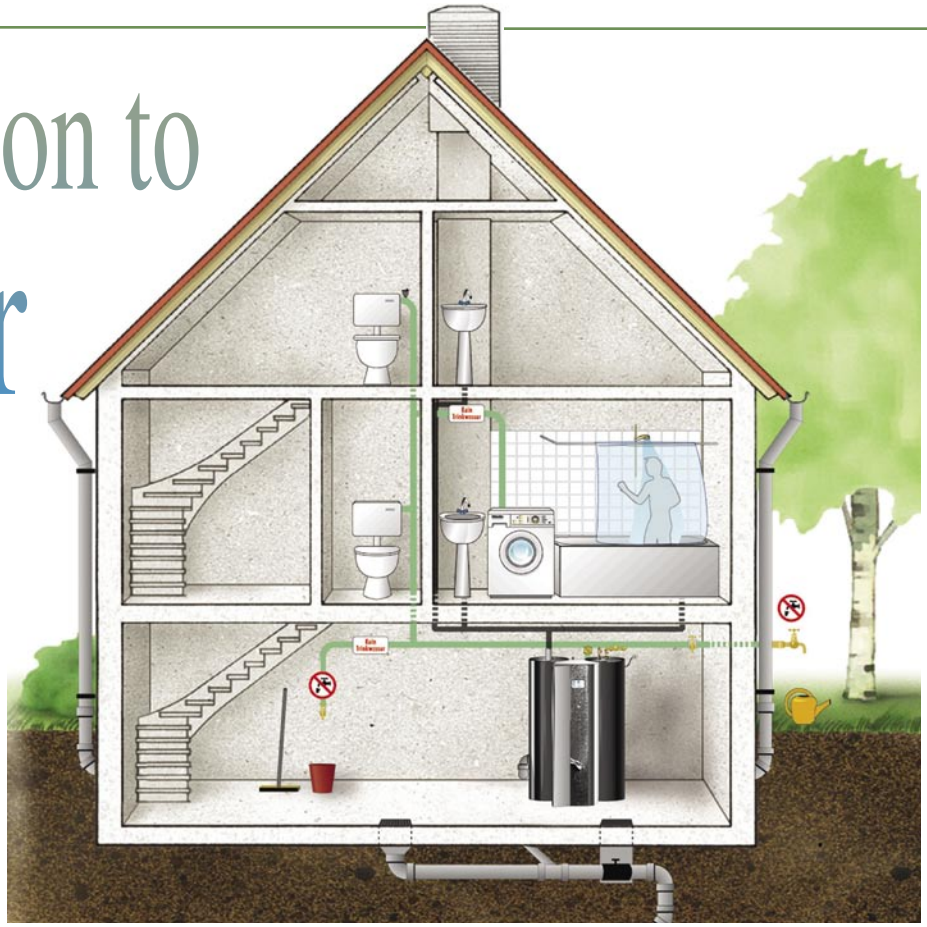
An Introduction to Greywater (Part I)

Reusing this valuable resource for irrigation, conservation, and environmental health.

By Art Ludwig



Any wastewater generated in the home, except water from toilets, is called greywater. Dish, shower, sink, and laundry greywater make up 50 to 80 percent of residential "wastewater." It's a shame to lose this precious resource when greywater can be reused for other purposes, especially landscape irrigation.

Toilet-flush water is called blackwater. There are a few systems, such as branched-drain green septic systems or constructed wetlands, that can safely recycle toilet water; they will not be discussed in the context of this article, though I do address them in my book, *Create an Oasis with Greywater.*

Contaminated or difficult-to-handle greywater, such as solids-laden kitchen sink water or water used to launder diapers, I call "dark greywater," though most regulators consider these blackwater. However, the level of pathogens in even the darkest greywater is a small fraction of that in blackwater.

Wastewater without added solids, such as warm-up water from the hot water faucet, reverse-osmosis purifier drain water, or refrigerator compressor drip, is called clearwater.

What to Do With Greywater?

Conventional plumbing systems dispose of greywater via septic tanks or sewers. The many drawbacks of this practice include overloading treatment systems, contaminating natural waters with poorly treated effluent, and a high ecological/economic cost.

Instead, you can reuse this water. The most common reuse of greywater is for irrigation. It can also be cascaded to toilet flushing or for laundry.

Why Use Greywater?

It is said that there is no such thing as "waste," just misplaced resources. Greywater systems turn "wastewater" and its nutrients into useful resources. Why irrigate with drinking water when most plants thrive on used water containing small bits of compost?

Unlike many ecological stopgap measures, greywater use is part of the fundamental solution to many ecological problems. The benefits of greywater recycling include:

• *Reduced use of freshwater.* Greywater can replace freshwater for some uses. This saves money and increases the effective water supply, especially in regions where irrigation is needed.

• *Less strain on septic tanks or treatment plants.* Greywater, which comprises the majority of the wastewater stream, contains vastly fewer pathogens than blackwater and 90 percent less nitrogen (a nutrient that is a problematic water pollutant). Reducing a septic system's flow by getting greywater out greatly extends its service life and capacity.

• *More effective purification.* Greywater is purified to a spectacularly high degree in the upper, most biologically active region of the soil. This protects the quality of natural surface and groundwaters.

• *Feasibility for sites unsuitable for a septic tank.* For sites with slow soil percolation or other problems, a greywater system can partially or completely substitute for a costly, over-engineered septic system.

• *Reduced use of energy and chemicals.* This reduction is due to the reduced amount of freshwater and wastewater that needs pumping and treatment. If you provide your own wa-

ter or electricity, you'll benefit directly from lessening this burden.

• *Plant growth.* Greywater can support a flourishing landscape where irrigation water might otherwise not be available.

• *Reclamation of nutrients.* Loss of nutrients through wastewater disposal into rivers or oceans is a subtle but highly significant form of erosion. Reclaiming otherwise wasted nutrients in greywater helps maintain the land's fertility.

• *Increased awareness of, and sensitivity to, natural cycles.* The greywater user, by having a reason to pay more attention to the annual progression of the seasons, the circulation of water between the Earth and the sky, and the needs of plants, benefits intangibly but greatly by participating directly in the wise husbandry of vital global nutrient and water cycles.

When Not to Use Greywater

There are a number of possible reasons not to use greywater, or to use it only during certain times of year:

• *Insufficient space.* In some situations, neighbors are too close, or the yard too small or nonexistent.

• *Inaccessible drainpipes.* If all plumbing is entombed under a concrete slab, accessing most of the greywater won't be economical.

• *Unsuitable soil.* Soil that is either extremely permeable or impermeable may preclude the use of a greywater system.

• *Legality concerns and/or permit hassles.* In much of the industrialized world, the legality of greywater systems is a "grey" area. However, there seems to be movement toward a less paranoid, more realistic official attitude, concurrent with increased experience and improved systems, not to mention water shortages and pollution problems.

Elements of a Greywater System

What a greywater system does is collect greywater, then divide and distribute the flow among planted areas. Most of the systems are variations on this basic functionality, even those systems designed primarily to get rid of greywater rather than extract value from it. The "hardware" that accomplishes this generally consists of:

1. Greywater source(s): washing machine, shower, bathtub, and/or sinks.

2. Collection plumbing: pipes that transport greywater from the house to one or more points just outside the house.

3. Surge tank, filter, and pump: optional elements that add complexity and cost but make the distribution plumbing's job easier, especially for large flows.

4. Distribution plumbing: plumbing that transports greywater through the yard and divides it among plants.

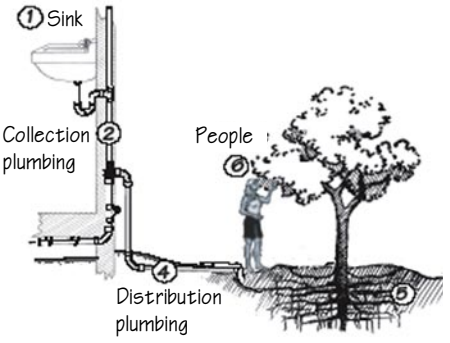
5. Receiving landscape: soil, roots, plants, and mulch basins that contain, cover, purify, and use the greywater.

6. People: those who design, make, and maintain the system, generate the greywater, tend the garden, and eat the fruits.

Very Context-Dependent

A small change in your context—siting, sources, irrigation need, percolation rate, etc.—can mean drastic changes in your system selection and design. Most individual systems will follow the middle path: a carefully considered and optimized do-it-yourself residential retrofit system for gravity-flow irrigation, not too ritzy, built without a permit, in a moderate climate, with a plumber involved in the collection plumbing, and a septic or sewer backup.

Elements of Greywater Systems



Drain to Mulch Basin

However, multiple side trips from this main path may apply to you. For example, a quick and dirty (instead of carefully considered and optimized) approach is not necessarily wrong. Greywater systems can be slapped together without much thought or trouble—and the vast majority are. Greywater work is pretty forgiving, so no matter how it gets done, you'll realize a portion of the possible benefits.

If your system is to be for disposal only and not irrigation (for example, to take the pressure off a septic system), then information on optimizing irrigation efficiency will concern you only inasmuch as it helps you spread greywater over a wide area and avoid overloading the soil with water.

If your system is to be retrofitted to an existing building, you're pretty much stuck working with what you've got. But if it's for new construction, you have the opportunity to make everything better integrated—a much more challenging and potentially rewarding task.

If permits are involved, you'll need to deal with legal requirements that push you to do impractical things. To get through this maze, you may choose to arrange plumbing conventionally first, to pass inspection, and then add greywater plumbing later. If you keep blackwater and greywater lines separate, installing a greywater system later is easy.

A failing septic leach field can be restored to function by lowering or eliminating the flow of greywater through it. It is worth noting that savings on septic tank pumping and leach field replacement will pay for almost any greywater system.

A Few Assessments

A site map is a great aid for designing a system. A map with a scale of 1:100 with 1' contours is ideal. If such a map is not available, make a sketch showing the house, boundaries, irrigated areas, natural water features, utility lines, routes of plumbing under the house, and so forth.

Evaluating your water resources is important as well. The first question for any human habitation is, Where

does the water come from? Ideally, for minimum impact and long-term sustainability, rain should be the primary water source, followed by greywater, followed by gravity-flow spring or creek water, followed by well or municipal water. Wherever the water comes from, note its characteristics and limitations.

If you aim to live ecologically, thoroughly explore conservation options before turning to reuse. Because of the unavoidable inefficiencies inherent in greywater systems, the gain from reducing consumption with water-conserving fixtures is always greater than that from reusing the water.

For any system in any context, I recommend doing at least a rough reality check to make sure the quantities of output and intended use are in the same ballpark. It is commonly assumed that however much greywater there is and however much irrigation is needed, they'll magically match up. Even if you don't want to reuse the greywater, it's good to have an idea of how much you've got in order to know if your disposal/treatment area is big enough. For most purposes, you can just take the home's population and multiply it by an approximate daily use figure, as shown in the chart below.

Homes without water-conserving fixtures generate about 55 gal/person/day. Efficient fixtures cut this daily output to 40 gal/person/day, or enough to water four mature fruit trees or a dozen shrubs in an average climate. Extreme conservation habits can cut production to 5 gal/person/day.

On your site map, note where the greywater sources are and (if they are not combined) how much of the total flow comes from each set of sources. Group fixtures that share a common drain into subtotals (for example, the bathroom sink, tub, and shower often share a drain), and note where their plumbing goes.

Consider whether it is appropriate to move any greywater sources (such as a washing machine), add an outdoor shower, or take any other action to improve the fit of water sources to irrigation need. The places where greywater is generated should ideally be high on the property, so you can irrigate more area by gravity.

You should also note variations in the population of water users. If everyone goes away in the dry season for an extended time, this obviously affects the system's design; you won't want to set up water-loving plants to be irrigated by greywater only.

Check Slopes and Elevations

This step is crucial for collection plumbing and gravity-powered greywater distribution, especially branched-drain systems, where slopes must be accurately measured.

Check the slope from beginning to end of the intended system with a water level. You need to establish that there is enough fall to get from the greywater sources to destination plants with a constant downhill slope (generally 1/4" per foot, or 2 percent).

In the landscape, the pipes should ideally still be at surface level, and in no case more than 12" belowground. For proper flow, drainpipes must inexorably get lower with distance from the source, and also with the negotiation of each obstacle, change of pipe size, etc.—and the pipe elevation can't ever go back up again.

Note these elevations on your site map. From slope measurements, you can determine which sources can water which plants. Remember that you actually need a bit more than 2 percent slope from end to end, to allow for obstacles and other "fall eaters."

Check the Soil Perk

You should have at least an idea of the perk rate for any system. Quantitative measurement is necessary if a lot of greywater is going into a small area, or the perk appears to be low, or the soil is clayey.

How to Measure Perk

Dig holes to greywater discharge depth (usually 6" to 12") in the locations you wish to discharge it. Place stakes into the bottoms firmly. Mark reference elevations on the stakes and fill the holes with water two to four times, measuring each time how many inches the water drops in a given number of minutes. When it drops the same amount in the same amount of time, a couple of times in a row, that's your perk measurement. Convert the numbers to perk rate in minutes/inch (3" in 60 minutes is 20 min/inch, for example), then refer to the chart on page 31 to see how much area you need to treat that much water.

If it takes hours for the water to drop at all, or the water vanishes as fast as you can fill the hole, or if the holes fill with water by themselves, you've got a problem! If the perk is super slow, consider a constructed wetland. If it is super fast, add compost, mulch, and plants that will develop a dense network of roots to help purify greywater on its short journey through the soil.

Greywater Sources by Quality and Quantity

Source	Quality	Quantity
Washer	Good: Medium soap concentration	Large: 30-50 gal/load
Dishwasher	Poor: High salt & pH, some solids	Small: 5-10 gal/load
Kitchen sink	Good: High nutrients, but some grease	Large: 5-15 gal/person/day
Shower	Excellent: Minimal soap concentration	Large: 20 gal/person/day
Tub	Excellent: Minimal soap concentration	Variable: 40 gal/adult, 25 gal/child
Bathroom sink	Good: But higher soap concentration	Small: 1-5 gal/person/day
Reverse-Osmosis water purifier	Excellent: Clearwater w/ no solids	Medium: 3-5 gal/gallon drinking water used

The rate at which water absorbs into the soil—the percolation or perk rate—is an important variable in greywater system design. High clay content generally means slow perk, which can get dramatically worse if you add salt-laden greywater. Rock can have slow or no perk. Very slow perk can lead to standing water and noxious smells. Sand is high perk, gravel more so. Very fast perk can lead to groundwater contamination, though this is unlikely if there is a dense network of plant roots.

It is vital to know about the perk where the greywater is going before committing to a design. If you're putting a small amount of greywater in a big area, the only perk issue would be a really, really slow perk rate. If you have enough experience with your soil—digging holes to various depths, perhaps filling them with water, observing how water absorbs into the ground—to know it perks reasonably fast, you don't need a perk test.

If you are applying a large amount of greywater, or have a small area, or are applying greywater subsurface, a perk test is critical. Based on the result, you might change the size of the system by a factor of four or more, or even decide that a greywater system is infeasible.

A professional (read expensive) perk test is required for installing almost any septic system these days. These tests are usually done with a truck-mounted borer to a depth that is irrelevant to greywater systems. If you already have one of these tests in hand and it shows that the perk rate is okay several feet down, it is surely fine at greywater depth, but a free, do-it-yourself perk test that takes an hour gives you better information (see sidebar "How to Measure Perk").

Disposal Loading Rates

Infiltration rate, min/inch	Loading rate gal/day/sq. ft.	Area needed, sq. ft./gal/day
0-30	2.5	0.4
40-45	1.5	0.7
45-60	1.0	1.0
60-120	0.5	2.0

Gauge Your Treatment/Disposal Area

If you want only to dispose of greywater, you can differentiate prospective treatment areas on your site map by indicating how much greywater they can handle. In this case, the only concern is to not overload the soil or sensitive plants. Areas with higher perk rate and areas with more wind and sun can take more water. You don't want to apply too much water near the foundation of the house.

Assess Your Irrigation Need

Note by different colors or shades the vegetation types and the extent of irrigated areas and trees on your site map, indicating areas of plants that like wetter conditions. Or you can simply make a list of irrigated areas and how much water you think they want. Again, if your aim is to live ecologically, you should thoroughly explore conservation options in the landscape before turning to reuse to feed water-hog plants.

Estimating irrigation demand is an inexact science. Even getting within a factor of two of the real irrigation demand is an ambitious goal. As a rough rule of thumb, figure that your plants need about 1/2 gallon per week of water for each square foot of plant. Double this figure for desert, and halve it for a cool, humid climate. You can also double or halve this figure again for plants that use more or less water. For trees, calculate the area under the canopy and multiply it by the gallons per square foot per week.

This rule of thumb above does not account for variations in evapotranspiration rate by season, climate, plant type, seasonal loss of leaves, rainfall, and irrigation efficiency. It does, however, land you more or less where you'd end up if you did consider all those things.

Health Considerations

In practice, the health risk of greywater use has proved minimal. It is, after all, the water you just bathed in and the residue from the clothes you just wore not long ago. Despite all sorts of grievous misuse, there has not been a single documented case of greywater-transmitted illness in the United States. Nonetheless, greywater may contain infectious organisms, and it is poor practice to be constructing pathways for infecting people.

All greywater safety guidelines stem from these two principles: (1) greywater must pass slowly through healthy topsoil for natural purification to occur, and (2) systems must be designed so no greywater-to-human contact occurs before purification. Some potential health-related issues and their solutions are listed below.

Direct contact or consumption: Avoid cross-connections between freshwater and greywater plumbing and wear gloves when cleaning greywater filters.

System overload: Do not include water used to launder soiled diapers in the greywater supply, and don't store greywater for more than 24 hours.

Microorganisms on plants: Do not apply greywater directly on lawns, or to fruits and vegetables that are eaten raw, such as lettuce, carrots, and strawberries.

Microorganisms in respiratory system: Do not recycle greywater with sprinklers.

Chemical contamination: Avoid the use of nonbiodegradable (chemical) household cleaning products.

Contamination of surface water: Discharge greywater underground or into a mulch-filled basin, and water intermittently to avoid saturating the soil.

Art Ludwig will continue with Part II of this article in the next issue of BackHome, where he will discuss the practical aspects of branched-drain systems, radical plumbing, and mulch basin options. For more information on the book Create an Oasis with Greywater *see the review in BackHome No. 85 (Nov/Dec 2006) or go to www.oasisdesign.net/greywater.*