The Eight Rainwater-Harvesting Principles

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For a more detailed description of the Eight Rainwater-Harvesting Principles, see pp. 29-38 of *Rainwater Harvesting for Drylands and Beyond, Volume 1*, or pp. 4-7 of *Rainwater Harvesting for Drylands and Beyond, Volume 2*.

1. Begin with long and thoughtful observation.
   Use all of your senses to see where the water flows and how. What is working, what is not? Build on what works.

2. Start at the top – or highpoint – of your watershed and work your way down.
   Water travels downhill. Start at the top where there is less volume and velocity so it is easier to follow the next principle…

3. Start small and simple.
   Work at the human scale so you can build and repair everything. One thousand small strategies are far more effective than one big one when you are trying to infiltrate water into the soil.

4. Spread and infiltrate the flow of water.
   Rather than having water run erosively off the land's surface, encourage it to stick around, walk around, and infiltrate INTO the soil.

5. Always plan for an overflow route, and manage that overflow water as a resource.
   Always have an overflow for the water in times of extra-heavy rains, and use that overflow as a resource.

6. Maximize living, organic groundcover.
   Create a living sponge so the harvested water is used to create more resources, while the soil's ability to infiltrate and hold water steadily improves.

7. Maximize beneficial relationships and efficiency by "stacking functions."
   Get your water-harvesting strategies to do more than hold water. Berms or swales can double as high and dry raised paths. Plantings can be placed to cool buildings. Trees can be selected to provide food.

8. Continually reassess your system: the "feedback loop."
   Learn from your work – we begin again with the first principle.

Principles 2, 4, 5, and 6 are based on those developed and promoted by PELUM – the Participatory Ecological Land-Use Management association of east and southern Africa. Principles 1, 3, 7, and 8 are based on my own experiences and the insights gained from Mr. Zephaniah Phiri Maseko and other water harvesters.

Calculating Rainfall Volumes

from *Rainwater Harvesting for Drylands and Beyond, Volume 1*
by Brad Lancaster

Box 2.3. Calculating Rainfall Volumes

CALCULATING RAINFALL VOLUMES IN ENGLISH UNITS

To calculate the volume of rainfall in *cubic feet* that falls in an average year on a specific *catchment area*, such as your roof, yard, neighborhood, or other subwatershed:

CATCHMENT AREA (in square feet) multiplied by the AVERAGE ANNUAL rainfall (in feet) equals the TOTAL RAINWATER FALLING ON THAT CATCHMENT IN AN AVERAGE YEAR (in cubic feet)

(or)

CATCHMENT AREA (ft^2) × AVG RAINFALL (ft) = TOTAL RAINWATER (ft^3)

If you normally measure annual rainfall in inches, simply divide inches of rain by 12 to get annual rainfall in feet. For example, folks in Phoenix, Arizona get about 7 inches of annual rainfall, so they would divide 7 by 12 to get 0.58 foot of annual rain.

Once you get your answer in cubic feet of annual average rainfall, convert cubic feet to gallons by multiplying your cubic foot figure by 7.48 gallons per cubic foot. The whole calculation looks like this:

CATCHMENT AREA (ft^2) × RAINFALL (ft) × 7.48 gal/ft^3 = TOTAL RAINWATER (gal)

For example, if you want to calculate how much rainwater in gallons falls on your 55 foot by 80 foot (4,400 square feet) lot in an normal year where annual rainfall averages 12 inches the calculation would look like this:

4,400 square foot catchment area × 1 foot of average annual rainfall × 7.48 gallons per cubic foot = 32,912 gallons of rain falling on the site in an average year

CALCULATING RAINFALL VOLUMES IN METRIC UNITS

To calculate the volume of rainfall falling on a specific catchment area in liters:

CATCHMENT AREA (in square meters) × AVERAGE ANNUAL RAINFALL (in millimeters) = TOTAL RAINWATER FALLING ON A CATCHMENT AREA IN AN AVERAGE YEAR (in liters)

CALCULATING THE VOLUME OF RAINFALL ON A SPECIFIC CATCHMENT FOR A GIVEN RAIN EVENT IN ENGLISH OR METRIC UNITS.:

Use the calculations above, but enter the amount of "rainfall from a given rain" in place of "average annual rainfall."

Note: Appendix 3 "Calculations" provides more detailed information on conversions, constants, and calculations for water harvesting.

Calculating Runoff Volumes

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Box 2.4. Calculating Runoff Volumes

You can get a ballpark estimate of runoff volume from any sloped surface by multiplying the volume of rain that falls on that surface by its "runoff coefficient"—the average percentage of rainwater that runs off that type of surface. For example, a rooftop with a runoff coefficient of 0.95 estimates that 95% of the rain falling on that roof will run off.

The runoff coefficient for any given surface depends on what the surface is composed of. Rainfall intensity also affects the coefficient: the higher the rainfall intensity, the higher the runoff coefficient. Ranges and averages of various runoff coefficients I use in the southwest U.S. are as follows:

- A roof or impervious paving (such as an asphalt street): 0.80–0.95
- Sonoran Desert uplands (healthy indigenous landscape): range 0.20–0.70, average 0.30–0.50
- Bare earth: range 0.20–0.75, average 0.35–0.55
- Grass/lawn: range 0.05–0.35, average 0.10–0.25
- For gravel use the coefficient of the ground below the gravel.

The runoff coefficient for earthen surfaces is greatly influenced by soil type and vegetation density. Large-grained porous sandy soils tend to have lower runoff coefficients while fine-grained clayey soils allow less water to infiltrate and therefore have higher runoff coefficients. Whatever your soil type, the more vegetation the better, since plants enable more water to infiltrate the soil.

CALCULATING ROOF RUNOFF: AN EXAMPLE IN METRIC UNITS

Determine the size of a roof catchment by measuring only the outside dimensions—or "footprint"—of the roof's edge (if your house has a roof with overhangs the roof's footprint will be larger than the building's footprint). Ignore the roof slope; no more rain falls on a peaked roof than falls on a flat roof with the same footprint. (See figure 2.5).

To calculate the runoff in liters from a metal roof's 9 meter × 10 meter "footprint" (90 square meters) in a climate averaging 304 millimeters of rain a year:

90 square meter roof × 304 millimeters of average annual rainfall = 27,360 liters of rain falling on the roof in an average year.

$$90 \text{ m}^2 \times 304 \text{ mm} = 27{,}360 \text{ liters/average year}$$

Multiply the above figure by the roof surface's runoff coefficient 0.95*:
27,360 liters × 0.95 = 25,992 liters running off the roof in an average year.

Note*: 5 to 20% of runoff from impervious catchment surfaces such as roof can be lost due to evaporation, wind, overflow of gutters, and minor infiltration into the surface itself. In volume 3, the chapter on cistern components includes a table for runoff coefficients specific to roof type.

CALCULATING YARD RUNOFF: AN EXAMPLE IN ENGLISH UNITS

Let's say we are on a site receiving 18 inches of rain in an average year, and the neighbor has about a 25 foot by 12 foot bare section of his yard that drains onto our example property. The soil is clayey and compacted.

Determine the available rainwater running off that section of the neighbor's yard onto our land by multiplying its catchment area (300 square feet) by the average annual rainfall in feet (1.5) by 7.48 (to convert the answer to gallons):

$$\text{CATCHMENT AREA (ft}^2\text{)} \times \text{RAINFALL (ft)} \times 7.48 \text{ gal/ft}^3 = \text{TOTAL RAINWATER (gal)}$$

300 × 1.5 × 7.48 = 3,366 gallons of rain falling on that section of the neighbor's yard in an average year.

Multiply that figure by the soil surface's runoff coefficient of 0.60:

3,366 × 0.60 = 2,019 gallons annually running off the neighbor's compacted yard into ours. Add that to our site's annual rainwater budget.

Watergy (Water/Energy) Cost Calculator

for You and Your Community

interactive version available online at: www.harvestingrainwater.com/watergy-climate/online-watergy-calculator

How many gallons of water does it take to produce one kWh of energy from each of the following sources?[1]

Source:	**gal/kWh**
Hydroelectric (high)	56.000
Hydroelectric (low)	30.078
Solar Thermal (Calif)	0.900
Nuclear	0.785
Coal	0.510
Natural Gas (SC)[5]	0.415
Landfill	0.350
Biofuel	0.350
Solar Thermal (Ariz)	0.311
Natural Gas (CC)[5]	0.195
Geothermal	0.005
Solar PV	0.001

*The average American household uses 920 kWh of electricity/**month**,*[2] *while an average Arizona household uses 1095 kWh/**month**.*[2] *If the electricity for one such household*[3] *came solely from each source below, how much water would be used by each household per **month**?*

Source:	**gal/mo U.S.**	**gal/mo AZ**
Hydroelectric (high)	51,520	61,320
Hydroelectric (low)	27,672	32,935
Solar Thermal (Calif)	828	986
Nuclear	722	860
Coal	469	558
Natural Gas (SC)[5]	382	454
Landfill	322	383
Biofuel	322	383
Solar Thermal (Ariz)	286	341
Natural Gas (CC)[5]	179	214
Geothermal	5	5
Solar PV	1	1

*How many gallons of water **per month** would an average U.S. community*[3] *of x households use to generate its electricity if all its electricity came from each source listed below?*

Excel users: Fill in top purple box w/ # of h'holds in your area

	#H'holds in ??	**#Tucson H'holds:**[4]
Source:	**0**	**200,845**
Hydroelectric (high)	0	12,315,815,400
Hydroelectric (low)	0	6,614,912,421
Solar Thermal (Calif)	0	197,932,748
Nuclear	0	172,641,341
Coal	0	112,161,890
Natural Gas (SC)[5]	0	91,268,989
Landfill	0	76,973,846
Biofuel	0	76,973,846
Solar Thermal (Ariz)	0	68,396,761
Natural Gas (CC)[5]	0	42,885,429
Geothermal	0	1,099,626
Solar PV	0	219,925

1. Water Costs of Electricity in Arizona, a Project Fact Sheet from the Arizona Water Institute (Tucson AZ), from a 2007 investigation by Pasqualetti & Kelley. Fact sheet ID: AWI-07-102 Pasqualetti. // 2. www.eia.doe.gov/cneaf/electricity/esr/table5.html // 3. Both U.S. & AZ figures calculated using AZ watergy info, but keep in mind that water lost to evaporation in colder and/or more humid climates will be lower than in Arizona. See Pasqualetti for further discussion.
4. 2008 estimate, www.census.gov // 5. Natural Gas (SC) = single-cycle natural gas & Natural Gas (CC) = combined-cycle natural gas.