	1,200	942
November	0.93	0.50	0.46	0.29	1,200	348
December	0.46	0.50	0.23	0.14	1,200	172
Annual Totals	38.1		23.75			14,242

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. (HELPFUL HINT: When installing a new landscape, group plants with similar water requirements together. This makes it easier to calculate the amount of water needed to maintain those plants.)

CALCULATING DEMAND, METHOD 1 :

DEMAND = ET (in inches) x PLANT FACTOR x .623 x IRRIGATED AREA

This method for calculating demand is based on monthly evapotranspiration (ET) information. (Appendix III provides ET information for six different regions in New Mexico.) ET is multiplied by the "Plant Water Use Coefficient," which represents the percentage of ET needed by the plant. (See Appendix IV for information on plant coefficients. In the example that follows, the plants require approximately 50 percent of ET.) Irrigated area refers to how much area is planted. (Do not include unplanted portions of the landscape in your calculation of demand.)

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 moderate 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 previous page), Eva calculates the potential water needs (demand) for her rainwater-irrigated area. From Appendix III, she enters the evapotranspiration rate for the Albuquerque area into Column A.

2. Since Eva's landscape is primarily moderate water use plants, she uses a plant coefficient of 0.5 (see Appendix IV). She enters this value in Column B.

3. She then multiplies A by B to get the estimated number of inches of water her plants will require. She enters the result in Column C.

4. She multiplies Column C by 0.623 to convert inches to gallons per square foot and 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 fully capitalize on the available rainfall she should have enough storage to accommodate her cumulative water storage needs (see Sample Worksheet on page 15 and sidebar on page 16).

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 March 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. In Albuquerque, 1 unit of water = 1 ccf). 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.

SAMPLE DEMAND WORKSHEET (METHOD 2)
Established Landscapes
Average Winter Consumption=9 CCF

Month	Monthly Use in CCF	Average Winter Use in CCF	Landscape Use in CCF	Convert CCF to Gallons	Landscape Use in Gallons
Jan	7	9	0	748	0
Feb	11	9	2	748	1,496
Mar	13	9	4	748	2,992
Apr	15	9	6	748	4,488
May	18	9	9	748	6,732
Jun	19	9	10	748	7,480
Jul	18	9	9	748	6,732
Aug	15	9	6	748	4,488
Sep	14	9	5	748	3,740
Oct	12	9	3	748	2,244
Nov	10	9	1	748	748
Dec	9	9	0	748	0

Calculate Storage/Municipal Water Requirement. Once you've calculated the potential water supply from harvested water and your landscape water demand, use a "checkbook" method to determine your monthly harvested water 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 the sample worksheets on page 12), 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.

WHAT IS EVAPOTRANSPIRATION?

Evapotranspiration, usually referred to as "ET" for convenience, 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 don't 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.

CALCULATING CUMULATIVE STORAGE & MUNICIPAL USE

The "Storage" column in this completed 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 Municipal Use column to indicate the amount of supplemental water needed to satisfy irrigation water demand for that month.

SAMPLE STORAGE/MUNICIPAL USE WORKSHEET

Month	Yield Gallons	Demand Storage	Cumulative Storage Gallons (yield-demand)	Municipal Use
Year 1				
Jan*	355	0	355	0
Feb*	365	0	720	0
Mar	437	538	619	0
Apr	456	1,032	43	0
May	556	1,712	0	1,113
Jun	592	2,381	0	1,789
Jul	1,193	2,680	0	1,487
Aug	1,385	2,404	0	1,019
Sep	929	1,652	0	723
Oct	737	942	0	205
Nov	437	348	89	0
Dec*	446	0	535	0
Year 2				
Jan*	355	0	890	0
Feb*	365	0	1,255	0
Mar	437	538	1,154	0
Apr	456	1,032	578	0
May	556	1,712	0	578
Jun	592	2,381	0	1,789
Jul	1,193	2,680	0	1,487
Aug	1,385	2,404	0	1,019
Sep	929	1,652	0	723
Oct	737	942	0	205
Nov	437	348	89	0
Dec*	446	0	535	0

*No demand is shown for the months of December through February in this example because it assumes rain falling on the landscape will be sufficient to meet water demand for those months, and that all harvested water will be put into storage. (Though not reflected here, November and March should also experience less demand for the same reason.)

As shown on the preceding page, Eva's landscape demand during the summer months will always require the use of a supplemental water supply. 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 water 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 the month in which rainfall occurs. Demand may increase when the weather is warmer than normal, and will increase as the landscape ages and plants grow larger. Demand will also be greater during the period of time when new plants are getting established.

CALCULATING YOUR MAXIMUM STORAGE REQUIREMENTS

To determine your maximum storage requirements, find the largest number in the cumulative storage column for year 2 on the preceeding page. In that example, February is the month with the most water in storage: 1,255 gallons. That figure represents the maximum amount of storage capacity required, which means that a container with approximately 1,300 gallons of storage capacity would suffice.

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

Options for increasing the supply include the following:

* Increase the catchment area or catchment (runoff) coefficient
* 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

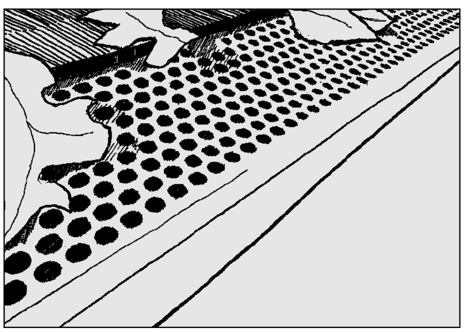
Step #3. Final design and construction—Use your site analysis information and your potential supply and demand calculations to size and locate catchment areas. If possible, size the catchment to accommodate the maximum landscape water requirement. If you cannot do this you may want to reduce plant water 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 water 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 water, 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 VI 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.

GRAVITY FLOW TIP BOX

GRAVITY FLOW EQUALS .433 POUNDS PER SQUARE INCH FOR EACH FOOT OF ELEVATION.

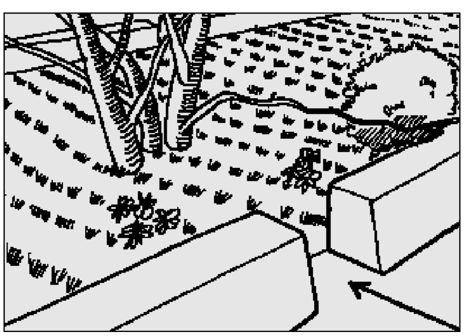
System Maintenance. Developing a water harvesting system is actually an ongoing process that can be improved and expanded over time. Once the initial construction is complete, it will be necessary to "field test" your system during rain events. Determine whether the water is moving where you want it, 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. Water harvesting systems should be inspected before each rainy season — and ideally after every rain event — to keep the system operating at optimum performance.



Gutter leaf filter.

TABLE–1
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 watering basins as plants grow.
- Monitor Water Use.
  Once your system is operating, it's recommended that you monitor landscape water use so you'll know just how much water you're saving. If you've constructed water harvesting basins in an existing landscape, use last year's water bills to compare your pre-harvesting and post-harvesting water use. If you're adding new plants to a water harvesting area, the water savings begin as soon as they're in the ground, and the savings continue every time they're irrigated with harvested rainwater!



Parking lot curb cutout directing water into planted area.

APPENDIX I

	*INCHES OF AVERAGE MONTHLY RAINFALL FOR NM TOWNS												
**NM Towns	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Abiquiu Dam	0.38	0.26	0.51	0.55	0.83	0.71	1.59	2.01	1.13	0.88	0.53	0.34	9.71
Alamogordo	0.73	0.52	0.46	0.32	0.50	0.83	2.13	2.13	1.68	1.05	0.54	0.81	11.68
Albuquerque	0.39	0.40	0.48	0.50	0.61	0.65	1.31	1.52	1.02	0.81	0.48	0.49	8.66
Animas	0.70	0.54	0.49	0.19	0.17	0.45	2.20	2.36	1.46	0.99	0.57	1.03	11.15
Belen	0.28	0.40	0.40	0.26	0.31	0.63	1.40	1.32	0.90	0.98	0.20	0.39	7.45
Bernalillo	0.43	0.49	0.56	0.43	0.58	0.55	1.47	1.50	0.83	0.95	0.44	0.47	8.68
Carlsbad	0.43	0.44	0.30	0.53	1.24	1.53	1.73	1.96	2.34	1.24	0.49	0.51	12.72
Clayton	0.27	0.40	0.65	1.21	2.39	1.91	2.64	2.31	1.68	1.09	0.50	0.38	15.44
Clines Corners	1.05	0.82	0.99	1.00	1.60	1.61	2.72	3.16	2.24	1.49	1.04	1.00	18.71
Clovis	0.43	0.43	0.59	1.04	2.10	2.60	2.62	2.96	2.16	1.61	0.56	0.60	17.71
Corrales	0.43	0.39	0.67	0.65	0.68	0.82	1.63	1.95	1.18	0.85	0.91	0.64	10.80
Crownpoint	0.52	0.51	0.49	0.50	0.36	0.67	2.06	1.89	0.85	0.85	0.46	0.61	9.75
Cuba	0.89	0.69	0.88	0.68	0.80	0.80	2.07	2.28	1.38	1.11	0.80	0.72	13.09
Deming	0.48	0.54	0.34	0.20	0.16	0.37	2.07	1.90	1.22	0.79	0.52	0.89	9.50
Española	0.47	0.43	0.59	0.58	0.89	0.75	1.50	1.94	1.00	0.90	0.57	0.50	10.12
Estancia	0.54	0.53	0.64	0.55	1.01	0.97	2.19	2.38	1.51	1.13	0.64	0.80	12.87
Farmington	0.58	0.50	0.55	0.51	0.36	0.46	0.80	1.07	0.83	1.11	0.49	0.62	7.89
Fort Sumner	0.39	0.40	0.44	0.59	1.16	1.47	2.42	2.81	1.80	1.37	0.55	0.49	13.90
Gallup	0.89	0.73	0.89	0.53	0.64	0.47	1.54	1.93	1.13	1.00	0.99	0.74	11.50
Grants	0.51	0.43	0.52	0.45	0.57	0.57	1.71	2.10	1.35	1.10	0.56	0.66	10.52
Hobbs	0.48	0.45	0.46	0.80	2.09	1.83	2.16	2.42	2.66	1.58	0.57	0.58	16.06
Jemez Springs	1.08	0.88	1.02	0.89	1.07	1.07	2.61	3.12	1.58	1.50	1.06	0.94	16.83
Las Cruces	0.52	0.33	0.23	0.21	0.33	0.66	1.46	2.27	1.31	0.82	0.46	0.76	9.17
Los Alamos	0.91	0.79	1.10	0.94	1.31	1.38	3.14	3.78	1.82	1.42	0.98	0.98	18.53
Los Lunas	0.35	0.42	0.46	0.44	0.49	0.57	1.23	1.76	1.21	1.06	0.46	0.53	8.98
Pecos	0.66	0.65	0.86	0.73	1.14	1.29	3.00	3.48	1.86	1.09	0.80	0.63	16.21
Raton	0.37	0.39	0.71	0.91	2.51	2.25	2.87	3.34	1.88	0.92	0.49	0.41	17.07
Roswell	0.42	0.46	0.29	0.60	1.33	1.63	2.01	2.48	2.16	1.06	0.51	0.59	13.52
Ruidoso	1.17	1.20	1.21	0.63	0.94	1.94	4.05	4.03	2.65	1.54	0.85	1.63	21.85
Sandia Park	3.10	1.24	1.44	0.93	1.14	1.12	3.00	3.00	1.83	1.40	1.31	1.20	20.44
Santa Fe	0.65	0.74	0.79	0.94	1.33	1.05	2.35	2.17	1.52	1.11	0.62	0.71	13.99
Shiprock	0.51	0.43	0.46	0.40	0.52	0.32	0.63	0.98	0.67	0.86	0.57	0.59	6.93
Silver City	1.25	0.85	0.84	0.55	0.21	0.58	2.78	2.48	1.91	1.21	0.49	1.07	14.17
Socorro	0.39	0.39	0.33	0.37	0.59	0.62	2.59	1.77	1.46	0.97	0.37	0.56	10.40
Taos	0.71	0.63	0.83	0.77	1.17	0.89	1.62	1.98	1.25	1.03	0.84	0.68	12.40
Tijeras	0.63	0.97	1.06	0.90	0.78	0.88	2.45	2.42	1.57	1.46	0.80	1.18	15.10
T or C	0.47	0.37	0.33	0.21	0.42	0.81	1.72	2.11	1.37	0.96	0.54	0.96	10.26
Tucumcari	0.26	0.47	0.39	0.87	1.49	1.78	3.30	2.40	1.46	0.94	0.50	0.27	14.11
Vaughn	0.44	0.44	0.35	0.51	0.92	1.60	1.99	2.56	1.41	0.87	0.41	0.38	11.87

* Data obtained from the Western Region Climate Center and the National Oceanic and Atmospheric Agency

** The average rainfall for more specific locations may vary from the averages shown here. In Albuquerque, for example, average rainfall ranges from 8.51 inches a year at the airport to 14.00 inches a year near the Sandia foothills.

APPENDIX II

RUNOFF COEFFICIENTS		
	HIGH	LOW
ROOF 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, with vegetation	0.60	0.10
LAWN Flat, sandy soil	0.10	0.05
Flat, heavy soil	0.17	0.13

APPENDIX III

	*AVERAGE EVAPOTRANSPIRATION FOR SELECTED AREAS IN NM												
Areas	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Northwestern Plateau (Gallup)	0	0.33	0.86	1.87	3.37	4.95	6.15	5.37	3.56	1.91	0.60	0	28.9
Northern Mtns. (Santa Fe)	0	0.30	0.68	1.56	2.82	4.26	5.05	4.51	3.02	1.63	0.52	0	24.3
Eastern Plains (Clovis)	0.35	0.55	1.27	2.53	4.31	6.23	7.00	6.30	4.26	2.42	0.91	0.45	36.5
Western Mtns. (Grants)	0.26	0.41	0.98	1.87	3.23	4.85	5.67	4.94	3.41	1.92	0.71	0.35	28.6
Central Valley (Albuquerque)	0.38	0.64	1.44	2.76	4.58	6.37	7.17	6.43	4.42	2.52	0.93	0.46	38.1
Central Highlands (Mountainair)	0.26	0.41	0.98	1.94	3.33	4.85	5.48	4.81	3.39	1.91	0.71	0.35	28.4
Southeastern Plains (Carlsbad)	0.52	0.78	1.68	3.10	4.95	6.79	7.33	6.66	4.69	2.84	1.17	0.66	41.1
Southern Desert (Las Cruces)	0.56	0.83	1.78	3.11	4.94	6.91	7.66	6.80	4.88	2.97	1.24	0.68	42.3

* Data obtained from the Toro Company, "Rainfall–Evapotranspiration Data," Form #490-1358

APPENDIX IV

PLANT WATER USE COEFFICIENTS	
PLANT TYPE	PERCENTAGE
Low Water Use	0.20
Medium Water Use	0.50
High Water Use	0.75

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. New plantings of all types require additional water. 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're unsure of a plant's water use requirements, consult the City of Albuquerque's Xeriscape Guide.

Low water use plants include grasses such as Blue Grama and trees such as Desert Willow.
Medium water use plants include grasses such as Buffalograss and trees such as Modesto Ash.
High water use plants include grasses such as Kentucky Bluegrass and trees such as Globe Willow.

Demonstration Garden photo courtesy of Santa Fe Greenhouses, Santa Fe, New Mexico

APPENDIX V

WORKSHEET #1: SUPPLY CALCULATIONS

	A	B	C	D	E	F
Follow the lettered instructions for each month.	From Appendix I 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 water 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 IV enter the ET amount in inches for each month.	From Appendix V enter the plant demand according to its water needs.	Multiply "A" by "B" to obtain plant water needs in inches.	Multiply "C" by 0.623 to convert inches to gallons per square foot.	Enter the total square footage of landscaping.	Multiply "E" by "D." 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 in CCF	Average Winter Use in CCF	Landscape Use in CCF	Convert CCF to Gallons	Landscape Use in Gallons
Jan					
Feb					
Mar					
Apr					
May					
Jun					
Jul					
Aug					
Sep					
Oct					
Nov					
Dec					

WORKSHEET #4:
STORAGE/MUNICIPAL USE
CALCULATIONS

Month	Yield Gallons	Demand Storage	Cumulative Storage Gallons (yield-demand)	Municipal Use
Year 1 Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				
Year 2 Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				

APPENDIX VI

GUIDELINES FOR GUTTERS AND DOWNSPOUTS

Gutters and downspouts are key components of 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're used on.

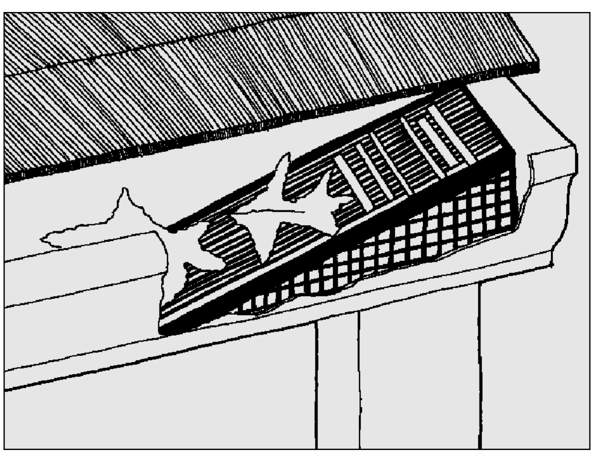
The following are general guidelines for the use of gutters and downspouts. Particular applications may vary, depending on the type of gutter selected and any special considerations, such as snow load or roof type. Consult a company that specializes in gutter design and installation for more information.

GUTTERS

- Select gutters that are at least 5 inches wide.
- Select galvanized steel (29-gauge minimum) or aluminum (.025-inch minimum) gutters.
- To enhance flow, slope sectional gutters 1/16 of an inch per 1 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 1/2 inch lower than the back.
- Provide gutter hangers at least every 3 feet. Space hangers every 1 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 1 square inch of downspout area for every 100 square feet of roof area. A 2-inch by 3-inch downspout will accommodate 600 to 700 square feet; a 3-inch by 4-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 4-inch diameter pipe to convey water to the storage container or filter.

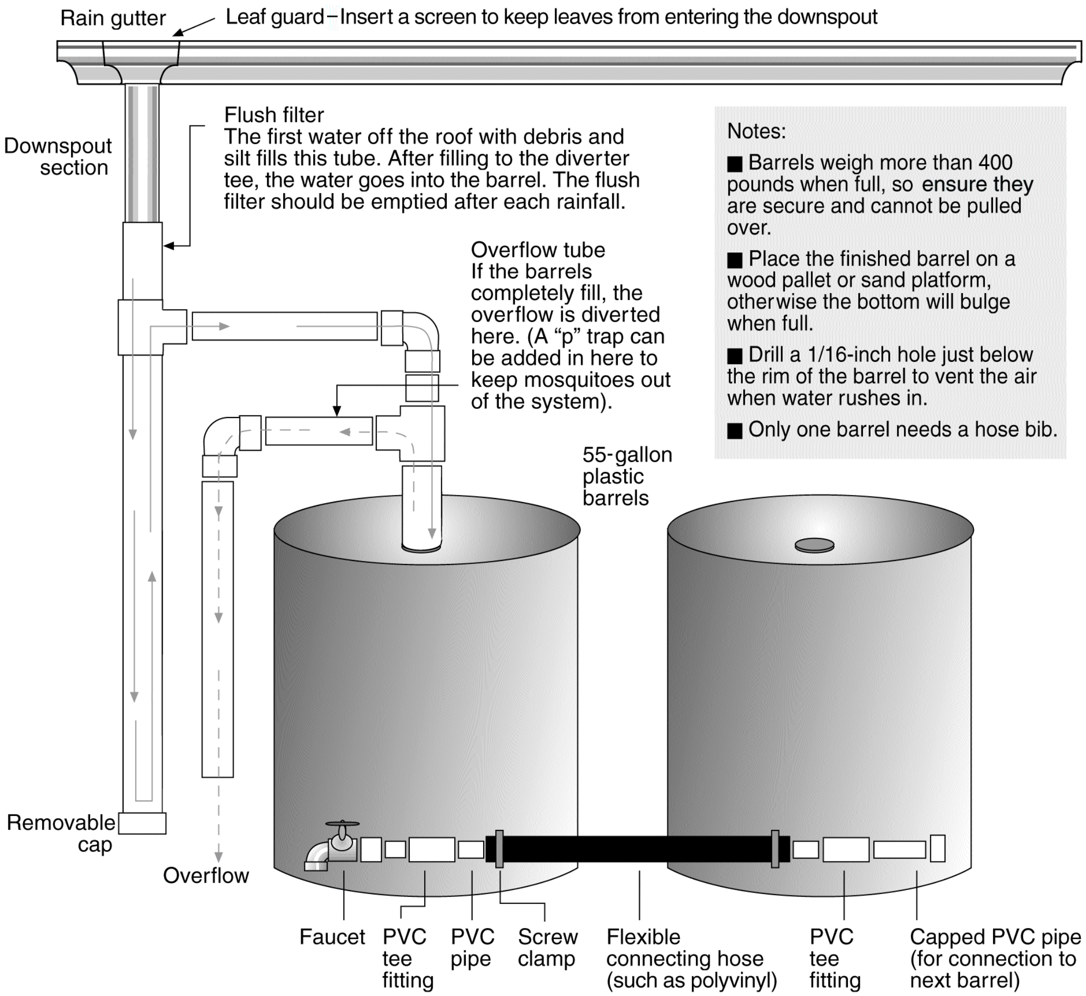


Gutter drain filter.

APPENDIX VII

HOW TO BUILD A RAINBARREL

BUILDING YOUR OWN RAIN BARREL SYSTEM



Notes:

- Barrels weigh more than 400 pounds when full, so ensure they are secure and cannot be pulled over.
- Place the finished barrel on a wood pallet or sand platform, otherwise the bottom will bulge when full.
- Drill a 1/16-inch hole just below the rim of the barrel to vent the air when water rushes in.
- Only one barrel needs a hose bib.

PUTTING THE BARREL PARTS TOGETHER

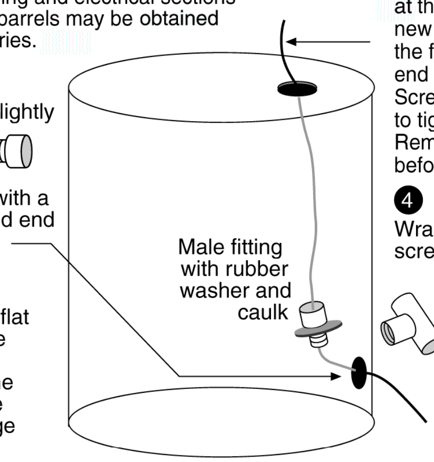
Parts can be found in the plumbing and electrical sections of building supply stores. Used barrels may be obtained from detergent or bakery industries.

1

Use a hole saw to cut a hole slightly smaller than your 3/4-or 1-inch male threaded fitting, about 3 inches above the bottom of the barrel. Enlarge with a file just enough so the threaded end of the fitting will slide in tightly.

2

Make a rubber washer from a flat rubber pad (use the same hole saw for the hole, then cut the outside with scissors). Push the washer over the threads of the fitting so it's snug. Apply a large bead of silicone caulk to the washer.



3

Slide a wire or string down through the hole at the top of the barrel, thread it through the new hole at the bottom, and use it to guide the fitting into position. Pull the threaded end to the outside.
Screw on a threaded electrician's lock nut to tighten. Allow caulk to dry several hours. Remove lock nut and add caulk near hole before adding next fitting.

4

Wrap teflon tape around the threads and screw on a female threaded tee fitting.

5

Glue a PVC connector for the faucet on one slip-joint end of the tee. On the other end, glue a short piece of PVC pipe. Attach a cap to this end, or if you're adding another barrel, slide on a length of polyvinyl black hose and tighten with a screw clamp.

Source: Albuquerque Journal, June 26, 1999 Carol Cooperrider Used with Permission

APPENDIX VIII

WHERE TO GO FOR MORE INFORMATION

PUBLICATIONS

• *Introduction to Permaculture*, by Bill Mollison. Tagari Publications, 1988.

• *The Negev—The Challenge of a Desert, Second Edition*, by Michael Evenari, Leslie Shanan, and Naphtali Tadmor. Harvard Press, 1982.

• "Water Harvesting Traditions in the Desert Southwest," by Joel Glansburg, in the *Permaculture Drylands Journal*, #30, pp. 25-27. Permaculture Institute, USA, Summer 1998.

• "Water Conservation Through an Anasazi Gardening Technique," by Carleton S. White, David R. Dreesen, and Samual R. Loftin in the *New Mexico Journal of Science*, Volume 38, pp. 251-278. New Mexico Academy of Science, November 1998.

• *Ferrocement Water Tanks and Their Construction*, by S.B. Watt. Intermediate Technology Publications, 1978.

• "Constructing Quick and Inexpensive Water Cisterns for Zone One Use," by Dan Dorsey in the *Permaculture Drylands Journal* #24, pp. 8-10. Permaculture Institute, USA, December 1995.

OTHER RAINWATER HARVESTING GUIDES

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

• *Harvesting Rainwater for Landscape Use,* by Patricia H. Waterfall. Arizona Department of Water Resources, 1998.

ORGANIZATIONS

American Rainwater Catchment Systems Association
P.O. Box 685283
Austin, TX 78768-5283

Center for Maximum Potential Building Systems
8604 F.M. 969
Austin, TX 78724
(512) 928-4786

Permaculture Institute, USA
Casa Las Barrancas Farm
P.O. Box 3702
Pojoaque, NM 87501

Green Builders Program, Home Builders Association of Central New Mexico
5931 Office Blvd. NE
Albuquerque, NM 87109
(505) 344-3294

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City of Albuquerque
Jim Baca, Mayor

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