

Appendix 3

Water-Harvesting Calculations

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Box A3.1. Abbreviations, Conversions, and Constants for English and Metric Measurement Units

Note: * items are approximate or rounded off

[†] Water density changes slightly with temperature.

ABBREVIATIONS FOR ENGLISH UNITS

inches = in

feet = ft

square feet = ft²

cubic feet = ft³

gallons = gal

pounds = lb

pounds per square inch of pressure = psi

acre = a

acre feet = AF

CONVERSIONS FOR ENGLISH UNITS

To convert cubic feet to gallons, multiply cubic feet by 7.48 gal/ft³ *

To convert inches to feet, divide inches by 12 in/ft

To convert gallons of water to pounds of water, multiply gallons by 8.32 lb/gal *[†]

To convert cubic feet of water to pounds, multiply cubic feet by 62.23 lb/ft³ *[†]

To convert acre feet of water to gallons, multiply acre feet by 325,851 gal/AF

To convert acre feet of water to cubic feet, multiply acre feet by 43,560 cubic feet/AF

CONSTANTS

Pounds of pressure per square inch of water per foot of height = 0.43 psi/ft *[†]

Ratio between a circle's diameter and its circumference is expressed as $\pi = 3.14$ *

ABBREVIATIONS FOR METRIC UNITS

millimeters = mm

centimeters = cm

meters = m

liters = l

kilograms = kg

hectare = ha

CONVERSIONS FOR METRIC UNITS

1 liter of water weighs 1 kilogram

1 cubic meter = 1,000 liters

To convert Fahrenheit (F) to Celsius (C) for actual indoor/outdoor temperature measure ("it's 70 degrees outside today"), subtract 32 from Fahrenheit temperature, multiply result by 5, then divide by 9.

To convert Fahrenheit (F) to Celsius (C) for temperature difference ("it's 20 degrees hotter today than yesterday"), multiply Fahrenheit by 5, then divide by 9.

CONVERTING BETWEEN ENGLISH UNITS AND METRIC UNITS

To convert inches to millimeters, multiply inches by 25.4 mm/in

To convert inches to centimeters, multiply inches by 2.54 cm/in

To convert feet to meters, multiply feet by 0.30 m/ft *

To convert square feet to square meters, multiply square feet by 0.093 m²/ft² *

To convert cubic feet to cubic meters, multiply cubic feet by 0.028 m³/ft³ *

To convert gallons to liters, multiply gallons by 3.79 liter/gal *

To convert pounds to kilograms, multiply pounds by 0.45 kg/lb *

To convert acres to hectares, multiply acres by 0.405 ha/a *

To convert miles to kilometers, multiply miles by 1.6 km/mi *

Best technique to measure rainfall: Buy a simple rain gauge for \$10 or so from a hardware or feed store, plant and garden nursery, or a scientific supply house. A rain gauge that is tapered at the bottom makes reading small amounts of rainfall easier.

For resources documenting local rainfall rates and other climatic information, see appendix 6, section G.

Equation 1A.

Catchment Area of Rectangular Surface (English units)

$$\text{length (ft)} \times \text{width (ft)} = \text{catchment area (ft}^2\text{)}$$

EXAMPLE:

A house measures 47 feet long by 27 feet wide at the drip line of the roof. Note that it does not matter whether the roof is flat or peaked; the roof dimensions at the drip line are the same. It is the “footprint” of the roof’s drip line that matters.

$$\begin{aligned} 47 \text{ ft} \times 27 \text{ ft} &= 1,269 \text{ ft}^2 \\ 1,269 \text{ ft}^2 &= \text{catchment area} \end{aligned}$$

If the roof consists of two or more rectangles, calculate the area for each rectangle and add together. Again, take the view of a falling raindrop, and only look at the “footprint” of the roof’s drip line. Roof pitch cannot be seen from above and does not matter. With conical, octagonal, or other non-standard roof shapes, again calculate the area based on the *drip line*.

Equation 1B.

Catchment Area of Rectangular Surface (metric units)

$$\text{length (m)} \times \text{width (m)} = \text{catchment area (m}^2\text{)}$$

EXAMPLE:

$$\begin{aligned} 15 \text{ m} \times 9 \text{ m} &= 135 \text{ m}^2 \\ 135 \text{ m}^2 &= \text{catchment area} \end{aligned}$$

Again, all the considerations in Equation 1A will apply.

Equation 2A.

Catchment Area of Triangular Surface (right triangle)

Multiply the lengths of the two shorter sides of the triangle then divide by 2 = catchment area

EXAMPLE:

A triangular section of roof measures 9 feet by 12 feet by 15 feet. This is a right triangle, with the 90-degree angle between the 9-foot and 12-foot sides. Taking the measurements of the two shorter sides:

$$\begin{aligned} (9 \text{ ft} \times 12 \text{ ft}) \div 2 &= \text{catchment area (ft}^2\text{)} \\ 108 \text{ ft}^2 \div 2 &= 54 \text{ ft}^2 \end{aligned}$$

$$54 \text{ ft}^2 = \text{catchment area}$$

Equation 2B.

Catchment Area of Triangular Surface (standard math formula)

Multiply the triangle's base times its height then divide by 2 = catchment area
where the base can be any side, and the height is measured perpendicularly from the base to the opposite vertex.

EXAMPLE:

You want to know the area of a triangular section of patio. The length of the section in front of you is 20 feet (triangle base) and you measure 4 feet perpendicularly to the opposite vertex of the triangle.

$$(20 \text{ ft} \times 4 \text{ ft}) \div 2 = \text{catchment area (ft}^2\text{)}$$

$$80 \text{ ft}^2 \div 2 = 40 \text{ ft}^2$$

$$40 \text{ ft}^2 = \text{catchment area}$$

Equation 2C.

Catchment Area of Triangular Surface (Heron's formula)

This formula, attributed to Heron of Alexandria (first century A.D.), involves no trigonometry. It only needs the square root (sqrt) function found on most electronic or computer calculators. It may be useful when dealing with non-right triangles where you can measure (or know) all sides of the triangle.

Step 1: Determine the lengths of the sides of the triangle. These are a, b, c.

Step 2: Calculate s.

$$(a + b + c) \div 2 = s$$

Step 3: Calculate S, using:

$$s \times (s - a) \times (s - b) \times (s - c) = S$$

Step 4: Calculate the catchment area, which is the square root of S.

$$\text{sqrt } S = \text{catchment area}$$

Equation 3.

Catchment Area of Circular Surface

$$\pi \times r^2 = \text{catchment area}$$

Note: r = radius of the circle. A circle's radius is half the circle's diameter.

EXAMPLE:

A circular roof has a 25 foot diameter. Divide the diameter by 2 to get the *radius* of 12.5 feet.

$$\pi \times (12.5 \text{ ft} \times 12.5 \text{ ft}) = \text{catchment area (ft}^2\text{)}$$

$$3.14 \times 156.25 \text{ ft}^2 = 490.62 \text{ ft}^2$$

$$490.62 \text{ ft}^2 = \text{catchment area}$$

Equation 4A.

Possible Volume of Runoff from a Roof or Other Impervious Catchment Area (English units)

$$\text{catchment area (ft}^2\text{)} \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 = \text{maximum runoff (gal)}$$

Note: For a more realistic and conservative estimate see Equation 5.

EXAMPLE CALCULATING ANNUAL RUNOFF:

Calculate the gallons of rain running off the roof in an average year from a home that measures 47 feet long and 27 feet wide at the drip line of the roof. (In the example below, the roof dimensions at the drip line are included in the calculation; the catchment area is the same whether the roof is flat or peaked.) Rainfall in this location averages 10.5 inches per year, so you will divide this by 12 inches of rainfall per foot to convert inches to feet for use in the equation. (Note: You can use the same equation to calculate the runoff from a single storm, by simply using the rainfall from that storm instead of annual average rainfall in the equation.) Since the roof is a rectangular area, use the following calculation for catchment area:

$$\begin{aligned} &(\text{length (ft)} \times \text{width (ft)}) \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 = \text{maximum runoff (gal)} \\ &(47 \text{ ft} \times 27 \text{ ft}) \times (10.5 \text{ in} \div 12 \text{ in/ft}) \times 7.48 \text{ gal/ft}^3 = \text{maximum runoff (gal)} \\ &1,269 \text{ ft}^2 \times 0.875 \text{ ft} \times 7.48 \text{ gal/ft}^3 = 8,306 \text{ gal} \end{aligned}$$

$$8,306 \text{ gal} = \text{runoff}$$

EXAMPLE CALCULATING RUNOFF FROM A SINGLE RAIN EVENT:

Calculate the maximum gallons of rain running off the roof in a single rain event from a home that measures 47 feet long and 27 feet wide at the drip line of the roof. It is not unusual for heavy storms in the example area to drop three inches of rain. To determine the runoff from such a rain event you will divide the 3 inches of rainfall by 12 inches of rainfall per foot to convert inches to feet for use in the equation. Since the roof is a rectangular area, use the following calculation for catchment area:

$$\begin{aligned} &(\text{length (ft)} \times \text{width (ft)}) \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 = \text{maximum runoff (gal)} \\ &(47 \text{ ft} \times 27 \text{ ft}) \times (3 \text{ in} \div 12 \text{ in/ft}) \times 7.48 \text{ gal/ft}^3 = \text{maximum runoff (gal)} \\ &1,269 \text{ ft}^2 \times 0.25 \text{ ft} \times 7.48 \text{ gal/ft}^3 = 2,373 \text{ gal} \end{aligned}$$

$$2,373 \text{ gal} = \text{maximum runoff}$$

Equation 4B.

Possible Volume of Runoff from a Roof or Other Impervious Catchment Area (metric units)

$$\text{catchment area (m}^2\text{)} \times \text{rainfall (mm)} = \text{maximum runoff (liters)}$$

Calculations for annual rainfall, a rainy season, or an event would be similar to those for English units.

Box A3.2. Estimating Rainfall Runoff Using Rules of Thumb

Rough rule of thumb for calculating rainfall runoff volume on a catchment surface (English units):

You can collect 600 gallons of water per inch of rain falling on 1,000 square feet of catchment surface.

On the really big scale:

You can collect 27,000 gallons of water per inch of rain falling on 1 acre of catchment surface.

Rule of thumb for calculating rainfall volume on a catchment surface (metric units):

You can collect 1,000 liters of water per each 10 millimeters of rain falling on 100 square meters of catchment surface.

On the really big scale:

You can collect 100,000 liters of water per 10 millimeters of rain falling on one hectare of catchment surface.

Equation 5A.

Estimated Net Runoff from a Catchment Surface Adjusted by its Runoff Coefficient (English units)

$$\text{catchment area (ft}^2\text{)} \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 \times \text{runoff coefficient} = \text{net runoff (gal)}$$

Impervious catchment surfaces such as roofs or non-porous pavement can lose 5% to 20% of the rain falling on them due to evaporation, and minor infiltration into the catchment surface itself. The more porous or rough your roof surface, the more likely it will retain or absorb rainwater. On average, pitched metal roofs lose 5% of rainfall, allowing 95% to flow to the cistern. Concrete or asphalt roofs retain around 10%, while builtup tar and gravel roofs can retain 15% to 20%. However, the percent of retention is a function of the size and intensity of the rain event, so more porous roof surfaces could absorb up to 100% of small, light rain events. To account for this potential loss, determine the runoff coefficient that is appropriate for your area and impervious catchment surface (0.80 to 0.95).

EXAMPLE CALCULATING NET ANNUAL RUNOFF FROM A ROOF:

Calculate the net gallons of rain running off the roof in an average year from a home that measures 47 feet long and 27 feet wide at the drip line of the roof. Rainfall in this location averages 10.5 inches per year, so you will divide this by 12 inches of rainfall per foot to convert inches to feet for use in the equation. (Note: You can use the same equation to calculate the runoff from a single storm, by simply using the rainfall from that storm instead of annual average rainfall in the equation.) Assume that the loss of water that occurs on the catchment surface is at the high end of the range so you get a conservative estimate of *net runoff*. This means you select a *runoff coefficient* of 80%, or 0.80. Since the roof is a rectangular area, use the following calculation for catchment area:

$$\begin{aligned} &(\text{length (ft)} \times \text{width (ft)}) \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 \times 0.80 = \text{net runoff (gal)} \\ &(47 \text{ ft} \times 27 \text{ ft}) \times (10.5 \text{ in} \div 12 \text{ in/ft}) \times 7.48 \text{ gal/ft}^3 \times 0.80 = \text{net runoff (gal)} \\ &1,269 \text{ ft}^2 \times 0.875 \text{ ft} \times 7.48 \text{ gal/ft}^3 \times 0.80 = 6,644 \text{ gal} \end{aligned}$$

$$6,644 \text{ gal} = \text{net runoff}$$

Based on this, a realistic estimate of the volume of water that could be collected off the 47 foot by 27 foot example roof in an average year is 6,644 gallons.

Pervious surfaces such as earthen surfaces or vegetated landscapes can infiltrate up to 100% of the rain falling on them. Their runoff coefficient 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 the soil type, the more vegetation the lower the runoff coefficient since plants enable more water to infiltrate the soil. Below are some runoff coefficients for the southwestern U.S., although these are just rough estimates since runoff rates are also affected by rainfall intensity and duration. The more intense or the longer the rainfall the greater the runoff, since more rain is infiltrated in the soil before the soil becomes saturated. A very light rainfall may just evaporate, and not run off or infiltrate at all.

- 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

EXAMPLE CALCULATING NET ANNUAL RUNOFF FROM A BARE SECTION OF YARD:

In an area receiving 18 inches of rain in an average year, you want to calculate the runoff from a 12 foot by 12 foot bare section of yard that drains to an adjoining infiltration basin. The soil is clayey and compacted, and you estimate its runoff coefficient to be 60% or 0.60.

$$\begin{aligned}\text{catchment area (ft}^2\text{)} \times \text{rainfall (ft)} \times 7.48 \text{ gal/ft}^3 \times \text{runoff coefficient} &= \text{net runoff (gal)} \\ 12 \text{ ft} \times 12 \text{ ft} \times (18 \text{ in} \div 12 \text{ in/ft}) \times 7.48 \text{ gal/ft}^3 \times 0.60 &= \text{net runoff (gal)} \\ 144 \text{ ft}^2 \times 1.5 \text{ ft} \times 7.48 \text{ gal/ft}^3 \times 0.60 &= 969 \text{ gal}\end{aligned}$$

$$969 \text{ gal} = \text{net runoff}$$

Based on this, a realistic estimate of the volume of runoff that could be collected off the 12 foot by 12 foot section of bare earth within the adjoining infiltration basin is 969 gallons in an average year.

EXAMPLE CALCULATING RUNOFF FROM A SINGLE STORM EVENT ON ESTABLISHED LAWN (GRASS):

The runoff coefficient for this established lawn is assumed to be 20% or 0.20, and the maximum storm event is 3 inches:

$$\begin{aligned}12 \text{ ft} \times 12 \text{ ft} \times (3 \text{ in} \div 12 \text{ in/ft}) \times 7.48 \text{ gal/ft}^3 \times 0.20 &= \text{net runoff (gal)} \\ 144 \text{ ft}^2 \times 0.25 \text{ ft} \times 7.48 \text{ gal/ft}^3 \times 0.20 &= 54 \text{ gal}\end{aligned}$$

$$54 \text{ gal} = \text{net runoff}$$

Equation 5B.

Estimated Net Runoff from an Impervious Catchment Surface Adjusted by its Runoff Coefficient (metric units)

$$\text{catchment area (m}^2\text{)} \times \text{rainfall (mm)} \times \text{runoff coefficient} = \text{net runoff (liters)}$$

EXAMPLE:

In an area receiving 304 millimeters of rain a year, you have a rooftop catchment surface that is 15 meters long and 9 meters wide, and you want to know how much rainfall can realistically be collected off that roof in an average year. You want a conservative estimate of annual *net runoff*, so you use a *runoff coefficient* of 80% or 0.80. (Since the roof is a rectangular area, use the following calculation for catchment area as in Equation 1B—catchment area (m²) = length (m) × width (m)—which is figured into the calculation below.)

$$(\text{length (m)} \times \text{width (m)}) \times \text{rainfall (mm)} \times 0.80 = \text{net runoff (liters)}$$

$$(15 \text{ m} \times 9 \text{ m}) \times 304 \text{ mm} \times 0.80 = \text{net runoff (liters)}$$

$$135 \text{ m}^2 \times 304 \text{ mm} \times 0.80 = 32,832 \text{ liters}$$

$$32,832 \text{ liters} = \text{net runoff}$$

A realistic estimate of the volume of water that could be collected off this 15 meter by 9 meter roof in a year of average rainfall is 32,832 liters.

Equation 6.

Cistern Capacity Needed to Harvest the Roof Runoff from a Large Storm Event

$$\text{catchment area (ft}^2\text{)} \times \text{rainfall expected in a local high volume storm (ft)} \times 7.48 \text{ gal/ft}^2 \times \text{runoff coefficient} = \text{catchment runoff (gal)}$$

EXAMPLE:

A water harvester with a 1,200 ft² roof lives in an area where a single storm (or two storms just a few days apart) can unleash 3 inches of rain.

$$1,200 \text{ ft}^2 \times (3 \text{ inches} \div 12 \text{ inches}) \times 7.48 \text{ gal/ft}^2 \times 0.80 = \text{catchment runoff (gal)}$$

$$1,200 \text{ ft}^2 \times 0.25 \text{ ft} \times 7.48 \text{ gal/ft}^2 \times 0.80 = 1,795 \text{ gal}$$

$$1,795 \text{ gal} = \text{catchment runoff}$$

This is the *minimum cistern volume* needed to capture the roof runoff for this size storm.

Note: The above calculation is meant to give a rough estimate of a tank size that will reduce water loss to overflow from the tank and extend the availability of a lot of rainfall long after the rain event only—it is not based on estimated water needs. It is a quick and easy calculation for those simply wanting to supplement their water use with efficient rainwater tank storage. I often recommend beginner water harvesters start with a tank not exceeding a 1,500 gallon capacity. The system can always be expanded later. To start small you don't need to begin with a tank harvesting all the roof's runoff; rather begin by sizing a tank capturing water from just one section of the roof.

Equation 7.

Water Storage Capacity Needed for a Household Committing to Use Harvested Rainwater as the Primary Water Source (English units)

number of people $\times$ daily water consumption (gal/person/day) $\times$ longest drought period (days) = needed storage capacity (gal)

EXAMPLE:

If three people live in the household used in the above examples, each person consumes an average of about 50 gallons per day, and the typical dry season in their area lasts 140 days then:

$3 \text{ people} \times 50 \text{ gal/person/day} \times 140 \text{ days} = 21,000 \text{ gal}$

21,000 gal = needed water capacity

If the people in this household are planning to live primarily off rainwater at their current water consumption rate they would be wise to plan for at least 21,000 gallons of water collection and storage capacity to get them through up to 140 days of dry times.

If the needed water capacity (and needed catchment area) seems too large to be feasible, see how much you can realistically reduce your water consumption, then do the calculation again. For example, if the same household could reduce its daily water consumption to 20 gallons/person/day only 8,400 gallons of water collection and storage capacity would be needed.

Note: The above calculation will give a ballpark estimate of minimum tank capacity to meet dry season demand in expected drought. Sufficient catchment directing water to the tank is also needed to ensure the tank is full or close to full on day one of the dry season. See volume 3 of *Rainwater Harvesting for Drylands and Beyond*, for additional calculations and considerations.

Equation 8. Potential Gravity-Fed Water Pressure from Your Tank (English units)

height of water above its destination (ft) $\times$ water pressure per foot of height (psi/ft) = passive water pressure (psi)

For every foot your source of water is above the elevation of the place where it will be used you develop 0.43 psi/ft of passive water pressure (gravity is the only force being used to create that pressure). The source of water may be in a tank, or a gutter and its associated downspout. The place you use the water may be a garden bed, a fruit tree basin, or any other location where supplemental water is needed.

EXAMPLE:

The folks with the new 8-foot-tall tank want to figure out how much passive water pressure will be available to deliver water from the tank to their squash plants placed in basins 6 inches (0.5 ft) below the surrounding land surface. The height of water in the 8-foot tank is 4 inches below the top of the tank due to the presence of an overflow pipe that allows excess rainwater to safely flow out of the tank during large storms. Based on this information the height of water above its destination is around 8.1 ft. Using Equation 8, calculate the passive water pressure as follows:

$$8.1 \text{ ft} \times 0.43 \text{ psi/ft} = 3.48 \text{ psi}$$

3.48 psi = passive water pressure

As the cistern water is used, the water pressure will drop with the dropping level of water (head) in the tank. Also, keep in mind that friction between water and the walls of a hose, pipe, or irrigation line will cut down on water pressure, so to maintain pressure try to use the water close to the tank, reducing the length of pipe or hose. For example, place a garden on the east side of your tank where the veggies will be shaded from the hot afternoon sun by the bulk of the tank, and you won't need a hose any longer than 25 feet (7.6m).

EXAMPLE:

I often place cisterns so their base is at least 2.5 feet above the garden or basin receiving the stored water. This guarantees me at least 1 psi of gravity-fed pressure even when the tank is nearly empty.

height of water above its destination (ft) $\times$ water pressure per foot of height (psi/ft) = passive water pressure (psi)

$$2.5 \text{ ft} \times 0.43 \text{ psi/ft} = 1.08 \text{ psi}$$

1.08 psi = passive water pressure

Equation 9A.

Storage Capacity of a Cylinder (Can Apply to Both a Cylindrical Cistern or a Length of First Flush Pipe) (English units)

$$\pi \times (\text{cylinder radius (ft)})^2 \times \text{effective cylinder height* (ft)} \times 7.48 \text{ gal/ft}^3 = \text{capacity (gal)}$$

Note: r = radius of the circle

*Effective height is the height of water you can get back out of the tank when it's full, as opposed to the total height of water in the tank, which includes several inches of water that can never be drained out due to an out-flow pipe above the bottom of the tank.

EXAMPLE:

The householders above are considering using a cylindrical tank to store their rainwater. They want to determine the capacity of a tank with a diameter of 3 feet and a height of 8 feet. The radius of the tank is one half the diameter, so it is 1.5 feet. Since they realize the effective tank storage height is going to be reduced by 4 inches because of the raised outlet 4 inches from the bottom of the tank, and by another 5 inches because of the bottom of the tank overflow pipe being 5 inches below the top of the tank, the effective height is going to be 7.25 feet. Using Equation 9A, they calculate the usable capacity of the tank as follows:

$$\pi \times (1.5 \text{ ft})^2 \times 7.25 \text{ ft} \times 7.48 \text{ gal/ft}^3 = \text{capacity (gal)}$$

$$3.14 \times 2.25 \text{ ft}^2 \times 7.25 \text{ ft} \times 7.48 \text{ gal/ft}^3 = 383 \text{ gal}$$

383 gal = capacity

Equation 9B.

Storage Capacity of a Cylinder (Can Apply to Both a Cylindrical Cistern or a Length of First Flush Pipe) (metric units)

$$\pi \times (r \text{ (m)})^2 \times \text{effective cylinder height (m)} \times 1,000 \text{ liter/m}^3 = \text{capacity (liters)}$$

See notes for Equation 9A.

Equation 10A.

Storage Capacity of a Square or Rectangular Tank (English units)

$$\text{length (ft)} \times \text{width (ft)} \times \text{effective height (ft)} \times 7.48 \text{ gal/ft}^3 = \text{capacity (gal)}$$

EXAMPLE:

A household decides to install a rectangular tank that has interior dimensions: 8 feet tall, 6 feet long, and 4 feet wide. The tank outlet tap is located 4 inches above the bottom of the tank. The underside of the overflow pipe is located 5 inches below the top of the tank. They calculate the effective height of water as 7.25 ft, so the calculation is as follows:

$$6 \text{ ft} \times 4 \text{ ft} \times 7.25 \text{ ft} \times 7.48 \text{ gal/ft}^3 = 1,302 \text{ gal}$$

$$1,302 \text{ gal} = \text{capacity}$$

Equation 10B.

Storage Capacity of a Square or Rectangular Tank (metric units)

$$\text{length (m)} \times \text{width (m)} \times \text{effective height (m)} \times 1,000 \text{ liter/m}^3 = \text{capacity (liters)}$$

See notes with Equation 10A.

Equation 11A.

Cistern's One-Time Dollar Price for Storage Capacity (English units)

$$\text{price of cistern (dollars)} \div \text{storage capacity (gal)} = \text{price of storage capacity (dollars/gal)}$$

EXAMPLE:

The tank in Equation 10A holds 1,302 gallons of water, and would cost around \$850 to purchase and install:

$$\$850 \div 1,302 \text{ gal} = \$0.65/\text{gal}$$

$$\$0.65/\text{gal} = \text{price of storage capacity}$$

Equation 11B.

Cistern's One-Time Price for Storage Capacity (metric units)

$$\text{price of cistern} \div \text{storage capacity (liters)} = \text{price of storage capacity (price/liter)}$$

See notes with Equation 11A. For non-USA currencies, substitute the appropriate currency.

Equation 12A.

Weight of Stored Water (English units)

$$\text{stored water (gal)} \times 8.32^* \text{ lb/gal} = \text{weight of stored water (lb)}$$

EXAMPLE:

A 55-gallon drum under a rainspout has filled to the very top with water and you need to figure out how much it weighs to decide whether you can move it.

$$55 \text{ gal} \times 8.32^* \text{ lb/gal} = 457.6 \text{ lb}$$

$$457.6 \text{ lb} = \text{weight of stored water}$$

Water is extremely heavy. Do not underestimate the force you are dealing with when you store it. Platforms supporting storage tanks must be able to hold the water's weight!

*Note: Water density changes slightly with temperature.

Equation 12B.

Weight of Stored Water (metric units)

$$1 \text{ liter of water weighs } 1 \text{ kilogram}$$

So:

$$\text{stored water (liters)} \times 1 \text{ kg/liter} = \text{weight of stored water (kg)}$$