How to size your greywater-harvesting basins or subsurface infiltration chambers to handle expected household greywater discharges

excerpted with permission from chapter 12 of
"Rainwater Harvesting for Drylands and Beyond, Volume 2, 2nd Edition"
by Brad Lancaster
available at deep discount direct from the author at www.HarvestingRainwater.com

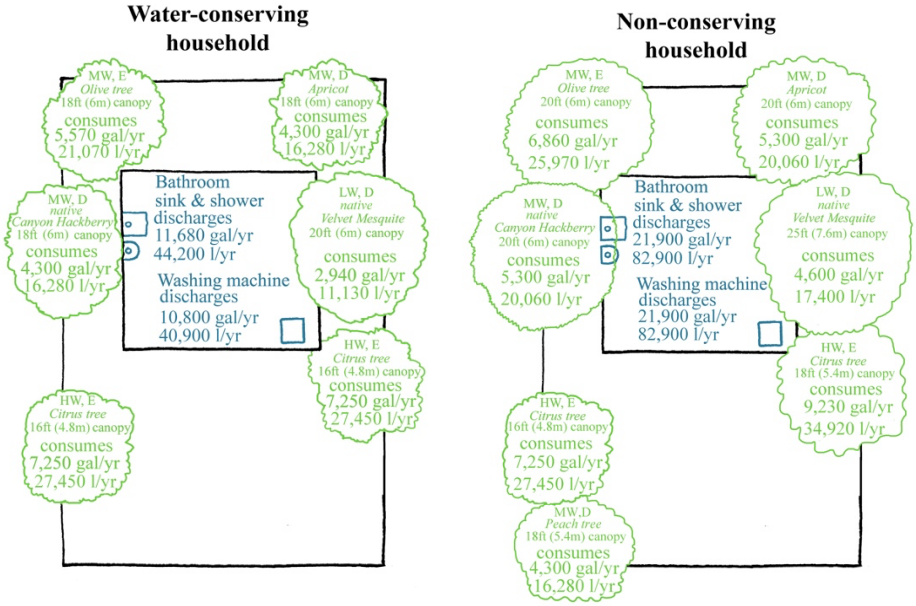


Fig. 12.20. Sample site plans show average annual greywater discharge for a water-conserving household (left) and non-conserving household (right) where four people live (based on boxes 12.6 and 12.8, then rounded to even numbers). In addition, annual water needs of trees within easy reach and downslope of household greywater sources are shown. Water needs are based on appendix 4, in *Volume 1, 3rd Edition*. (LW = Low-water-use tree, MW = medium-water-use tree, HW = high-water-use tree, D = deciduous, E = evergreen, native = native plant)

STEP ONE: Estimate the volume of your accessible *AVERAGE* greywater discharge (see fig. 12.20; and boxes 12.6 and 12.8 – *at end of this handout*) to determine the volume of greywater available for irrigation. Then estimate the irrigation needs of your existing or planned landscape.

Using the figures from box 12.8 (and calculations below) we created an example of average annual greywater discharge for a water-conserving household of four people on the left-hand side of fig. 12.20:

• Shower: 4 people X 1 shower/person/day X 6 gallons (22.7 liters)/shower = 24 gallons (90.8 liters) average daily discharge

• Bathroom sink: 4 people X 2 gallons (7.6 liters)/person/day = 8 gallons (30.4 liters) average daily discharge

• Shower and sink: 24 gallons (90.8 liters) daily shower discharge + 8 gallons (30.4 liters) daily sink discharge = 32 gallons (121.2 liters) average daily bathroom greywater discharge

For average monthly figures, multiply the daily figure by 30 days.

For average annual figures, use estimates of use/person/year from box 12.8 for the calculations above, rather than using estimates of daily use per person.

To estimate irrigation needs for specific plants, see appendix 4 in *Rainwater Harvesting for Drylands and Beyond, Volume 1, 3rd Edition*.

To get a ballpark estimate of your current outdoor monthly water use, compare your water bills from the irrigation season—typically drier summer months, to a season when little or no irrigation is needed—typically winter months. The difference is more or less your outdoor water use.

Average greywater discharge in this example can meet 71% (22,480 gallons [85,096 liters]) of the irrigation needs in the water-conserving household (left hand example in fig. 12.20). Ideally, harvested rainwater makes up the remaining 29% (9,130 gallons [34,560 liters]) of the landscape's water needs. Native trees can get this from passive earthworks, but less hardy exotic fruit trees will likely also need cistern water to make up the difference in dry seasons. At sites with lower available water, reduce plant density and size, or switch to lower-water-use plants.

In the non-conserving household (right-hand side of fig. 12.20), the higher volume of greywater discharge can allow for an increase in plant density and water use, and/or plant size. Greywater discharge can meet 100% (42,840 gallons [162,167 liters]) of current irrigation demand. As the household begins to conserve water, available greywater will decrease and the need for rainwater harvesting will increase. At this site, higher greywater discharges will require larger basins or subsurface chambers (see step two).

STEP TWO. Size basins or subsurface chambers based on the expected *PEAK greywater flow in a day* and on your soil's percolation rate to avoid unwanted oversaturation of soil and failure of the system.

Estimating *PEAK* greywater flow in a day

What is the possible peak (extreme) greywater flow in a day for your household?

Let's say you want to harvest shower greywater from your one-bathroom, water-conserving household, which has a low-flow 1.8 gallon/min (6.8 liter/minute) showerhead. You usually have 4 people showering 5 minutes each once a day. But how much greywater would be produced if you had 2 guests and everyone (6 people) showered twice in one day (maybe you all played in mud puddles after your morning showers).

Using water use estimates in box 12.8:

6 people X 2 showers each X 9 gallons (34 liters) per shower = 108 gallons (408 liters) peak daily flow rate. Remember that number.

Estimating the percolation/infiltration rate of your soil

Do a simple soil percolation/infiltration test in the area(s) where you plan to harvest greywater (see box 12.11 in *Rainwater Harvesting for Drylands and Beyond, Volume 2, 2nd Edition*).

After estimating peak daily flow and then doing an infiltration test for the soil where you plan to infiltrate your greywater, use table 12.1 to determine the minimum infiltration surface area you need on the bottom of your mulched basin(s) or subsurface chamber(s) based on the estimated peak daily flow they will receive.

Table 12.1. Maximum greywater loading rates and minimum greywater infiltration areas based on soil's infiltration rate and peak greywater discharge volumes.

Row	Column 1	Column 2	Column 3	Column 4	Column 5	Column 6
	Soil's infiltration rate, *minutes/inch*	Maximum loading rate of infiltration area, *gpd/ft²*	Infiltration surface area needed for peak greywater volume, *ft²/gpd*	Soil's infiltration rate, *minutes/cm*	Maximum loading rate of infiltration area, *liters/m²/day*	Infiltration surface area needed for peak greywater volume, *m²/liters/day*
1	0-30	2.5	0.4	0-12	102	0.010
2	30-45	1.5	0.7	12-18	61	0.017
3	45-60	1.0	1.0	18-24	41	0.025
4	60-120	0.5	2.0	24-47	20	0.049
	ft^2/gpd = square feet of infiltration area needed per gallon per day			cm = centimeter m^2 = square meters		
	Note: These rates are conservative. Can be up to 3-5 gpd/ft^2 (122-204 liters/day/m^2) for greywater, up to 10 gpd/ft^2 (407 liters/day/m^2) for secondary treated effluent. Note: Adapted from *The New Create an Oasis with Greywater* by Art Ludwig					

For example, let's say your soil's infiltration rate is 35 minutes, which means it takes 35 minutes for an inch of water to infiltrate into the saturated soil (14 minutes to infiltrate a centimeter into saturated soil). Go to column 1 on table 12.1 (column 4 for metric units).

Find the line below that contains your soil's infitration rate, which in this case is row 2. Remember, in Step 4 earlier, you calculated your peak daily flow rate as 108 gallons (408 liters). Now move to the right along row 2 to column 3, where you see that the infiltration surface area needed is 0.7 square feet per gallon per day. Now do the following calculation:

108 gallons peak greywater flow per day X 0.7 square foot of infiltration area per gallon per day = 75.6 square feet minimum infiltration surface area at the bottom of basin or subsurface chamber to infiltrate your peak flow of greywater.

Or (in metric): 408 liters peak greywater flow per day X 0.017 square meters of infiltration area per liter per day = 6.9 square meters minimum infiltration surface area at the bottom of basin or subsurface chamber to infiltrate your peak flow of greywater.

That's a big basin! Or if you're using subsurface chambers, you'd need seven of them (each Quick 4 Plus Low Profile chamber having 11.32 square feet or 1.05 square meters of bottom surface area within them). The needed basin/chamber size would increase even more if you had a slower soil infiltration rate.

The easiest way to reduce the basin size or number of chambers is to reduce the volume of greywater entering the system.

Just switching from a 1.8 gallon/minute (6.8-liter/ minute) showerhead to a 1 gallon/minute (3.8-liter/ minute) showerhead would reduce the peak daily flow to 60 gallons (227 liters) and the needed basin or chamber bottom surface area to 42 square feet (3.9 m^2), requiring four chambers.

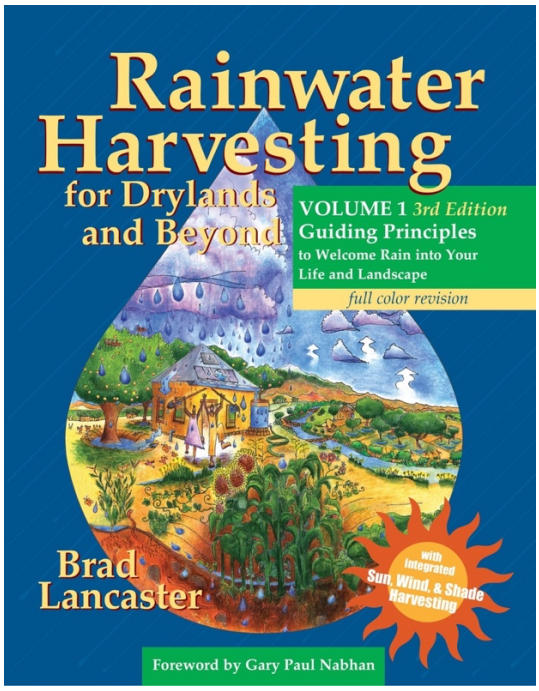
Another option to reduce the peak flow is to divert some greywater flow to the sewer or septic system (figs 12.5 – 12.8), but you might not remember to divert it, so don't count on that when sizing your system.

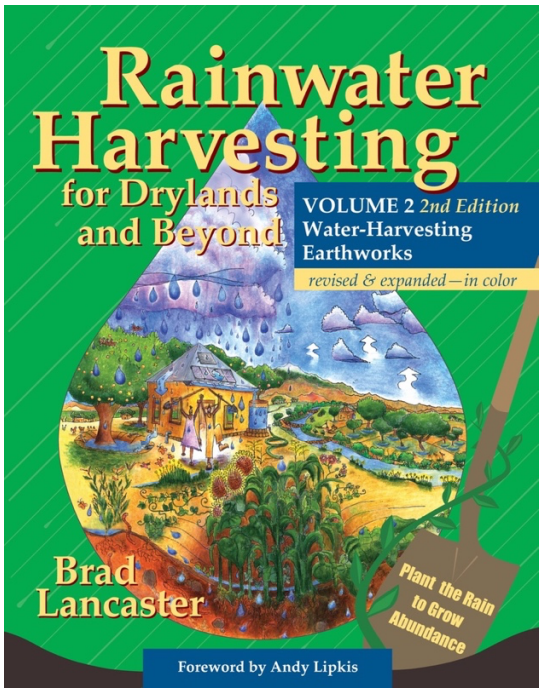
You can increase the infiltration rate of water into soil over time by increasing roots, organic matter, and life in the soil. Do this by planting within and beside the basin or near the chamber(s) to increase roots. Add compost and/or wood chip mulch to support beneficial soil microorganisms such as mycorrhizal fungi.

You can reduce the size of a single basin or single chamber run by diverting the greywater flow to additional basins or chamber runs. Size the combined surface area of all the basins or chambers to handle the peak daily flow (see step 3).

STEP THREE. Determine your options for diverting greywater flow to multiple destinations.

See chapter 12 of *Rainwater Harvesting for Drylands and Beyond, Volume 2, 2nd Edition* for more.





Box 12.6. Per Capita Indoor Water Use for Average (Non-Conserving) American

Fixture	Average Volume/Use	Average Frequency	Average Use/Person/Day	Average Use/Person/Week	Average Use/Person/Year
Washing Machine	40.9 gal/load (155.0 liters/load)	0.37 loads/day (2.52 loads/week)	15.0 gal (56.8 liters)	105.0 gal (398.0 liters)	5,475.0 gal (20,750.0 liters)
Shower	17.2 gal (65.2 liters) The average shower was 8.2 minutes with a flo rate of 2.22 gal/minute (8.4 liters/minute)	0.67 showers/day (4.69 showers/week)	11.6 gal (44.0 liters)	81.2 gal (307.7 liters)	4,234.0 gal (16,046.9 liters)
Bathroom Faucet	Data Not Available	Data Not Available	3.4 gal* (12.9 liters)	23.8 gal (90.2 liters)	1,241.0 gal (4,703.4 liters)
Bathtub	24.0 gal (91.0 liters)	0.05 baths/day (Most Americans take showers instead of baths)	1.2 gal (4.5 liters)	8.4 gal (31.8 liters)	438.0 gal (1,660.0 liters)
TOTALS			31.2 gal (118.2 liters)	218.4 gal (827.7 liters)	11,388.0 gal (43,160.5 liters)

Figures for average volume/use, average frequency, and average use/person/day are from www.h2ouse.org, except for bathroom faucets. The original source of data is *Residential End Uses of Water* by P.W. Mayer, W.B. DeOreo, E. Opitz, J. Kiefer, B. Dziegielewski, W. Davis, and J.O. Nelson, a study sponsored and published by the American Water Works Association Research Foundation, Denver, Colorado in 1999. Water use was measured in 1,200 households in ten U.S. and two Canadian cities.

*Source of average American daily use estimate for bathroom faucet: http://www.watersavertech.com/Aquacraft_Savings_Report.pdf.

Box 12.8. Estimates of Personal Indoor Water Use with Efficient Fixtures and Water-Conserving Habits

Fixture	Factors Affecting Volume/Use	Frequency and Volume Assumptions	Use/Person/Day	Use/Person/Week	Use/Person/Year
Efficien Washing Machine	Volume per use affected by washer efficienc , washer capacity, and adjustability of water levels. Efficien washers available in U.S. generally use 18 to 25 gal/load* (68 to 95 liters/load). Some use only 10 gal/load (37.9 liters/load). Capacities range from 1.6 to 3.8 ft^3* (0.045 to 0.108 m^3).	Average U.S. frequency: 0.37 loads/day (2.52 loads/week) (see box 12.6). Volume per load: 20 gal (75.8 liters/load)	7.4 gal (25.0 liters)	51.8 gal (175.1 liters)	2,701.0 gal (9,130.1 liters)
Shower	Volume per use affected by showerhead type, shower length, water line pressure, and the size valve is opened to. Low flow showerheads range from 1.5 to 2.5 gal/min* (5.7 to 9.5 liters/min). Ultra low flow showerheads range from 0.8 to 1.5 gal/min (3.0 to 5.7 liters/min).	Assumed average U.S. frequency: 0.67 showers/day (4.69 showers per week) (see box 12.6) Volume per use: 5 minutes/shower assuming flow rate 1.8 gal/min (6.8 liters/min) for total 9 gal/shower (34.1 liters)	6.0 gal (22.7 liters)	42.0 gal (159.2 liters)	2,190.0 gal (8,300.1 liters)
Bathroom Sink	Volume per minute affected by aerator type at faucet outlet, size valve is opened to, and length of time faucet is on during sink use. Faucets with an attached low flo aerator range between 0.5 to 1.5 gal/min (1.9 to 5.7 liters/min).	Assumptions: faucet turned off part of time during sink use; low flow aerator is installed. (Assuming 8 uses/day, 15 sec/use, and 1.0 gal/min (3.8 liter/min) aerator	2.0 gal (7.6 liters)	14.0 gal (53.1 liters)	730.0 gal (2,766.7 liters)
Bath	Americans typically take showers instead of baths. This estimate assumes baths typically used for washing children use low volume of water for safety reasons, and occasional use by adults who want full bath for therapeutic value.	Assumed average U.S. frequency 0.05 baths/day; volume 24 gal/use (91.0 liters) (see box 12.5)	1.2 gal (4.5 liters)	8.4 gal (31.8 liters)	438.0 gal (1,660.0 liters)
TOTALS			15.8 gal (59.9 liters)	110.6 gal (419.2 liters)	6,059 gal (21,856.9 liters)

* gal = gallons, ft^3= cubic feet, gal/min = gallons per minute

Use rates estimates based on the following sources:
www.fypower.org/res/tools/products_results.html?id=100122; www.energystar.gov/index.cfm?c=clotheswash.pr_clothes_washers; www.cee1.org/resid/seha/rwsh/rwsh-main.php3; www.fypower.org/res/tools/products_results.html?id=100160; www.watersavertech.com/Aquacraft_Savings_Report.pdf; www.watersaver.org/indoorwateruse.asp;
www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13050

- High efficiency washing machines cut energy and water use by half or more. Efficient machines use very little detergent (e.g.: 2 Tablespoons [30 cubic cm] of liquid detergent for a washer with a 2.65 ft^3 [0.075 m^3] capacity). Horizontal axis (front loaders) are the most efficient
- To estimate your showerhead's flow rate hold a gallon container under the showerhead and record the time it takes to fill in seconds. The bucket will get heavy (8.5 lbs or 3.8 kg) so you may want to put it on a step ladder. Then divide 60 by the seconds of fill time to calculate flow rate in units of gallons/minute. Example: If it takes 30 seconds to fill: 60 ÷ 30 = 2 gallons per minute (7.5 liters per minute). Since 1992, flow rates for faucets and showerheads made in the U.S. must be 2.5 gallons per minute or less at 80 pounds per square inch (9.5 liters per minute or less at 552 kilopascals).