



# Rainwater Harvesting 101



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# RAINWATER HARVESTING 101

COUNCIL ON THE ENVIRONMENT OF NEW YORK CITY

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August 2008

## PREFACE

The Council on the Environment of NYC (CENYC) is a hands-on non-profit that has been improving New York City's environment for over thirty years. CENYC's dedicated staff green our neighborhoods, create the environmental leaders of the future, promote waste prevention and recycling, and run the largest farmers market program in the country. CENYC achieves its mission through the following projects and programs: The Open Space Greening Program, Greenmarket, The New Farmer Development Project, Environmental Education Training Student Organizers, Learn It, Grow It, Eat It and Office of Recycling Outreach and Education.

The Open Space Greening Program (OSG) empowers people in neighborhoods throughout the city to create, manage and sustain community gardens and park/playgrounds. OSG provides best practices workshops, services, tools, donated plant material, and open space planning/mapping information and other services. Grow Truck provides tools, donated supplies, plants and horticultural advice and assistance to gardening groups all over New York City. The Plant-A-Lot Project gives substantial material and technical assistance to several new gardens each year and helps the 45 existing gardens created in prior years.

Since 2002, OSG staff has taken the lead in building and maintaining rainwater harvesting systems in community gardens across the five boroughs, leading educational workshops, assisting community gardeners in identifying alternate water resources and building low cost systems. CENYC is an active member of the Water Resources Group, a network of NYC greening and environmental organizations promoting sustainable water conservation practices in NYC. The New York State Department of Environmental Conservation (DEC) recognized CENYC's efforts with The Environmental Excellence Award in 2006. This manual was created to disseminate to a wide audience the design parameters and building techniques used by CENYC staff.

Summer intern was able to prepare this document thanks to a grant from The New York State Department of Environmental Conservation in 2008 for Pollution Prevention. Ms. Leung provided many of the photos, charts, and drawings used. OSG staff, Lars Chellberg, and Lenny Librizzi provided invaluable guidance, advice, and editing of the manual. CENYC Executive Director Marcel Van Ooyen and Assistant Executive Director Julie Walsh edited the text. Additional information and assistance was provided by NYC community gardeners and members of the Water Resources Group.

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# Introduction

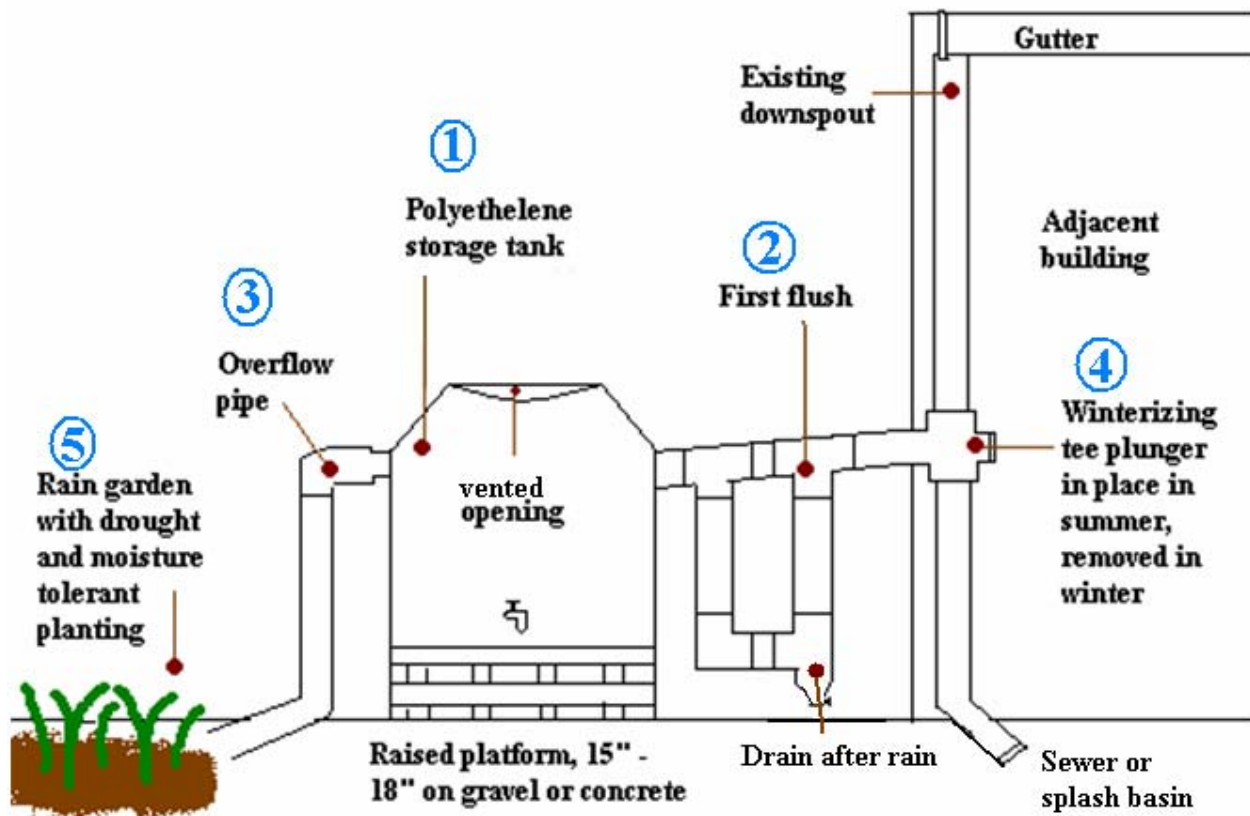
"It isn't easy to come up with 'one size fits all' instructions for building rainwater harvesting systems because of variations in styles of roofs, downspouts, storage tanks, and garden layouts. You have to use a combination of research, common sense, ingenuity, and dumb luck to design and build your system."

-Lenny Librizzi, Assistant Director of Open Space Greening at the CENYC

Rain water harvesting (RWH) is the means of collecting and storing rain water in large, durable containers, usually, collecting from rooftop gutters. RWH systems come in a variety of shapes and sizes (see pictures below).

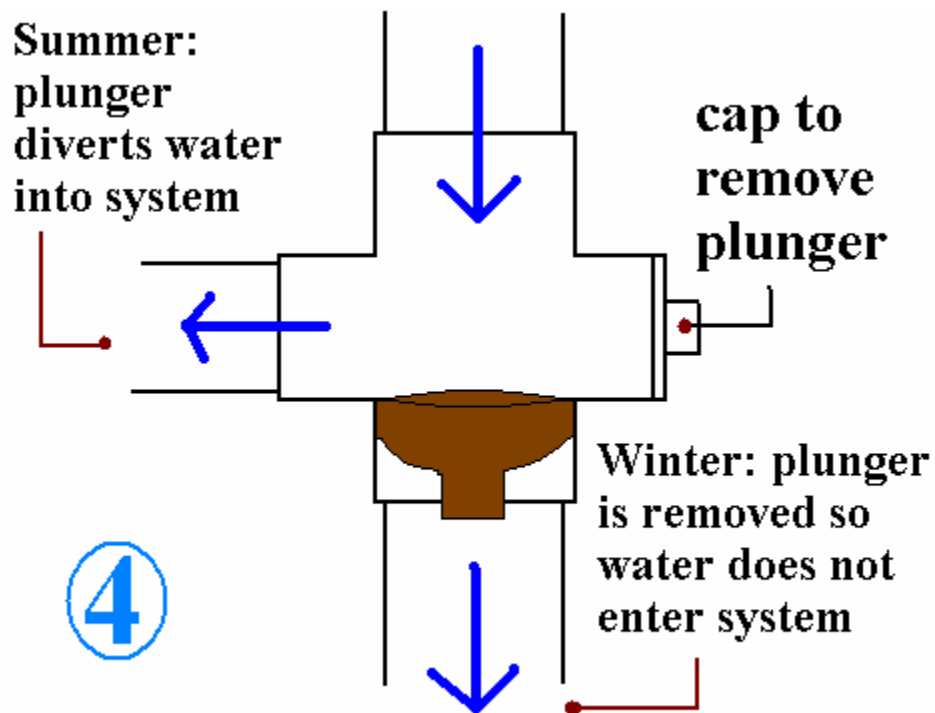


Rain water harvesting systems are fairly easy to construct. Tanks in NYC community gardens range in size from 300 to 1000 gallons but can be as small as 55 gallons and as big as 10,000 gallons. Rain water collected from the downspout of an adjacent building or shed in the garden is redirected to the water storage area in the garden. The RWH system includes 3 parts (see drawing): the tank **(1)**, the first flush **(2)** and the overflow pipe **(3)**.



During a rainfall event water from the gutter flows into the downspout. Instead of the water going into the sewer system, the rainwater harvesting system diverts the water into pipes. This diverter consists of a 3 way tee with a plunger in place during the summer. This plunger keeps the water from entering the downspout and forces it to flow into the harvesting system. It is taken out in the winter when rainwater is no longer collected **(4)**.

Here is a closer view of how the plunger works.



The pipes lead to a roof washer system which is a containment area for the first few gallons of water. Since the initial flushes of water contain rooftop debris and leaves, the roof washer acts as a filtering system by separating the dirty water from the cleaner water. Once the roof washer is full, the cleaner water enters the rain tank. As soon as the tank is full, excess water flows into the overflow pipe which leads to an adjacent rain garden (5), is directed back to where it originally flowed or piped underground. A rain garden is a plot containing hardy plants that can survive with both saturated and dry soil.

# History of rainwater harvesting

Rainwater harvesting is an ancient practice. Many different cultures have used this technology for agricultural purposes. The Philippines have been using rain water for rice terraces for thousands of years now. Indian history indicates that rain water systems have been in use since 3000 BC. Usage can also be traced back 2000 years ago in Thailand and other parts of Southeast Asia, where simple gutters were used to fill jars and pots. The earth dams of ancient Egypt were used to control runoff. Ancient rain water cisterns can still be seen on the islands of Capri and Malta.

In addition to rainwater harvesting, the Romans also used their systems as air conditioners. When the water evaporated, it created a cooling effect in the microclimate. As their populations started to increase, the Romans developed underground cisterns. This way, less water would be lost due to evaporation. They connected these cisterns to above ground pools as a means of water filtration. When these pools overflowed, the cleaner water would enter the cisterns. This design was an inspiration for modern day rain barrels. The Roman's shallow pool mirrors the modern day roof washer or first flush system.

The world's largest cistern is the Yerebatan Sarayi, built by Caesar Justinian in 527 AD. It is located in modern day Turkey and is a popular tourist attraction. It is 140 meters by 70 meters big and can store up to 80,000 meters<sup>3</sup> of water. This huge structure is completely underground and involves a series of intersecting vaults. Binbirdik is another cistern in Istanbul, created by Caesar Constantine in 389 AD that can store 80,000 meters<sup>3</sup>. However construction of these cisterns stopped due to the difficulty of building underground and the outbreak of human fecal contamination in large cities. <sup>1</sup>

In the 1970's, a new technology of rain water harvesting was developed where storm water was stored in well storage tanks in the form of different sized ponds. A thin layer of red clay was used to line the bottom of the pond to prevent seepage and trees were planted around the pond to prevent excessive evaporation. Over 40,000 of these systems were built in the Loess Plateaus of China. <sup>2</sup>

Although rain water harvesting was a significant and successful design in the past, its popularity has declined over the centuries. Urbanization demanded a more centralized water supply system. Watersheds and pipelines came into use and running water became one of the world's greatest inventions. However, due to modern day water pollution and drought, rainwater harvesting techniques have come back into practice again.



# Benefits of rainwater harvesting in urban areas

By keeping storm water out of the sewage system, gardeners help keep their local water bodies clean. Because most of NYC is paved over, rainwater can't be absorbed by the ground. Instead, it runs across the pavement, picking up oil, street debris, animal feces and other waste as it moves. This runoff then enters the sewer system.

Unfortunately, not all runoff makes it to a treatment plant before entering the city's rivers and harbor. This is because most of NYC is on a combined sewer system, whereby the same pipes are used to transport both storm water runoff and household waste to sewage treatment plants. If these treatment plants overflow, the contaminated water then enters the water bodies surrounding NYC.

During dry weather the sewage treatment system generally works well, but these treatment plants can only handle about twice their dry weather volume. This means that heavy rains often result in combined sewer overflows (CSOs), which release untreated wastewater, storm water and street debris into local waterways. Untreated sewage can carry disease causing pathogens and nutrient rich organic material, which can choke the Harbor's ecosystem.

Not only can rainwater harvesting prevent water pollution, it also conserves water. Typical systems can store up to 1000 gallons of water. Harvesting during rainy days in spring and summer provides a source of water for the dry spells between rain events. Instead of running the hose to water your garden, you can use the rainwater stored in your tank. This will relieve the strain on our reservoirs and also save you money on your water bill. Forty percent of household water consumption is used on domestic irrigation! <sup>3</sup>

Rainwater harvesting has proven to be successful. The 35 rain water harvesting systems working in NYC's community gardens collect 422,900 gallons of water every year. That's enough for 264,313 toilet flushes!

Of course small scale construction of rainwater systems is not enough to significantly impact our environment. However, if rain barrels were used more extensively and rain gardens became a larger part of city landscape planning, water conservation would have a greater environmental impact. We would experience cleaner water bodies, less flooding and lower water costs.

Rain water harvesting has great potential to reduce rainwater flow into storm drains by collecting rainwater in gardens and can reduce the dependence on the NYC watershed. Every drop of water counts and conservation is the most sustainable, cost-effective source of water supply for our region.

# Current efforts

Community gardeners across North America and around the world have revived the practice of using rain barrels in their gardens out of necessity.

In **Seattle**, budget constraints and rising water prices spawned the construction of rainwater harvesting systems. Some of Seattle's rainwater harvesting systems are works of art. Here gate pillars support the flow of rainwater from the building on the right into the cistern on the left. Seattle Public Utilities have recommended changes to the land use and building codes that encourage water conservation. SPU has also sponsored some wildly successful sales of rain barrels to Seattle residents.



The special curves on this gate represent the monthly rain fall in Seattle and the amount of water collected year round.



The overflow pipe of this Seattle cistern creates a mini waterfall.



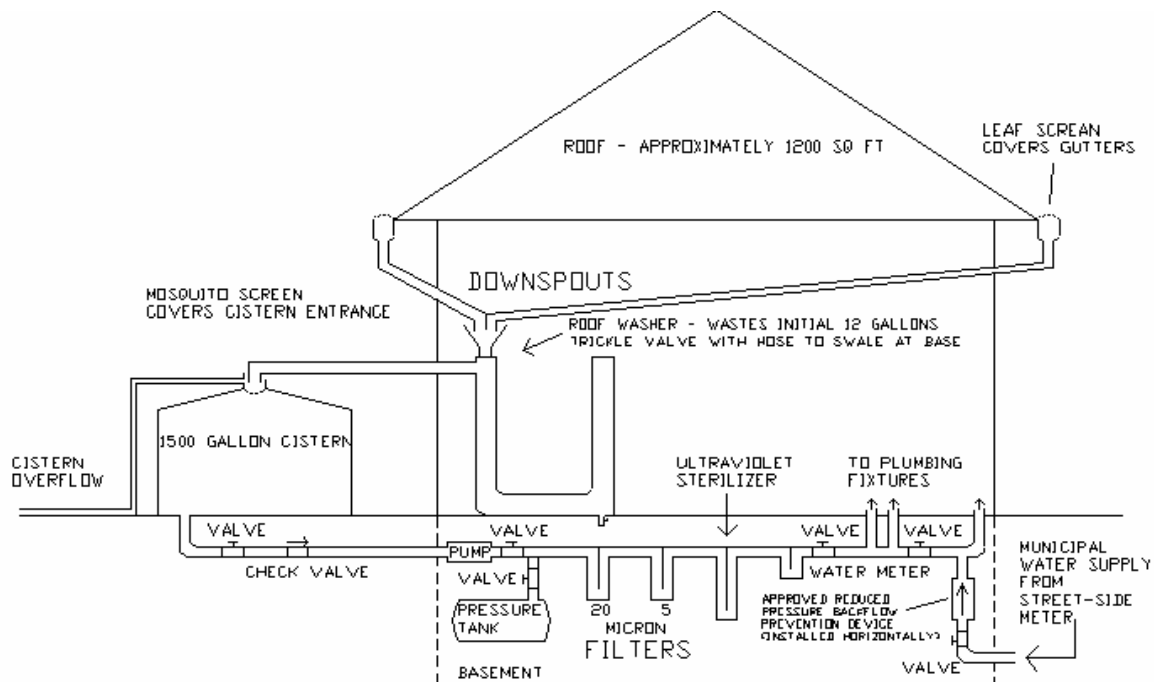
A cat enjoying the rain garden in Kansas City.

The 10,000 Rain Gardens Program in **Kansas City** is an example of regional efforts to educate and introduce water conservation to the Kansas City community. Rain gardens are areas of vegetation on porous ground that can filter and drain excess storm water. Kansas City officials encourage their residents to plant these gardens on their own property.

The City of **Vancouver** designs and manufactures rain barrels for residents to use for irrigation (see picture on right). Vancouver subsidizes the cost of the rain barrels by 50%. Over 2000 barrels have already been sold.



**Portland, Oregon**, granted a permit for a household to harvest rainwater for use indoors during all but the dry summer months (see sketch and picture below). The water undergoes enough filtering to meet EPA's standards for drinking water. In 1998 this system cost less than \$1,500 to install.







**Maplewood, Minnesota** has forged a coalition between its water and sanitation departments and residential landowners to plant large-scale curbside rain gardens that reduce storm-water sewage (see picture on left).

The Minnesota Arboretum uses its parking lots to demonstrate best landscape practices such as planting rain gardens and using permeable pavers to reduce contamination caused by storm water runoff (see picture on right).



The City of **Toronto** Downspout Disconnection Program offers a free service to homeowners to disconnect downspouts from the sewer system and install rain barrels which are available at a discount.

**Chicago** also encourages its citizens to disconnect downspouts. In addition, Chicago's Water Agenda 2003 included a rooftop garden initiative, a pilot program for permeable alleys, and rain gardens planted in the City's rights-of-way.

**Austin** offers rebates of up to \$30 for newly installed rain barrels and of up to \$500 for installation of rainwater harvesting systems, following design approval by the City.

In 2001, the first Drought Emergency to be announced since 1989 was declared in **New York City**. The reservoir levels were 40% below normal which resulted in mandatory water use restrictions. The Water Resources Group (WRG) was founded as a response to this single drought year. Since then WRG and CENYC have built 35 rainwater harvesting systems in New York City, collecting over 422, 900 gallons of storm water per year.

"New York City currently lags behind other cities like Boston and Chicago, which capture 90% of their combined sewage overflow; New York City only captures about 70%, according to the city"<sup>4</sup>



# Materials

Every rain water harvesting system is different but they do have similarities. Here is a comprehensive list of tools and supplies. Your system will use many of these but may not require all of them.

## Tools:

- Drill
- Hole saw attachment or jigsaw
- Screw drivers
- Hammer
- Level
- PVC saw (see top saw in picture) and metal hacksaw (bottom saw)
- Tin snips or sheet metal shears
- Crimping tool (see picture on right) and cable cutting tools



## Gutters:

- Gutter lengths
- Leaders and bends
- Pre-fabricated gutter hangers
- Plumbing strap (for securing pipes to wall)
- Flexible, accordion style expandable plastic pipe
- Tube of gutter sealant and caulk gun to apply it
- PVC cleaner and cement
- Teflon tape (for creating a water tight seal on threaded bushings)



## Barrel storage system:

- Tanks and PVC parts or other materials to construct the manifold. Here we have a capped 4 way tee (see leftmost picture) and a 90° and 45° elbow respectively (see rightmost picture)
- Window screen or screened vents for mosquito proof vent
- Bulk head fittings (An elongated compression fitting, which will allow pipe, to run through a bulkhead)
- Platform material such as treated lumber, plastic lumber or concrete blocks
- Eyebolts (for securing tank)
- Spigot
- Metal flanges of corresponding size to spigot and hardware
- Rope or cabling supplies to secure the tank



# Where to obtain supplies

*Polyethylene tanks* are best purchased locally because of high shipping costs. Search online for local suppliers. You can personally ship smaller tanks and save on extra expenses. Here are some websites that sell tanks:

- <http://www.liquidlogictanks.com/index.html>
- <http://www.tank-depot.com/>
- <http://www.rainbarrelsource.com/>
- <http://www.rainbarrelsandmore.com/>
- <http://www.aquabarrel.com/>

*Drip irrigation* suppliers include:

- <http://www.dripdepot.com/>
- <http://www.dripirrigation.com/>
- <http://www.rainbird.com/drip/index.htm>
- <http://www.dripworksusa.com/>
- <http://www.netafim.com/>
- <http://www.chapindrip.com/>
- <http://www.farmtek.com>

*Downspout filters* and a variety of other specialized parts for systems can be purchased from:

- <http://www.starkenvironmental.com/a-1-filtration.html>
- <http://www.braewater.com/>
- <http://www.rainharvesting.com.au/default.asp>
- <http://downspoutfilter.com/index.php>
- <http://rainharvest.com/shop/default.asp>

*Tools and PVC gutter pieces* can be purchased at your local hardware stores. Lowes or Home Depot also sells these items. For locations near you, visit their websites at <http://www.lowes.com/> or <http://www.homedepot.com>.

# Cost Estimates

Note that the prices listed indicate the values in 2008. Adjust for a 15% – 20% annual increase.

*Polyethylene tanks:* Generally, tanks cost \$1 per gallon but it can sometimes be too big to transport on your own. Shipping costs are about an additional \$1 per gallon.

*Leaders and Gutters:* The number of leaders and gutters needed per site will vary depending on the roof configuration. A 10-foot long gutter is \$15.00, a 10 foot long 2"x 3" leader is \$9.00, and a 10 foot long 3"x 4" leader is \$16.00. Connecting parts, corners and bends are anywhere from \$2.00 to \$10.00.

*Platforms:* Platforms for containers can be made out of cinder blocks, plywood or any other sturdy material. While the tank is light when it is empty, remember that a full tank of water can weigh thousands of pounds. A small 55 gallon tank weighs over 400 pounds when full! Be sure that your platform is strong enough to withstand large weights. Cement blocks can be scavenged from construction sites. Should you have to purchase them, 8" x16" cement blocks are \$ 1.50 each. The lumber prices are \$16.00 for a pressure treated 8 foot long 2"x 10" piece or \$13.00 for a pine or fir 8-foot long 2"x 10" piece. An 8 foot long 4" x 4" piece costs \$12.00. 4" x 4" lumber laid lengthwise in alternating directions placed on a gravel base makes a sturdy platform (see picture on page 25). Using poured concrete pilings and a built wooden deck for a platform may cost about \$500.

*Miscellaneous Hardware and specialized parts:* This category includes accordion connector pieces, screens, sealants, sheet metal, screws, nuts, bolts, gravel, filtering parts and supplies, roof washers, weed fabric and other specialized parts. These parts will vary by site and type of barrel.

*Plumbing Supplies:* The amount of plumbing you need varies depending on the system you are making. This category includes overflow pieces, PVC pipes, connector pieces, rubber fittings, spigots, bulkhead fittings and the piping needed to draw the water away from the system. Upgrades will include soaker hoses or other type of overflow disperser and roof washers. A sophisticated drip irrigation system could add \$500 – 1000 to the cost.

*Tool Kit:* Some specialty tools are needed such as drill bits, screw bits, hacksaw blades, tin snips, hole saws, caulk gun, caulking or silicon, jig saw, pliers and tape measures.

### **Cost analysis for a 300 gallon rainwater system in 2008**

Tank	\$300
Shipping of Tank	\$300
Leaders and Gutters	\$100
Platform	\$300
Hardware	\$100
Plumbing	\$100
Tool Kit	\$50
Total Cost	\$1250

### **Cost analysis for a 1000 gallon rainwater system in 2008**

Tank	\$1000
Shipping of Tank	\$1000
Leaders and Gutters	\$200
Platform	\$600
Hardware	\$200
Plumbing	\$200
Tool Kit	\$50
Total Cost	\$3250

If there is not already an existing roof or shed nearby, a shade structure can be constructed. One possible design is the winged structure seen here:



### **Cost analysis for a 300 gallon rainwater system with winged structure in 2008**

Tank	\$300
Shipping of Tank	\$300
Leaders and Gutters	\$100
Platform	\$300
Hardware	\$100
Plumbing	\$100
Tool Kit	\$50
Materials for Shade Structure	\$2500
Total Cost	\$3750



# PVC Applications

Up to now PVC or polyvinyl chloride has been the key piping material in the rainwater harvesting systems in NYC community gardens. This hard plastic is inexpensive, durable, easy to use and readily available. Tees, elbows, bushings and couplings are all made out of PVC. Although PVC is fairly stable, there are environmental hazards in manufacturing and burning PVC. We are currently looking for other sources that are more environmentally benign but also having the same flexibility with parts as PVC does. Although metal can be an alternative, it can be costly. If there is a material that you think can be a replacement for PVC, please add your information or comment to this wiki:

[http://www.waterresourcesgroup.org/wiki/index.php?title=Main\\_Page](http://www.waterresourcesgroup.org/wiki/index.php?title=Main_Page).

In order to join PVC pipes together, use PVC specific cleaner primer and cement. PVC cleaner primer removes dirt and melts the surface for ultimate adhesion. After the pipe is clean, you can use cement to join the two pieces together. Only apply cleaner and cement to the outside part of the male piece (see picture on left) and the inside part of the female piece (see picture on right). It is important to hold the two pieces together for 20 seconds after applying the cement because they may move apart. After 20 seconds, the two pieces are permanently joined (see bottommost picture). Wipe off excess glue.



Use bushings and reducer fittings when it is necessary to change the size of your pipes. These come in a wide variety of glue (slip) and threaded designs.

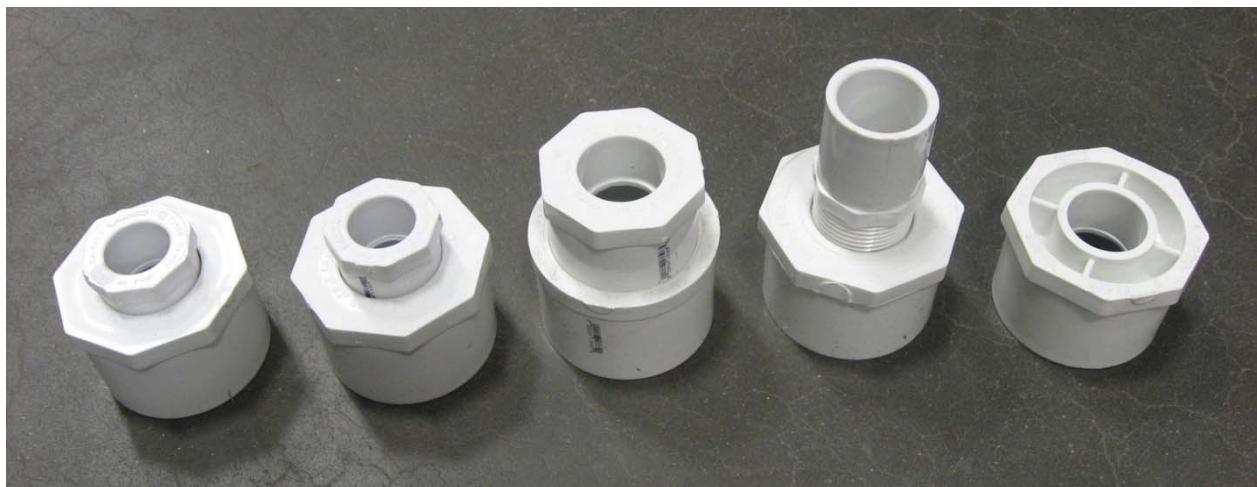


This 2"x 1 ¼" slip bushing connects a 2" (diameter) piece of pipe with a 1 ¼ "pipe. Slip bushings can be adhered using the cleaner and cement method mentioned above.

This 2"x 1" slip and thread bushing connects a 2" slip pipe with a 1" threaded pipe. Thread bushings can be adhered tightly using Teflon tape. Roll the tape starting at the end of the male thread bushing towards the middle. Two or three wraps are sufficient.



PVC parts are very versatile since no two rainwater harvesting systems are alike. Many different combinations of PVC parts can be used for the same function. Here are 5 different ways to connect a 2" pipe with a ¾ "pipe.



It is very important to align adjacent pipes. The two tees in the first picture (see picture below) must align exactly in order to connect to the same wall. Careless glueing will lead to problems. Use a hard, level surface such as a concrete floor to help you align pipes.



The pipes in the second picture (see picture on left) must be exactly perpendicular to each other. The tee on the left will connect to the barrel. The tee on the right will connect to existing pipes. Use a marker to indicate the points where the one pipe must meet the other.

The pictures above also point out the use of piping. Notice how the two tees are joined in each picture. In the second picture, the two tees are joined by using a small piece of pipe in between them, called a sleeve. The interior coupling is too short to be seen in this picture. In a situation where you want the tees to be further apart, such as in the first picture, just extend the size of the pipe to the desired length.

Although every rainwater system must be carefully planned before actual construction begins, it is very easy to miscalculate or measure incorrectly. Often times, errors are not realized at first. To fix a measurement or connection problem where the 2 pipes that were intended to connect do not match up, use two 45° degree elbows. A combination of two 45° elbows will produce almost any twist or angle desired.

Two 45° elbows can make a 90° degree twist or a 180° degree twist.



Two pipes that did not connect before can now be connected with the help of two 45° elbows.

It is also possible to shorten the PVC pipe by cutting and reconnecting it with a rubber coupling. Notice that the pipe below is too long to connect with the smaller pipes attached to the wall (see top picture). It was shortened and reconnected using a rubber coupling (see bottom picture).





# Sizing of the tank and roof washer

A variety of rainwater systems can be constructed for the same downspout and roof. Here are two different systems that have been installed over the years at the 1100 Block Bergen Garden in Brooklyn. It is generally better to have a single barrel rather than multiple barrels because of possible leakage from the numerous connections. The 9 barrels in the original system had 17 connections. There were 17 locations where leakage could occur as opposed to 1 location in the current system.



The capacity of the system should be determined by two factors: the size of the roof, which determines how much water can be collected and the size of the garden, which measures how

much water is needed. A 300 gallon vertical cylindrical storage tank is approximately 42 inches in diameter and 51 inches tall. A 1000 gallon polyethylene tank is approximately 92 inches in diameter by 60 inches tall or 61 inches in diameter by 100 inches tall.

The amount of water you can harvest varies depending on the size of your roof. You will be surprised how much water you will be able to collect from even the smallest roof. **The rule of thumb is 600 gallons of water per inch of rain per thousand square feet of catchment area.** Not all the rain that falls can actually be collected. Efficiency is usually presumed to be 75% depending on system design and capacity. Here is the basic formula for calculating the potential amount that can be collected:

$$\frac{(\text{Catchment area}) \times (\text{inches of rain}) \times (600 \text{ gallons}) \times (.75)}{1000 \text{ square feet}}$$

Remember that a roof can have several downspouts. Your catchment area only consists of the region where the downspout that is connected to the rain barrel collects from. Pay attention to the gutter and slope of the roof to determine which part is your catchment area. In order to calculate the catchment area, use measuring tape to determine the width and length of your roof in square feet. Multiply the length and width of your catchment area for the area of your roof.

The sample roof shown below (see picture below<sup>5</sup>) has a catchment area that is 40 feet wide and 30 feet long. Hence, it has a 1200 square foot roof (40 feet wide x 30 feet long). Assume that it rains 2 inches. We can now plug this information into our general formula (see equation above).



Catchment Area = 1200 square feet

Amount of Rain = 2 inches

Gallons of water collected per inch of rain per 1000 square feet = 600 gallons

Percent Efficiency = 75% or .75

$$\frac{(1200 \text{ square feet}) \times (2 \text{ inches of rain}) \times (600 \text{ gallons}) \times (.75)}{1000 \text{ square feet}} = 1080 \text{ gallons}$$

Therefore a 1200 square foot roof will collect 1080 gallons of water on a day with 2 inches of rainfall. Using this formula and your region's average rainfall numbers combined with an estimated water need, you should be able to calculate the approximate size of your tank or barrel system.

Roof washer sizes also differ according to the size of the roof. **The rule of thumb is one to two gallons of roof washer capacity for every 100 square feet of catchment area.** A 1 foot length of 6 inch diameter PVC pipe holds 1.5 gallons. A 1 foot length of 4 inch diameter PVC pipe holds .66 gallons.

We will use the same 1200 square foot roof shown above as an example. Since the rule of thumb suggests one gallon of roof washer capacity for every 100 square feet of catchment area, the sample roof will need 12 gallons of roof washer capacity.

If you are using 6 inch diameter pipe, use the following formula:

*Number of gallons of roof washer capacity*

---

*1.5 gallons/ foot*

The size of our roof washer on our sample roof can be calculated by:

*12 gallons of roof washer capacity*

---

*= 8 feet of 6" pipe*

*1.5 gallons / foot*

If you are using 4 inch diameter pipe, use the following formula:

*Number of gallons of roof washer capacity*

---

*12 gallons*

---

*=*

*= 18 feet of 4" pipe*

*.66 gallons / foot*

*.66 gallons/ foot*

Therefore a 1200 square foot roof will need 8 feet of 6" diameter pipe or 18 feet of 4" diameter pipe. Remember it is possible to separate long lengths of roof washers into several, continuous pipes instead of just one long pipe.

# Construction

The first step of the construction project is to make a plan drawing. The plan drawing considers the location of the downspout and the amount of space available. Each system must include the tank, the first flush and the overflow. Here are some issues that should be considered in your planning:

- The most stable place to position your barrel is against a stable wall on level ground as close to the downspout as possible.
- Gravity moves water downhill. Be sure there is available space for a downward pitch in all pipes.
- The barrel on its platform is the highest point of the garden but the lowest point of the system.
- The overflow pipe should be directed toward a rain garden not toward pathways or structures.
- The overflow pipe should flow from the barrel's highest point.
- The spigot should be at the barrel's lowest point.







# Tanks

Tanks can be made from all sorts of materials such as cement (see picture on left<sup>6</sup>), metal, ceramic and wood (see picture on right<sup>7</sup>). In tropical countries, a terra cotta tank can be used. No wintering tee is necessary for these tanks because there is no danger of freezing.



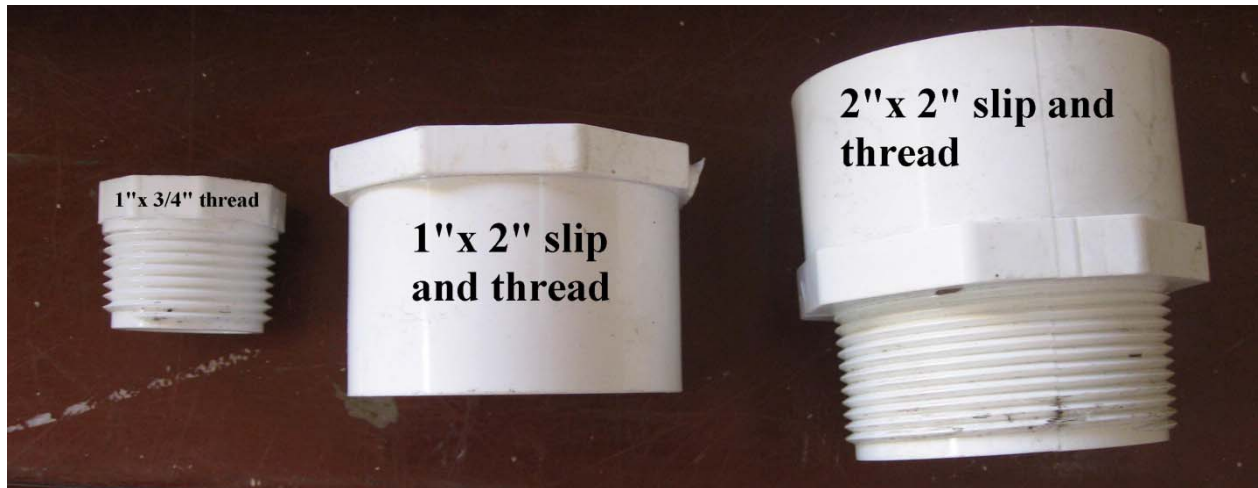
For design purposes, bladders can also be used to store water instead of tanks. Bladders are large, flexible bags functioning in a way similar to the water balloon (see picture on left<sup>8</sup>). This way, engineers can create storage tanks in a variety of shapes instead of the traditional cylinder.

The tank system includes the spigot, the inflow pipe, the overflow pipe, the lid and the platform it rests on.

*Spigot:* A variety of bushings can be used to connect the spigot. It is preferable to use a single reducer bushing but that is often not possible. For example, the tank's spigot hole is 2 inches in diameter. The spigot pictured here is a  $\frac{3}{4}$ " ball valve hose bib. In order to reduce the 2" opening to the  $\frac{3}{4}$ " spigot, the following 3 bushings were used:







*Lid:* The lid should remain closed at all times. Still water is a haven for mosquito larvae. Inspect the lid and any vents annually and clean as necessary

*Inflow and Overflow pipes:* Some tanks come with bulkhead fittings installed for the inflow and overflow pipes. For those that don't, a hole saw is used to drill a large hole in the barrel. Two bushing pieces, like the ones pictured below, are used to fashion a bulkhead fitting.



Use a marker to trace the hole you will cut for the threaded bushings. Make the hole tight to the threads. Once the hole is prepared, thread the first piece in from the outside.



Thread the second piece from the inside of the tank using a flexible wrench. Use gutter sealant to create a watertight seal.



*Platform:* The purpose of the platform is to raise the tank enough to get your watering can under the spigot and to create pressure flow for a hose. Spread a thick gravel base over an area slightly larger than the platform. This will promote good drainage and allow for final leveling once the platform is built.

A stable arrangement of cement cinder blocks, like this one, makes a great platform for small 55 gallon tanks but is not ideal for larger tanks. Since the blocks easily shift, rot resistant 4"X 4" or 6"X 6" lumber laid out in alternating rows is the best option for a platform. Steel platforms are also a possibility but are more costly. Be sure to level and compact the ground well where the tank will sit.



*Warning Signs:* Do not drink the water collected. Only use it to irrigate your garden. Installed PVC is inert and it is used as a water supply pipe for house trailers and other homes. The possible contamination is almost exclusively from harmful bacteria. For water to meet drinking water standards it must be treated, usually with chlorine, often filtered and sometimes treated with ultraviolet light. A warning sticker or sign should be placed on your rain barrel to avoid the possibility of anyone mistakenly drinking the water.





# Leaders

The leaders of the rain water harvesting system refer to the series of pipes that lead to the tank. This includes the pipe that connects the downspout, the wintering tee, the roof washer system and the pipe that connects the barrel. Gravity keeps the water flowing. Remember to put a downward pitch on all pipes. A quarter inch down for every linear foot will create an adequate pitch. Use a level (see picture below). It may be useful for someone to stand back to visually check the pitch and help you adjust the pipes as you are pitching them.



**Keep pipes pitched downward.**



**DO NOT pitch pipes upward.**

Keep the pitch of your pipes even and downhill. The picture on top is correct. The picture on the bottom has an upward pitch and will create problems.

*Connecting the downspout:* Our intent with rain water harvesting is to divert storm water, store it for future use and keep it out of the sewers. There are several options to divert the rain water: insert a 3 way tee into the downspout (see picture on left) or connect the existing downspout directly to the rain barrel (see picture on right). You can design your own custom diverter as well.



Another possibility is to replace the downspout entirely with pipes leading to your rain water harvesing system (see picture below and on the next page).





Connecting to the downspout is one of the last steps in construction of your system. You do not want to disconnect your downspout and start collecting rainwater with an unfinished system.

*Wintering tee:* The purpose of the wintering tee is to allow the water to be directed back into the sewers during freezing temperatures. Rain water should not be collected at that time because it may freeze and cause breaks in the system. A simple wintering tee utilizes a removable plunger head. The plunger head blocks water flow into the sewer and forces it to enter the system. It is removed during the winter and rain water will just flow straight down into the sewer (see picture on left and diagram on page 4). Complicated wintering tees include a filtering system. It operates with the same principle but instead of a removable plunger head, there is a removable filter which catches debris (see picture on right).



*Roof washer system:* Refer to 'Roof washers' on page 30.

*Connecting the barrel:* Refer to 'Tanks' on page 23.



Here are some ideas to help you with the design of your leader.



#### INFLOW

- 1: 90° elbow
- 2: 4" pipe
- 3: 90° elbow
- 4: 45° elbow
- 5: 4" pipe
- 6: 45° elbow

#### OVERFLOW

- 7: 2" bushing
- 8: 90° elbow
- 9: 2" pipe

This design uses a separate inflow and overflow pipe.



#### INFLOW

- 1: downspout
- 2: 4" rubber coupling
- 3: cap
- 4: 4 way tee
- 5: rubber coupling
- 6: 90° elbow
- 7: 4" sleeve
- 8: 4" rubber coupling
- 9: 3 way tee

#### OVERFLOW

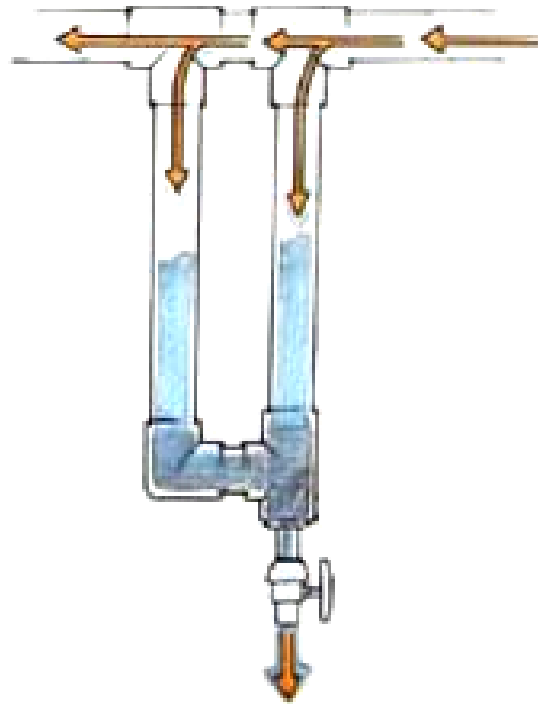
- 10: 45° elbow
- 11: 90° elbow
- 12: 4" pipe

This design uses the same tank opening for both the inflow and overflow.



# Roof Washers

Roof tops are prone to collect leaves and dirt. The rain carries all this debris with it as it enters the gutter and downspout. The roof washer or first flush system is a simple way to filter the water you collect. It is a series of pipes that storm water flows into before entering the rain barrel. Once the roof washer is full, water will begin to fill the rain barrel without mixing with the dirty water contained in the first flush. The appropriate size of the roof washer varies depending on the size of the roof. Refer to 'Sizing of the tank and roof washer system' on page 18 for details on how to calculate roof washer size. Small first flush systems can be a single downward pipe. However, to accommodate larger roofs, first flush systems can be constructed of multiple downward pipes.

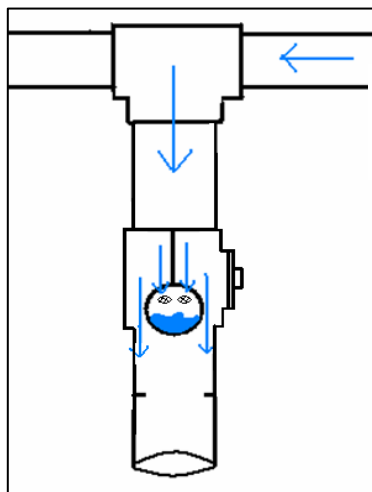


**The roof washer must be emptied promptly after a rain event and valve reset in the closed position** to be ready for the next rain. Drain the roof washer to a safe location. Include another spigot or valve in your design to drain the first flush.

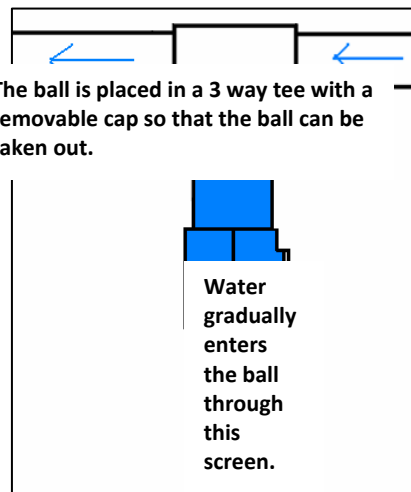


An alternative to the container method of the roof washer is a device like the Flow-Rate Diverter by Safe Rain. It consists of a plastic ball attached to a spring. The top of the ball contains a screen and a movable tab. During a rainfall event, water that enters the pipe will either flow into the ball or on its sides (see picture on left). The purpose of the screen on top is to gradually allow water to enter the ball. Once the ball is filled, it will sink down and block the drain (see picture on right). Water can then start filling up the pipe and start entering the tank. The moveable tab controls the amount of water that enters the ball by covering or exposing the screen as desired. For example, larger barrels that require larger roof washers require a screen that is less exposed. Larger amounts of water will have to pass through the pipe before the ball can be filled. The ball will have a small drip hole to slowly empty once the rain has ended to then return to its original position to be ready for the next rainfall.

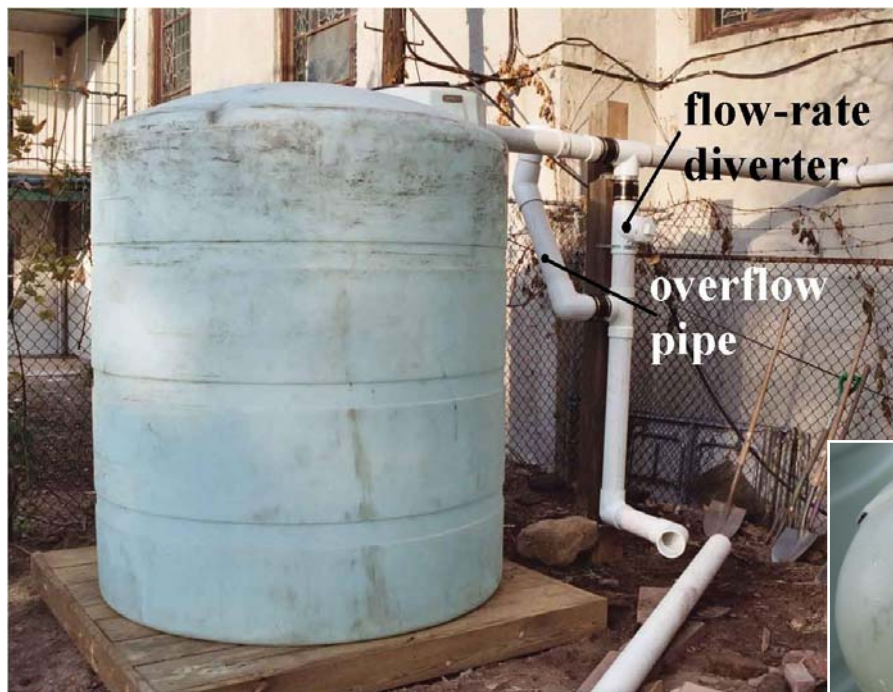
Entering rainwater will flow into this pipe. Some will enter the ball, making it heavier and some will flow past the ball and out of the pipe.



The ball is placed in a 3 way tee with a removable cap so that the ball can be taken out.



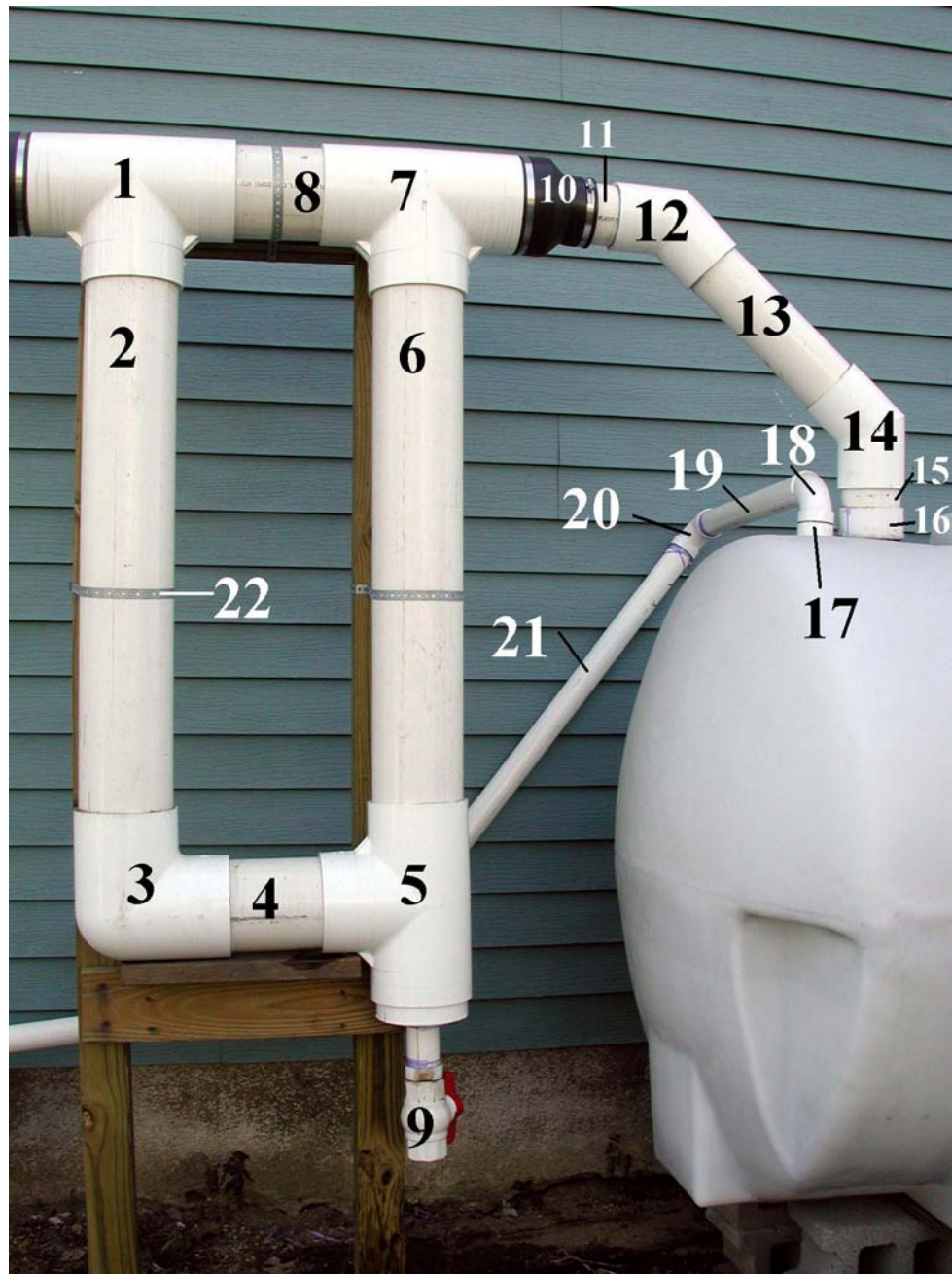
Once the ball is saturated with water, it will sink down and block the pipe. Water will fill up the pipe and finally enter the tank.



This device allows the overflow pipe to be connected to the roof washer pipe.

Water gradually enters the ball through this screen.

Here is an idea to help you design a roof washer of your own.



#### ROOF WASHER

- 1: 3 way tee
- 2: 6" pipe
- 3: 90° elbow
- 4: 6" pipe
- 5: 3 way tee
- 6: 6" pipe
- 7: 3 way tee
- 8: 6" pipe
- 9: drain valve

#### INFLOW

- 10: 6"x4" rubber coupling
- 11: 4" pipe
- 12: 45° elbow
- 13: 4" pipe
- 14: 45° elbow
- 15: 4" pipe
- 16: bushing

#### OVERFLOW

- 17: bushing
- 18: 90° elbow
- 19: 2" pipe
- 20: 90° elbow
- 21: 2" pipe

#### ANCHORING

- 22: plumber's strap

Although this rainwater harvesting system has a good roof washer design, it does not have a good overflow design. Excess water will back up into the inflow pipe before the overflow pipe starts working. The overflow pipe should also be the same diameter as the inflow pipe to avoid a bottleneck situation.



# Overflow pipes

When the rain barrel reaches its capacity, the overflow pipe discharges the excess water so that water won't start spilling out from around the lid. Cut a hole near the top of the barrel and connect an overflow pipe there. Be sure that the overflow pipe is not directed toward water-sensitive structures or areas where water can collect and do damage. The overflow pipe should be the same size as the inflow pipe so that a bottleneck situation is avoided during heavy rainfalls.

Here are some ideas to help you design an overflow pipe of your own.



**OVERFLOW**  
1: bushing  
2: 2" pipe  
3: 45° elbow  
4: 45° elbow  
5: 2" pipe





The overflow pipe is connected back to the sewer. Building systems close to the downspout requires less piping.

**OVERFLOW**  
 1: 2" pipe  
 2: 90° elbow  
 3: 2" pipe

Instead of directing water back into the sewer, you can direct the water into a rain garden, gravel filled trench or connect it to a drip irrigation system. Overflow can be turned into works of art. Here the overflow is turned into a small water course (see picture on below), which ultimately ends in a rain garden.



Rain gardens are depressed plots of land (see pictures below). It should be at the lowest point in the garden so that water can flow there easily. Dig a deep trench and fill it with 5 inches of gravel for seepage. Cover this area with burlap netting so that the soil will not sink down into the gravel. Place a couple of inches of soil on top and start planting. Only plants able to survive both dry and saturated soil should be grown. Native plants are also encouraged because they are more tolerant of local climate and soil conditions. These plants include wildflowers, ferns, shrubs and small trees.<sup>9</sup> Brooklyn Botanic Garden provides a thorough list of rain garden plants for different regions on their website at:

[http://www.bbg.org/gar2/topics/design/2004sp\\_raingardens.html](http://www.bbg.org/gar2/topics/design/2004sp_raingardens.html)



Bioswales are alternatives to rain gardens. They are depressions in the landscape with collections of rock, gravel and vegetation that act as a filter for water. They effectively strain silt, inorganic contaminants, organic chemicals and pathogens. The longer the water is trapped inside the bioswale, the easier it is for pollutants to be trapped. They are most commonly found surrounding a parking lot so that oil runoff can be filtered before entering the sewer system.<sup>10</sup>



# Anchoring

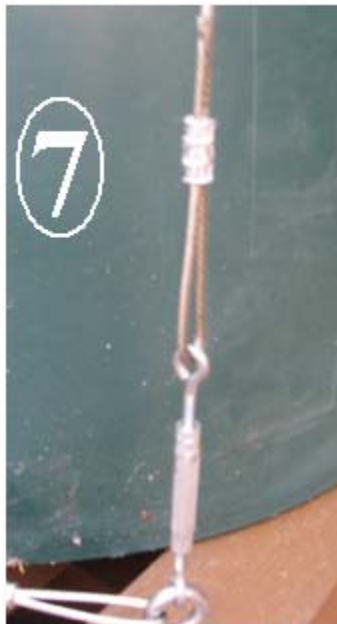
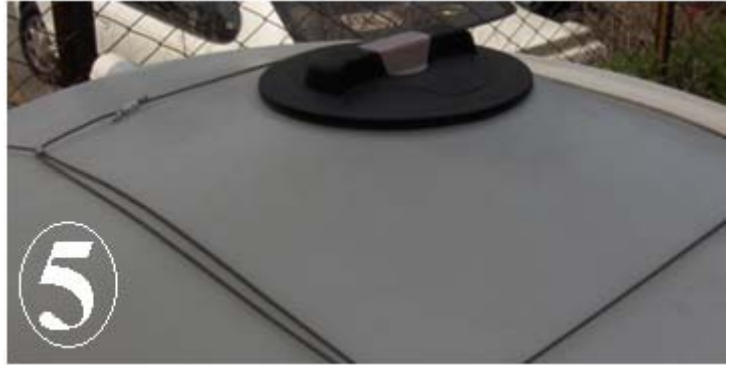
Because the rain barrel is fairly light and may tip or fall when it is empty, it is important to anchor the system to the platform or a structure. The easiest method to tie down your system is to use nylon rope. Steel cable is also a solution. Since cabling is more complicated, we will illustrate these steps.

Cut a piece of steel aircraft cable and slip 5 cable swedges in it. Use the first piece of cable swedge (**see picture 1**) and a crimping tool to connect it into a circle (**2**). Its circumference should be a less than the circumference of the rain barrel but more than that of the lid. Cut two more long pieces of steel cable. They should be at least twice the height of the rain barrel. Use one cable and slip it through two of the metal cable swedges that are already on the circle. Making sure both lengths of cable are even; use the crimping tool to secure the metal swedges in place. Do the same with the other cable and two metal swedges (**3**).



Screw a metal eyebolt into each of the four corners of your platform. Connect a turn buckle to each metal eyebolt (**4**). Place the series of cables onto your rain barrel. The circle should be on top of the rain barrel (**5**). The four hanging ends should be facing each corner of the platform. Loop the ends of the cables into the turn buckle (**6**). Use a metal swedge to secure the loop. Do this for all four corners. Finally, twist the turn buckles until the metal cables are taut (**7**) to finish securing your rain barrel (**8**).





For cinder block platforms, nail a thick wooden plank on top and use the eyebolt method mentioned above.

Pre-fabricated steel brackets are generally used to anchor horizontal tanks.





It is a good idea to anchor pipes as well. If the pipe is hugging the rain barrel, anchor the pipe to that platform using cable (**see picture 1**), perforated plumber's strap (**2**) or other methods.



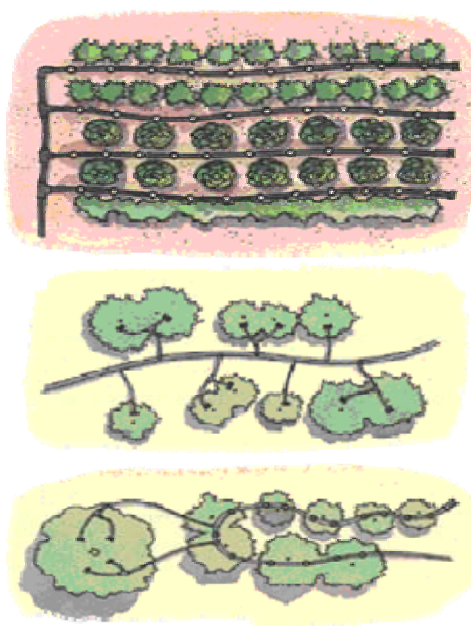
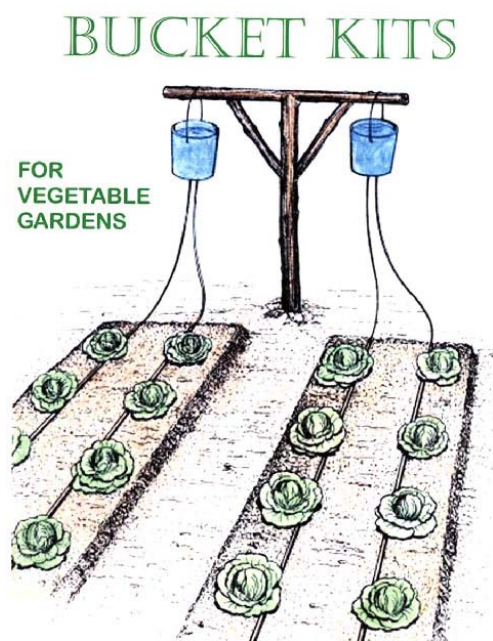
Pipes that are directly against the wall of a building can be secured to the wall using plumber's strap attached with tapcon screws, which seal the hole drilled in the wall to avoid leaks (**2**).



# Drip Irrigation

Drip irrigation systems reduce water use. Small amounts of water are supplied to the base of plants. Since the water is applied directly to the soil, rather than onto the plant, evaporation from leaf surfaces is eliminated. The water is also placed where it is needed rather than sprayed over the entire garden.

With a drip system, water flows into a series of thin flexible hose lines. These irrigation hoses have tiny holes at even intervals. These hoses are placed on the surface or beneath a layer of mulch. When water enters the system, it slowly trickles out of these holes and waters the roots of plants (see pictures below<sup>11</sup>). The overflow of rain water harvesting systems is sometimes connected to these smaller pipes.



Tubing comes in many sizes (see pictures below<sup>12</sup>). It is used to get the water from the source to the garden. A variety of fittings are available to go around corners and to connect pieces.



In most cases, no special tools or skills are needed. Plastic pipe is punched with an inexpensive tube punch that assures the proper hole size. Spaghetti tubes snap into the hole. No gluing is required. Because the holes are small, they can easily be plugged if you put one in the wrong place.

Gravity Feed Drip Irrigation Kits are used to connect to rain barrels and rainwater harvesting systems where the water pressure is low (see picture below<sup>13</sup>). This system uses small ¼ inch valves instead of emitters to avoid the problem of clogged emitters

The Premium Gravity Feed Drip Irrigation Kit contains **136** pieces ...

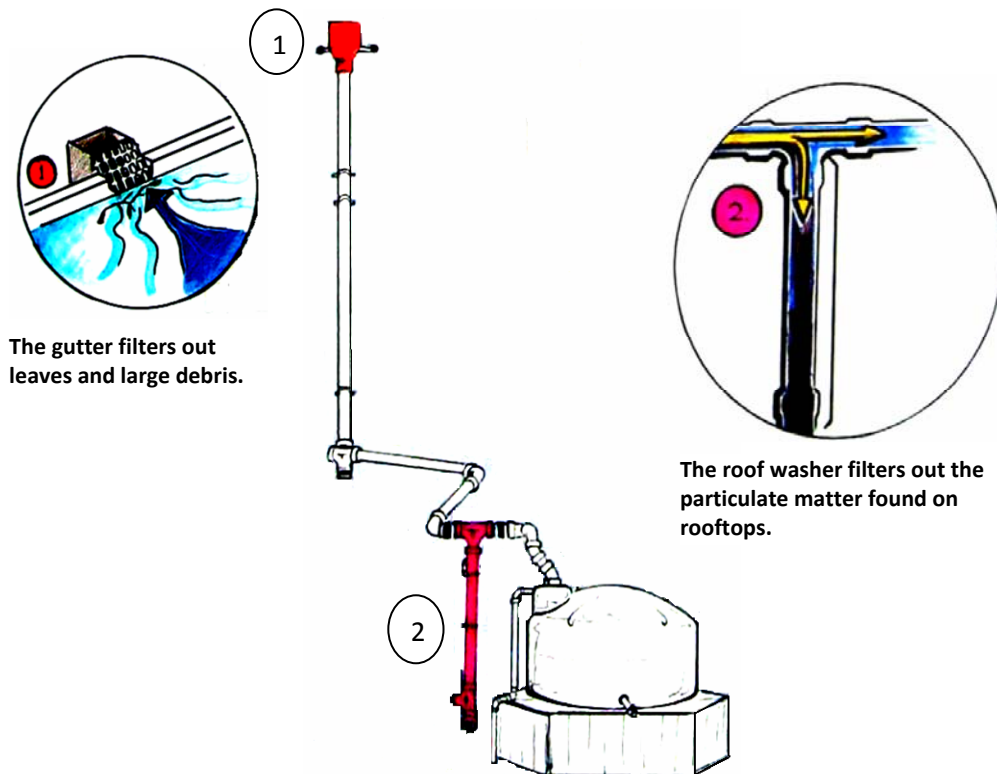


Drip Irrigation systems need planning, but are neither expensive nor difficult to install. Most drip irrigation suppliers will help you design a system to best meet your gardening needs. Drip systems require periodic maintenance. Check regularly for leaks and broken connections.



# Filtration Systems

This rain water harvesting system already has two means of filtration, one at the gutter (see **picture 1**) and the other at the roof washer (2).



This gutter screen that is put at the mouth of the downspout (see picture on right) prevents leaves and other large debris from entering the system. If you want to buy a filter, two choices are Rain Keeper Downspout filter for smaller roofs and the Rain Keeper Downspout collection filter for smaller systems. Refer to “Where to obtain supplies” on page 11 for more information.



# Treatment

During warm weather, bacteria may grow inside the storage tank. Organic matter also poses a problem as algae or other contaminants may grow in storage tanks. WRG recommends adding a small amount of chlorine, in the form of unscented household bleach, to your water storage tank. Do not use bleach with any additives like fragrances or softeners. A log should be kept to ensure the proper addition of the chemical. Store log with bleach container. Please remember to wear gloves when handling bleach, to store bleach in a cool, dry place and to label bottle clearly to avoid improper use. On the 1<sup>st</sup> of each month, add a small amount of bleach to *each* water storage container. If the tank is emptied and refilled in less than one month's time, an application of bleach should be added to the tank when it refills

<u>Tank Size</u>	<u>Amount of Bleach to Add</u>
1000 gallons	1/3 cup
750 gallons	1/4 cup
500 gallons	3 tablespoons
50 gallons	2 teaspoons

Regularly emptying the roof washer and the addition of a small amount of bleach to your tank will ensure the water is safe for watering vegetables. The water stored in the tanks is for ***irrigation purposes only***. It is safe to use on vegetables and other plants in the garden, but it is not safe to drink. The quality of this water does not comply with local and national drinking water standards.

# Aesthetics

“The most beautiful system is carefully constructed and incorporates a carefully thought out, well designed and installed plumbing system.”

-Lars Chellberg, CENYC staff member

Although a rain barrel is considered by some to be unsightly, it is easy to beautify your rain water harvesting system. PVC pipes and tanks can be covered by plants or painted (see pictures below).



A gazebo at this Seattle community garden covers an underground cistern that stores 5,000 gallons of collected rainwater (see picture below).





Promoting the sustainable practice of rain water harvesting is also important. For example, NYC community gardens use a “This garden harvests rain water” sign (see picture on right), a good idea to put in front of your system. Have printed information for people to learn more about rain water harvesting like this Water Resources Group brochure (see picture on left).



Sometimes it is necessary to break some basic RWH rules for aesthetic reasons. This rain water harvesting system has an inflow pipe that is pitched upward which means that it must rain enough for the water to fill up the roof washer and the inflow pipe before it can enter the tank. This was done so that the roof washer could be positioned below the brick wall and not interfere with the tree limb or the neighbor's views.



# Roofing Material

Roof tops are essential to any rain water harvesting system. Popular types of roofing include corrugated metal decking, shingles, rolled asphalt and cedar shake.

Corrugated metal decking can come in two forms- zinc coated or hot dipped galvanized. Because, zinc coated roofs rust easily, hot dipped galvanized roofs are more popular. These roofs are constructed simply by nailing down with sealing washers to your structure or screwing. Apply gutter sealant on any nail or screw to make sure water doesn't leak from these spots. Metal roofs provide great structural support for long amounts of time. It has the highest efficiency rate when it comes to rain water harvesting because of its waterproof surface. Its only downfall is the noise factor. It gets very loud when rain water clashes with the rooftop. It is an ideal roofing material for non residential structures.



Shingles are small pieces of overlapping wood or slate. Place a ½ inch wide piece of plywood on top of the structure. Start nailing shingles in a horizontal, overlapping fashion starting from the gutter line. Work your way up to the top of your roof, making sure your next row overlaps the previous row (see picture on left<sup>14</sup>).

Rolled asphalt or modified bitumen roofs occur most commonly on flatter rooftops. A large sheet of asphalt is simply glued down with tar or plastic. Asphalt roofs can either have a granular surface or a smooth surface. Although granular surfaces are slightly less efficient in catching rain water because it is easily trapped in the pieces of ground glass, it is preferred over smoother roofs. Granular roofs wear slowly, resist cutting and keep UV rays from degrading it. Typically, a few years after the granular roof is installed, it is painted with aluminum to lock in grains that may have fallen loose (see picture on right<sup>15</sup>).



Cedar shake or wooden roofs are installed in a vertically overlapping fashion. Wood is the least efficient in catching rain water because it is porous. However, once the wood is saturated, it will no longer absorb water (see picture on left<sup>16</sup>).

# Seasonal Maintenance

To ensure your health and safety the Water Resources Group recommends the following seasonal maintenance schedule for keeping your rainwater free of contaminants.

## Spring

- Close spigot
- Re-direct roof water from the drain pipe back into tank storage system by replacing the in-line plunger or changing the position of the valve
- Clean any winter debris from gutters, leader inlets and roof
- Repair any leaks in barrel or tanks
- Inspect and clean barrel tops
- Fill system with a few inches of water to check hose connections for leaks
- Inspect rope/cable retainers to assure that barrels are secure
- Be sure that your tank is labeled with a “do not drink the water” sign in all appropriate languages
- To help ensure that children do not drink the water remove the valve from spigot and store with tools

## Summer

- Keep the roof, gutters and leader inlets clear of debris, check monthly
- Inspect vents at top of each barrel to insure that they are clean and intact
- Visit your system during a heavy rain or shortly after to check for leaks and overflow problems.
- Any water from the overflow system should drain within 24 hours of a rainfall; if puddles form, you should move the outflow pipe to a more porous site or consider installing a small rain garden
- Inspect pipes and connectors regularly for any damage or disrepair
- Check man-way hatch on top of your tank to make sure it is securely closed

## Fall

- Remove plunger from the PVC joint to redirect water into the drain pipe to the sewer
- **Empty water from the entire system- roof washer and tank**
- Open main valve of storage tank and rain barrels
- Open valve on roof washer. Valves should remain open all winter to keep water from freezing in system
- Disconnect leader from system and re-route water as necessary for particular system
- Cover any openings in leaders



# Living with the RWH System

Now that you have built your rain water harvesting system, you have helped to conserve one of the Earth's most valuable resources. A rain barrel is not something you build and walk away from. It is important to make sure there are no leaks in your barrel and to drain the first flush after every storm.

**Remember to drain your roof washer and tank during the winter and to take out your wintering tee! Freezing water will BREAK the system.** The cracks seen in the two pictures below are from left over water freezing and expanding.



If properly built and maintained, your rain water harvesting system will last many years. Even the smallest tanks will save thousands of gallons of water.

It is essential to learn how to manage your water usage. Seventy percent of residential water use goes to outdoor activities. One third of that water is wasted (see diagram on right<sup>17</sup>). Using pumps or sprinklers to water plants are one of the most inefficient ways to irrigate. Plants only need to be watered at the roots. Sprinklers relentlessly waste water by randomly shooting out water to tree branches or leaves. Drip irrigation systems with outlets placed strategically next to plant roots are the most efficient ways to irrigate.



# Existing RWH Systems

Organic Gardening Magazine has been sponsoring construction of rain water harvesting systems in community gardens since 2007. Their Waterworks Project funded 30 systems in the past 2 years. Looking at existing rain water harvesting systems and talking to community gardeners may assist you in building your own. Locations in the USA and Canada include:

Aleman Farm - San Francisco, CA  
Ashview Community Garden - Atlanta, GA  
Aspen Farms - Philadelphia, PA  
Boyd Street Urban Farm - Portland, ME  
Bradner Gardens Park – Seattle, WA  
Brentwood Community Garden - Portland, OR  
Children Garden - Camden, NJ  
City Seeds Urban Farm - St. Louis, MO  
Dias y Flores – New York, NY  
The Farm Garden at the Early Childhood Education Center - Columbus, OH  
Fremont Community Garden - Sacramento, CA  
The Garden of Dreams - New York, NY  
Global Gardens - Tulsa, OK  
Gloryland Community Garden, Detroit, MI  
Growing Green Youth Garden, Buffalo, NY  
Guadalupe Montessori School, Silver City, NM  
Hope Community Garden - Toronto, ON Canada  
Marigold Meadows - Phoenix, AZ  
Master Peace Youth and Community Garden - Riverdale, MD  
Our Saviour Community Garden - Dallas, TX  
The 1100 Block Bergen Street Garden - Brooklyn, NY  
Urban Ministry Center - Charlotte, NC  
Wasatch Community Gardens - Salt Lake City, UT  
Woodlawn Garden - Portland, OR  
Xochiquetzal Peace Garden - Chicago, IL

For more information on these gardens, visit their website at:

<http://www.organicgardening.com/feature/0,7518,s1-2-10-1531-1-1X2X3-4,00.html>

This guide can be found on CENYC's website at:

<http://www.cenyc.org/openspace/rainwater/RWHHowTo.pdf>

# 10 Ways to Conserve Water

1. Turn off the faucet when brushing your teeth, washing your face and shaving.
2. Fix any leaky sinks, toilets or showerheads.
3. Wash only full loads- for clothing and dishes.
4. Do not run water to thaw meats.
5. Water plants at the roots.
6. Take showers instead of baths.
7. Replace showerheads and sink aerators with low flow ones.
8. Use a pitcher to store cold water in the refrigerator instead of running the tap every time.
9. Water plants during early mornings and late afternoons to reduce evaporation.
10. Do not flush the toilet unnecessarily. Dispose of bugs, cigarette butts and tissues another way. <sup>18 19 20</sup>

**The Water Resources Group** (WRG), a coalition of NYC greening & community garden groups is dedicated to the preservation of NYC water resources through gardening, ecological design and education programs. WRG is installing rainwater harvesting systems in gardens across NYC to conserve water and prevent pollution. For more information on how you can help conserve water in New York City, visit the Water Resources Group website at [www.waterresourcesgroup.org](http://www.waterresourcesgroup.org). The Water Resources Group meets every second Thursday of the month at 10 a.m. at the Council on the Environment of New York City, 51 Chambers Street, Room 214. All are welcome to attend.

If you have any questions regarding the construction of your rain water harvesting system e-mail Lenny Librizzi, Assistant Director of Open Space Greening at CENYC at [llibrizzi@cenyc.org](mailto:llibrizzi@cenyc.org).



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- <sup>1</sup> Hasse, Rolf. "Rain water reservoirs above ground structures for roof catchment." Welcome to Energy. 19 November 2003. 20 June 2008 <<http://ces.iisc.ernet.in/energy/water/paper/drinkingwater/rainwater/introduction.html>>
- <sup>2</sup> "An introduction to rain water harvesting." The WWW Virtual Library on Urban Environmental Management. 9 May 2008. 20 June 2008 <<http://www.gdrc.org/uem/water/rainwater/introduction.html>>
- <sup>3</sup> 10,000 Rain Gardens. 2008. 20 June 2008 <<http://www.rainkc.com/>>
- <sup>4</sup> "Water." The New York Observer. 21 April 2008: G 10.
- <sup>5</sup> "An introduction to rain water harvesting." The WWW Virtual Library on Urban Environmental Management. 9 May 2008. 20 June 2008 <<http://www.gdrc.org/uem/water/rainwater/introduction.html>>
- <sup>6</sup> "Rhizome Collective." Eco Warrior. 28 Nov 2007. 11 July 2008 <<http://hurricanecandice.wordpress.com/2007/11/28/rhizome-collective/>>
- <sup>7</sup> "Oak Whiskey Barrel." Rain Barrel by Aaron. 2003. 11 July 2008 <[www.ne-design.net/oak-whiskey-barrel.html](http://www.ne-design.net/oak-whiskey-barrel.html)>
- <sup>8</sup> "Products." RainDrops Cisterns Rainwater Harvesting and Storage. 23 June 2008. 11 July 2008 <[http://www.raindropscisterns.com/cat\\_photo\\_3.php](http://www.raindropscisterns.com/cat_photo_3.php)>
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- <sup>15</sup> Lexis Coatings. 20 June 2008 <<http://www.lexiscoatings.com/>>
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- <sup>18</sup> Lenz, Ericka. "10 easy ways to conserve water." Gaiam Life- Your Guide to a Better Life. 20 June 2008 <<http://life.gaiam.com/gaiam/p/10SimpleWaystoConserveWater.html>>
- <sup>19</sup> "10 ways to conserve water." Etowah Water and Sewer Authority. 2 February 2008. 2008 June 2008 <[http://www.etowahwater.org/FAQs/10\\_Ways\\_to\\_Conserve\\_Water/10\\_ways\\_to\\_conserve\\_water.html](http://www.etowahwater.org/FAQs/10_Ways_to_Conserve_Water/10_ways_to_conserve_water.html)>
- <sup>20</sup> "Ten Ways To Conserve Water Around The House And Help The Environment." The Good Human. 2 July 2007. 20 June 2008. <<http://www.thegoodhuman.com/2007/07/02/ten-ways-to-conserve-water-around-the-house-and-help-the-environment/>>

This manual was put together by Julia Leung, Lenny Librizzi, Assistant Director of Open Space Greening at CENYC and Lars Chellberg.

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After reading this manual, please fill out this feedback form and mail it to:

Council on the Environment of NYC

51 Chambers Street, Room 228

New York, NY 10007

On a scale of 1 – 10, 10 being the most agreeable, 1 being the least, assess the following statements:

This manual is easy to understand.

1      2      3      4      5      6      7      8      9      10

This manual contains clear instructions.

1      2      3      4      5      6      7      8      9      10

This manual helped you make your rain water harvesting system.

1      2      3      4      5      6      7      8      9      10

You understand how a rain water harvesting system works.

1      2      3      4      5      6      7      8      9      10

You are no longer interested in rain water harvesting.

1      2      3      4      5      6      7      8      9      10

You would recommend this manual to your friends.

1      2      3      4      5      6      7      8      9      10

You know the importance of water conservation.

1      2      3      4      5      6      7      8      9      10

What are the strong points of this manual?

What are the weak points of this manual?