PERMACULTURE WATER MANAGEMENT:
Ecological Landscape Alliance Conference
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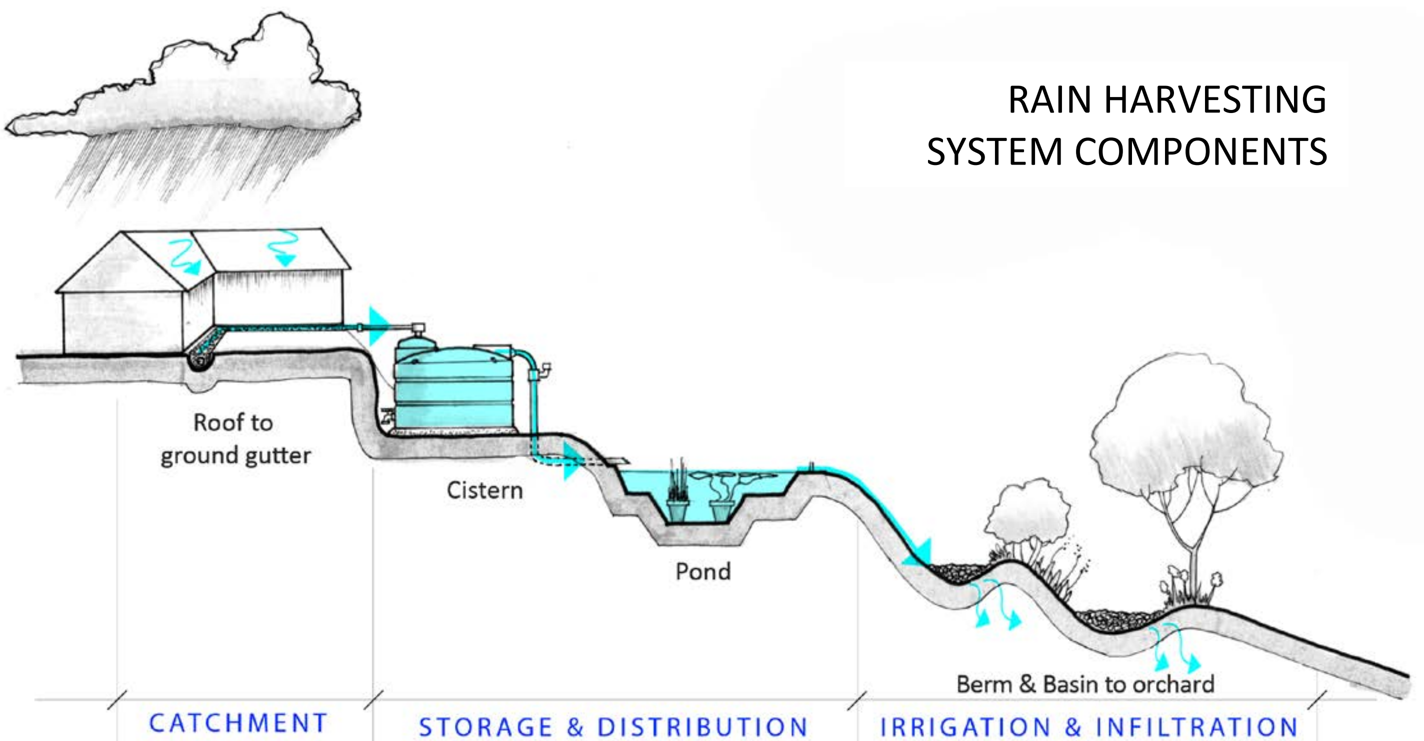
Overview

In most of the places where humans live, work, and grow food, rain falls from the sky. In the heavily developed Northeastern U.S. most of that water flows from our roofs, roads, and driveways into storm sewers or degraded stream systems where it becomes a conveyor of pollutants and vector of erosion. Meanwhile, we use many millions of gallons of water each day in our homes and to water our gardens and lawns. By capturing and storing rain water, we can minimize the negative impacts of stormwater while reducing our demand on energy intensive municipal systems and minimize ground water pumping to supply our watering needs.

A simplified rainwater harvesting system consists of three primary components; **catchment, storage, and distribution**. The catchment refers to the part of the system that captures falling precipitation, storage (what more to say) is the means by which this water is held until distributed, and the distribution component is how the water is transmitted to its intended beneficiary.



Catchment

The catchment is the part of the system that captures falling precipitation. In natural systems like watersheds, the catchment is defined and separated by high points in the landscape like ridge lines. All of the water falling into that watershed eventually makes its way to a low point like a stream or pond. The size of a catchment determines the total potential precipitation that you (or a river) could capture. Roofs are the most common catchment surface for household rainwater harvesting systems, but any surface from which precipitation can be concentrated such as a rock outcropping, driveway (watch out for pollutants), or even a tarp could work.

How much water falls on my roof?

1 square foot of roof yields 0.625 gallons of water during a 1 inch storm event. This is the equivalent of 62.5 gallons per 100 square feet (s.f.) of roof!

With an average rainfall of 3-4 inches a month, a **typical 2000 s.f. home** in the Northeast U.S. can capture around **2500 gallons of water each month**. That's more than 22,000 gallons per year waiting to be captured, stored, and put to use!

PLEASE NOTE: Up to 25- 30% of rainfall can be lost before entering a storage container through adhesion, evaporation and leakage. The calculation above is based on horizontal areas and does not take system losses into account.

Calculating Storage and Irrigation Needs

Storage

In natural systems, much of the water that falls in a watershed is stored in the soil as ground water, held in surface waters like lakes or ponds, and in the bodies of trees. These same strategies can be employed in our rain harvesting systems by building rain gardens to encourage water to soak into the ground, by mulching the ground to eliminate evaporation and promote infiltration, and in tanks or constructed ponds that can be used to irrigate the garden or supply drinking water.

The traditional garden wisdom of New Englanders suggests that stand-by garden crops (tomatoes, potatoes, peas, carrots, etc) grown in unmulched, annually tilled beds require a minimum of **1" of rain or irrigation per week**.

Therefore, a **400 square foot plot** that measures 20ft X 20ft requires approximately about **250 gallons a week** *Area of Garden (ft^2) X Irrigation Needs (in.) X 0.625(conversion factor)= Water Needed (ga.)*. To capture enough water to carry this garden through a 4-week period with no rain, we would need to design a system with a 1000 gallon capacity, that is the equivalent of 25 forty-gallon food-grade barrels, or a single livestock tank.

By mulching, using ground covers, and by adding organic matter to the soil, we can reduce these demands to just ½ an inch per week. However, due to plant transpiration even the most perfectly mulched vegetable garden will require water from either precipitation or irrigation.

WATER TANK CONFIGURATIONS

These scenarios can be applied to tanks of any size to create a customized system to suit the needs of any situation where container storage is called for. The optimal design may combine these strategies, i.e. a large single tank would overflow into 2 ganged tanks.

Single: i.e. prefab rain barrels, ferrocement tanks, plastic livestock tanks

Gang: All of the containers, whether prefab, recycled, or homemade, are connected near the bottom resulting in multiple tanks operating as a single unit that is filled and drained at nearly the same rate.

Serial: In this scenario, the tanks are connected near the top of each cistern through overflow pipes. Because of a "stepping down" in elevation from one tank to the other, the cisterns will fill sequentially. These make use of ready made concrete septic tanks, stock tanks, or custom built containers.

Thoughts and evaluations:

Each configuration has its own inherent advantages and disadvantages. Overall the ganged configuration require only one pump/outlet pipe, but are more subject to leaking that could drain down the whole system. The serial configuration is a more redundant system, as each tank is more independent. This system requires a pump/ outlet pipe for each tank.

Distribution

While gravity (water flows downhill) acts to distribute water in the landscape, natural features like streams, rock fissures, and ground water seeps also direct its flows. In the household rainwater harvesting system, trenches, pipes, buckets, and watering cans are some of the ways we can move water around. Drip irrigation systems are the most water efficient way to deliver controlled quantities of water to your gardens; however these can be expensive and are generally made of plastic.

Equations for Estimating

(Note- these are "quick and dirty" estimating tools, for more precise measurements, refer to references below):

Estimated Roof Area (ft^2)= Length of House (ft.) X Width of House (ft.)

Catchment (gallons)= Roof Area (ft^2) X Rain Event (in.) X 0.623 (ga/cu. ft) X 0.75 (Loss factor= runoff coefficient for roof + leak loss. This will vary for different roof surfaces and systems designs)

Water Supply Needed (ga.)= Area of Garden (ft^2) X Desired Depth of Irrigation (in.) X 0.623(ga/cu. ft)

First Flush Discard=1 gallon per 100 square feet of catchment (Roof Area X 0.01)

1 Cubic Foot = 7.48 Gallons; **1Gallon =** 0.134 Cubic Feet **1 inch** = 0.083 feet; **1 foot** = 12 inches

Resources

Background

Mollison, B. (1988) *Permaculture: A Designer's Manual*, Tagari Publications.
Yeomans, P.A. (1981) *Water for Every Farm/Using the Keyline Plan*, Second Back Row Press.

System Design

Lancaster, Brad. *Rainwater Harvesting for Drylands and Beyond.* Chelsea Green Publishing Company, 2006.
Ludwig, Art. *Water Storage: Tanks, Cisterns, Aquifers, and Ponds.* Oasis Design, 2005.

Raver, Anne. *Raindrops Keep Falling in My Tank.* New York Times. July 24, 2008
http://www.nytimes.com/2008/07/24/garden/24garden.html?_r=2&scp=1&sq=%22raindrops%20keep%20falling%20in%20my%20tank%22&st=cse&oref=slogin&oref=slogin

Supplies

Your local hardware and farm supply stores- These local businesses often have many of the fitting, piping, storage tanks, and other supplies that you will need.

Dripworks- California drip irrigation supplier, good customer support and convenient pre-packaged systems. http://www.dripworksusa.com/

Plastic Mart- Suppliers of tanks of any size. http://www.plastic-mart.com/

Sky Juice- Massachusetts based supplier of low pressure drip irrigation systems and components, great info on website. http://www.skyjuice.us/html/drip_irrigation.html

Calculating Runoff for Water Harvesting

You can estimate the volume of runoff from rainfall for any surface on your property. Calculating runoff is an important step in designing your water harvesting system. You should determine both your water supply and your water demand. Use this worksheet to determine your rainwater supply.

Useful Definitions:

1. Catchment Area: the area in which rain directly falls (i.e. a roof, a driveway, or a landscape). The area is the same regardless of slope; you can also think of the area as seen from a birds-eye view or as the horizontal surface space occupied.

2. Runoff Coefficient: the average percentage of rainfall that will run off a particular surface (i.e. a metal roof has a runoff coefficient of 0.95 or 95% runoff). The runoff coefficient will vary depending on the composition of the surface and the rainfall intensity. The higher the rainfall intensity, the higher the runoff coefficient.

3. Annual Rainfall: the average amount of rainfall over one year period for your location.

Runoff Coefficients for the United States

Surface	Runoff Range
ROOF	0.80 – 0.95 (Metal: 0.95, Concrete/asphalt: 0.90, Builtup tar/gravel: 0.85 – 0.80)
PAVING (concrete, asphalt)	0.90 – 1.00
BARE SOIL (flat)	0.20 – 0.75
SOIL WITH VEGETATION (flat)	0.10 – 0.60
GRASS/LAWN	0.05 – 0.35
GRAVEL	Use the coefficient of the ground below the gravel

*Chart adapted from 1) Lancaster, Brad. 2006. *Rainwater Harvesting for Drylands*, Vol.1.Rainsource Press and 2) Waterfall, Patricia. 2006. *Harvesting Rainwater for Landscape Use 2nd Ed.* Pima County Cooperative Extension.

1. CALCULATE YOUR CATCHMENT AREA

Rectangular Catchment Area:
Length of area (ft) x width of area (ft) = catchment area (ft^2)

1a) Roof: ______________ (ft) x ______________ (ft) = _________________ (ft^2)
length width catchment area

1b) Driveway: ______________ (ft) x ______________ (ft) = ________________(ft^2)
length width catchment area

1c) Soil/landscape: _____________(ft) x ____________ (ft) = _______________ (ft^2)
length width catchment area

*Equations from: Lancaster, Brad. 2006. *Rainwater Harvesting for Drylands*, Vol.1.Rainsource Press.

2. CALCULATE ANNUAL RUNOFF FOR EACH CATCHMENT AREA

General Equation:
catchment area (ft^2) x **rainfall (ft)** x **7.48 gal/ft^3** x **runoff coefficient = net runoff (gal)**

Use the Runoff Coefficient Chart to make an educated guess on the runoff coefficient for each.

Note: *Rainfall in equations is measured in feet not inches.* **1 inch = 0.083 feet**

2a) Roof:

_____________ (ft^2) x _______ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

2b) Driveway:

_____________ (ft^2) x _______ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

2c) Bare Soil or Landscape:

_____________ (ft^2) x _______ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

3. CALCULATE RUNOFF FROM A LARGE STORM (3 INCHES OR 0.25 FT)

The equation for calculating runoff from a storm is the same as annual runoff, just substitute the storm rainfall amount for annual rainfall.

3a) Roof:

____________ (ft^2) x __0.25__ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

3b) Driveway:

____________ (ft^2) x __0.25__ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

3c) Bare Soil or Landscape:

____________ (ft^2) x __0.25__ (ft) x 7.48 gal/ft^3 x _________ = _________ (gal)
catchment area rainfall coefficient net runoff

*Equations from: Lancaster, Brad. 2006. *Rainwater Harvesting for Drylands*, Vol.1.Rainsource Press.